Growing Cooler: The Evidence on Urban Development and Climate Change

Reid Ewing, Keith Bartholomew, Steve Winkelman, Jerry Walters, and Don Chen

with Barbara McCann and David Goldberg

This new book documents how key changes in land development patterns could help reduce vehicle greenhouse gas emissions. Based on a comprehensive review of dozens of studies by leading urban planning researchers, the book concludes that urban development is both a key contributor to climate change and an essential factor in combating it. The authors make the case that one of the best ways to reduce vehicle travel is compact development: building places in which people can get from one place to another without driving. This includes developments with a mix of uses and pedestrian-friendly designs. Changing demographics, shrinking households, rising gas prices, and lengthening commutes are contributing to the demand for smaller homes and lots, townhouses, and condominiums near jobs and other activities. Current government policies and regulations encourage sprawling, auto-dependent development. The book recommends changes that can be made to make green neighborhoods more available and more affordable.

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The policy recommendations presented in this book do not necessarily reflect the opinions of the Urban Land Institute.

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College Park, Maryland

Contents

Executive Summary

The phrase "you can't get there from here" has a new application. For climate stabilization, a commonly accepted target would require the United States to cut its carbon dioxide (CO_2) emissions by 60 to 80 percent as of 2050, relative to 1990 levels. Carbon dioxide levels have been increasing rapidly since 1990, and so would have to level off and decline even more rapidly to reach this target level by 2050. This publication demonstrates that the U.S. transportation sector cannot do its fair share to meet this target through vehicle and fuel technology alone. We have to find a way to sharply reduce the growth in vehicle miles driven across the nation's sprawling urban areas, reversing trends that go back decades.

This publication is based on an exhaustive review of existing research on the relationship between urban development, travel, and the CO_2 emitted by motor vehicles. It provides evidence on and insights into how much transportation-related CO_2 savings can be expected with compact development, how compact development is likely to be received by consumers, and what policy changes will make compact development possible. Several related issues are not fully examined in this publication. These include the energy savings from more efficient building types, the value of preserved forests as carbon sinks, and the effectiveness of pricing strategies—such as tolls, parking charges, and mileage-based fees—when used in conjunction with compact development and expanded transportation alternatives.

The term "compact development" does not imply high-rise or even uniformly high density, but rather higher average "blended" densities. Compact development also features a mix of land uses, development of strong population and employment centers, interconnection of streets, and the design of structures and spaces at a human scale.

The Basics

Scientific consensus now exists that greenhouse gas accumulations due to human activities are contributing to global warming with potentially catastrophic consequences (IPCC 2007). International and domestic climate policy discussions have gravitated toward the goal of limiting the temperature increase to 2°C to 3°C by cutting greenhouse gas emissions by 60 to 80 percent below 1990 levels by the year 2050. The primary greenhouse gas is carbon dioxide, and every gallon of gasoline burned produces about 20 pounds of CO_2 emissions.

Driving Up CO_2 Emissions

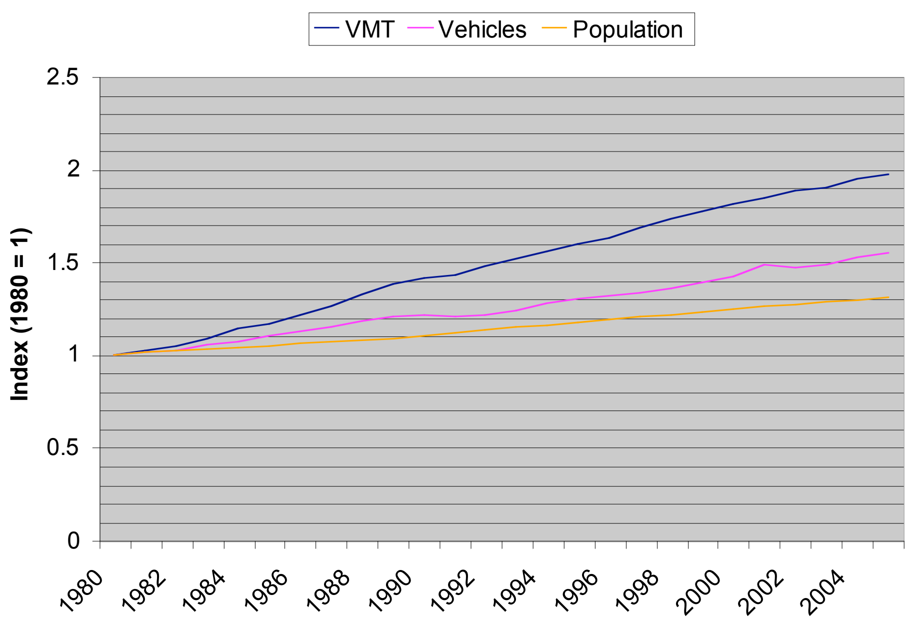
The United States is the largest emitter worldwide of the greenhouses gases that cause global warming. Transportation accounts for a full third of CO_2 emissions in the United States, and that share is growing as others shrink in comparison, rising from 31 percent in 1990 to 33 percent today It is hard to envision a "solution" to the global warming crisis that does not involve slowing the growth of transportation CO_2 emissions in the United States.

The Three-Legged Stool Needed to Reduce CO2 from Automobiles

Transportation CO2 reduction can be viewed as a three-legged stool, with one leg related to vehicle fuel efficiency, a second to the carbon content of the fuel itself, and a third to the amount of driving or vehicle miles traveled (VMT). Energy and climate policy initiatives at the federal and state levels have pinned their hopes almost exclusively on shoring up the first two legs of the stool, through the development of more efficient vehicles (such as hybrid cars) and lower-carbon fuels (such as biodiesel fuel). Yet a stool cannot stand on only two legs.

As the research compiled in this publication makes clear, technological improvement in vehicles and fuels are likely to be offset by continuing, robust growth in VMT. Since 1980, the number of miles Americans drive has grown three times faster than the U.S. population, and almost twice as fast as vehicle registrations (see Figure 0-1). Average automobile commute times in metropolitan areas have risen steadily over the decades, and many Americans now spend more time commuting than they do vacationing.

Figure 0-1 Growth of VMT, Vehicle Registrations, and Population in the United States relative to 1980 Values
Source: FHWA 2005.



This raises some questions, which this report addresses. Why do we drive so much? Why is the total distance we drive growing so rapidly? And what can be done to alter this trend in a manner that is effective, fair, and economically acceptable?

The growth in driving is due in large part to urban development, or what some refer to as the built environment. Americans drive so much because we have given ourselves little alternative. For 60 years, we have built homes ever farther from workplaces, created schools that are inaccessible except by motor vehicle, and isolated other destinations—such as shopping—from work and home. From World War II until very recently, nearly all new development has been planned and built on the assumption that people will use cars virtually every time they travel. As a larger and larger share of our built environment has become automobile dependent, car trips and distances have increased, and walking and public transit use have declined. Population growth has been responsible for only a quarter of the increase in vehicle miles driven over the last couple of decades. A larger share of the increase can be traced to the effects of a changing urban environment, namely to longer trips and people driving alone.

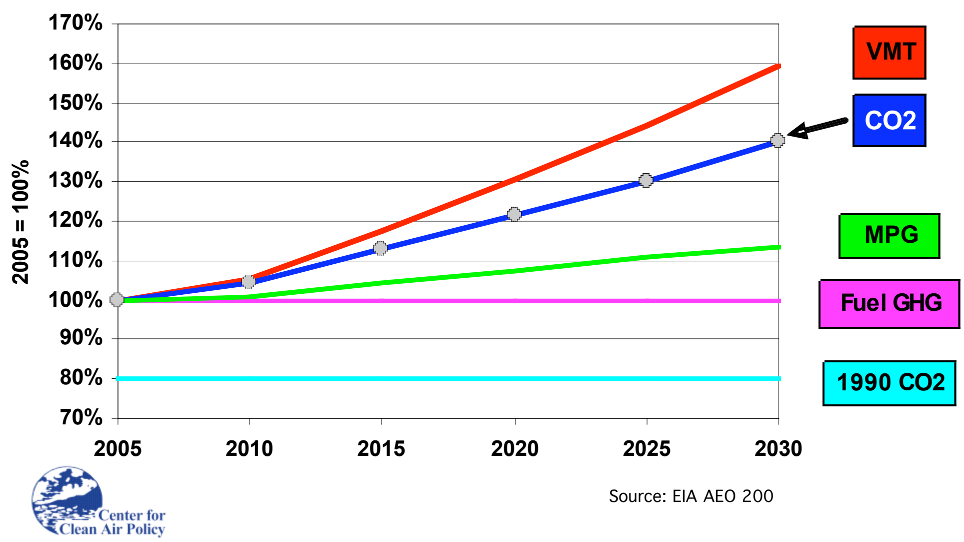
As with driving, land is being consumed for development at a rate almost three times faster than population growth. This expansive development has caused CO_2 emissions from cars to rise even as it has reduced the amount of forest land available to absorb CO_2.

How Growth in Driving Cancels Out Improved Vehicle Fuel Economy

Carbon dioxide is more difficult to control through vehicle technology than are conventional air pollutants. Conventional pollutants can be reduced in automobile exhaust with sophisticated emission control systems (catalytic converters, on-board computers, and oxygen sensors). Carbon dioxide, meanwhile, is a direct outcome of burning fossil fuels; there is no practical way to remove or capture it from moving vehicles. At this point in time, the only way to reduce CO_2 emissions from vehicles is to burn less gasoline and diesel fuel.

An analysis by Steve Winkelman of the Center for Clean Air Policy, one of the coauthors of this publication, finds that CO_2 emissions will continue to rise, despite technological advances, as the growth in driving overwhelms planned improvements in vehicle efficiency and fuel carbon content. The U.S. Department of Energy's Energy Information Administration (EIA) forecasts that driving will increase 59 percent between 2005 and 2030 (red line, Figure 0-2), outpacing the projected 23 percent increase in population. The EIA also forecasts a fleetwide fuel economy improvement of 12 percent within this time frame, primarily as a result of new federal fuel economy standards for light trucks (green line, Figure 0-2). Despite this improvement in efficiency, CO_2 emissions would grow by 41 percent (dark blue line, Figure 0-2).

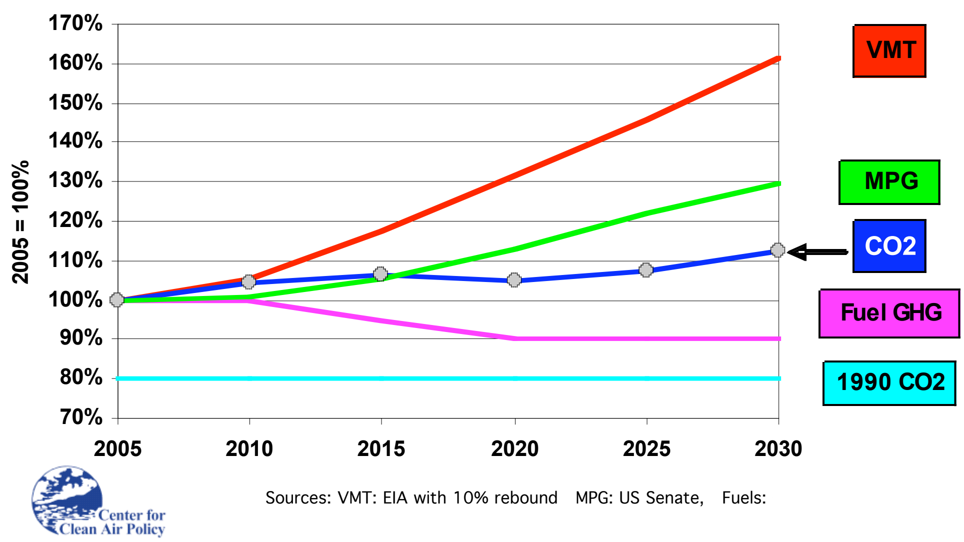
Figure 0-2 Projected Growth in CO_2 Emissions from Cars and Light Trucks
Source: EIA 2007.



U.S. fuel economy has been flat for almost 15 years, as the upward spiral of car weight and power has offset the more efficient technology. Federal and state efforts are underway to considerably boost vehicle efficiency and reduce greenhouse gas emissions. In June 2007, the U.S. Senate passed corporate average fuel economy (CAFE) standards that would increase new passenger vehicle fuel economy from the current 25 miles per gallon (mpg) to 35 mpg by 2020. (As of this writing, the House has not acted.). California plans to implement a low carbon standard for transportation fuels, specifically a 10 percent reduction in fuel carbon content by 2020.

Even if these more stringent standards for vehicles and fuels were to go into effect nationwide, transportation-related emissions would still far exceed target levels for stabilizing the global climate (see Figure 0-3). The rapid increase in driving would overwhelm both the increase in vehicle fuel economy (green line) and the lower carbon fuel content (purple line). In 2030, CO_2 emissions would be 12 percent *above* the 2005 level, and 40 percent above the 1990 level (turquoise line). For climate stabilization, the United States must bring the CO_2 level to 15 to 30 percent *below* 1990 levels by 2020 to keep in play a CO_2 reduction of 60 to 80 percent by 2050.

Figure 0-3 Projected Growth in CO_2 Emissions from Cars and Light Trucks Assuming Stringent Nationwide Vehicle and Fuel Standards*
Source: EIA 2007



As the projections show, the United States cannot achieve such large reductions in transportation-related CO_2 emissions without sharply reducing the growth in miles driven.

Changing Development Patterns to Slow Global Warming

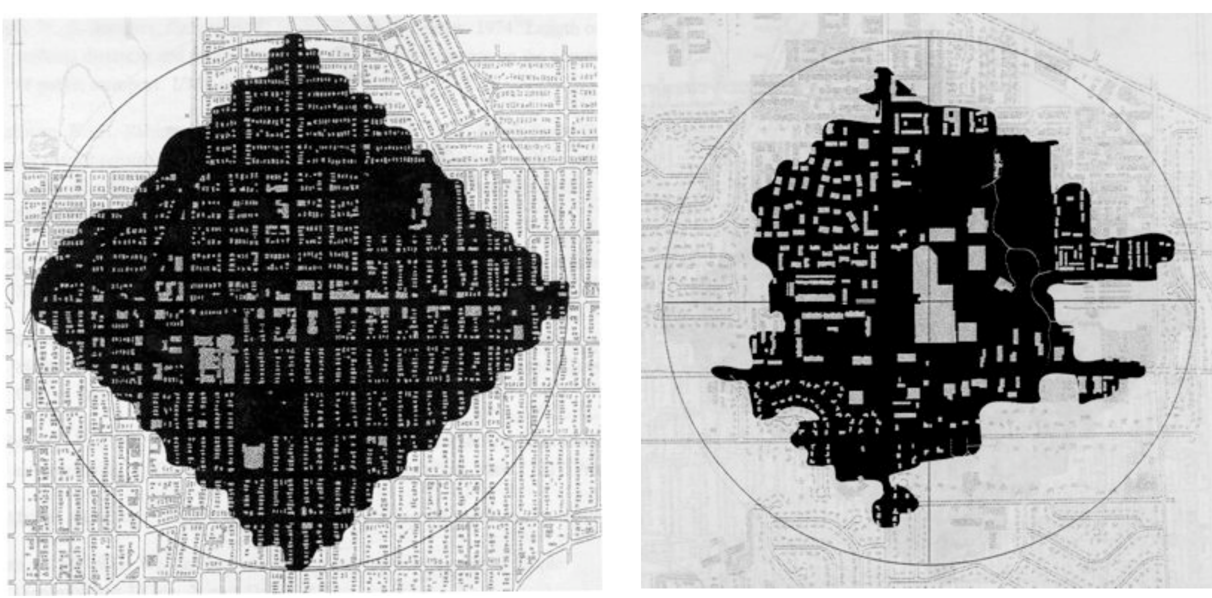
Recognizing the unsustainable growth in driving, the American Association of State Highway and Transportation Officials (AASHTO), representing state departments of transportation, is urging that the growth of vehicle miles driven be cut in half. How does a growing country—one with 300 million residents and another 100 million on the way by mid-century—slow the growth of vehicle miles driven?

Aggressive measures certainly are available, including imposing ever stiffer fees and taxes on driving and parking or establishing no-drive zones or days. Some countries are experimenting with such measures. However, many in this country would view such steps as punitive, given the reality that most Americans do not have a viable alternative to driving. The body of research surveyed here shows that much of the rise in vehicle emissions can be curbed simply by growing in a way that will make it easier for Americans to drive less. In fact, the weight of the evidence shows that, with more compact development, people drive 20 to 40 percent less, at minimal or reduced cost, while reaping other fiscal and health benefits.

How Compact Development Helps Reduce the Need to Drive

Better community planning and more compact development help people live within walking or bicycling distance of some of the destinations they need to get to every day—work, shops, schools, and parks, as well as transit stops. If they choose to use a car, trips are short. Rather than building single-use subdivisions or office parks, communities can plan mixed-use developments that put housing within reach of these other destinations. The street network can be designed to interconnect, rather than end in culs-de-sac and funnel traffic onto overused arterial roads. Individual streets can be designed to be "complete," with safe and convenient places to walk, bicycle, and wait for the bus. Finally, by building more homes as condominiums, townhouses, or detached houses on smaller lots, and by building offices, stores and other destinations "up" rather than "out," communities can shorten distances between destinations. This makes neighborhood stores more economically viable, allows more frequent and convenient transit service, and helps shorten car trips.

Figure 0-4 Destinations within One-Quarter Mile of Center for Contrasting Street Networks in Seattle
Source: Moudon et al. 1997.



This type of development has seen a resurgence in recent years, and goes by many names, including “walkable communities,” “new urbanist neighborhoods,” and “transit-oriented developments” (TODs). “Infill” and “brownfield” developments put unused lots in urban areas to new uses, taking advantage of existing nearby destinations and infrastructure. Some “lifestyle centers” are now replacing single-use shopping malls with open-air shopping on connected streets with housing and office space as part of the new development. And many communities have rediscovered and revitalized their traditional town centers and downtowns, often adding more housing to the mix. These varied development types are collectively referred to in this publication as “compact development” or “smart growth.”

How We Know that Compact Development Will Make a Difference: The Evidence

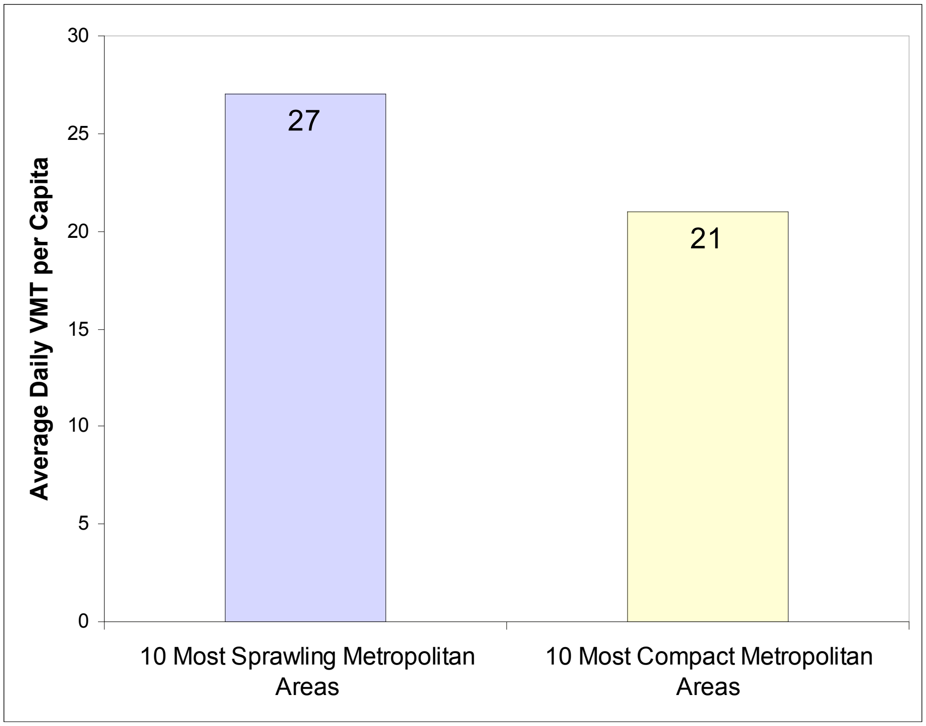
As these forms of development have become more common, planning researchers and practitioners have documented that residents of compact, mixed-use, transit-served communities do less driving. Studies have looked at the issue from varying angles, including:

- research that compares overall travel patterns among regions and neighborhoods of varying compactness and auto orientation;
- studies that follow the travel behavior of individual households in various settings; and
- models that simulate and compare the effects on travel of different future development scenarios at the regional and project levels.

Regardless of the approach, researchers have found significant potential for compact development to reduce the miles that residents drive.

A comprehensive sprawl index developed by coauthor Reid Ewing of the National Center for Smart Growth at the University of Maryland ranked 83 of the largest metropolitan areas in the United States by their degree of sprawl, measuring density, mix of land uses, strength of activity centers, and connectedness of the street network (Ewing, Pendall, and Chen 2002, 2003). Even accounting for income and other socioeconomic differences, residents drove far less in the more compact regions. In highly sprawling Atlanta, vehicles racked up 34 miles each day for every person living in the region. Toward the other end of the scale, in Portland, Oregon, vehicles were driven fewer than 24 miles per person, per day.

Figure 0-5 Average Daily Vehicle Miles Traveled
Source: Ewing, Pendall, and Chen 2002, p. 18.



This relationship holds up in studies that focus on the travel habits of individual households while measuring the environment surrounding their homes and/or workplaces. The link between urban development patterns and individual or household travel has become the most heavily researched subject in urban planning, with more than 100 rigorous empirical studies completed. These studies have been able to control for factors such as socioeconomic status, and can account for the fact that higher-income households tend to make more and longer trips than lower-income families.

One of the most comprehensive studies, conducted in King County, Washington, by Larry Frank of the University of British Columbia, found that residents of the most walkable neighborhoods drive 26 percent fewer miles per day than those living in the most sprawling areas. A meta-analysis of many of these types of studies finds that households living in developments with twice the density, diversity of uses, accessible destinations, and interconnected streets when compared to low-density sprawl drive about 33 percent less.

Many studies have been conducted by or in partnership with public health researchers interested in how the built environment can be better designed to encourage daily physical activity. These studies show that residents of communities designed to be walkable both drive fewer miles and also take more trips by foot and bicycle, which improves individual health. A recent literature review found that 17 of 20 studies, all dating from 2002 or later, have established statistically significant relationships between some aspect of the built environment and the risk of obesity.

Two other types of studies also find relationships between development patterns and driving: simulations that project the effect of various growth options for entire regions and simulations that predict the impact of individual development projects when sited and designed in different ways. In regional growth simulations, planners compare the effect of a metropolitan-wide business-as-usual scenario with more compact growth options. Coauthor Keith Bartholomew of the University of Utah analyzed 23 of these studies and found that compact scenarios averaged 8 percent fewer total miles driven than business-as-usual ones, with a maximum reduction of 31.7 percent (Bartholomew 2005, 2007). The better-performing scenarios were those with higher degrees of land use mixing, infill development, and population density, as well as a larger amount of expected growth. The travel models used in these studies would be expected to underestimate the impacts of site design, since most only crudely account for travel within neighborhoods and disregard walk and bike trips entirely.

Of the project-level studies, one of the best known evaluated the impact of building a very dense, mixed-use development at an abandoned steel mill site in the heart of Atlanta versus spreading the equivalent amount of commercial space and number of housing units in the prevailing patterns at three suburban locations. Analysis using transportation models enhanced by coauthor Jerry Walters of Fehr & Peers Associates (Walters, Ewing, and Allen 2000), and supplemented by the EPA's Smart Growth Index (to capture the effects of site design) found that the infill location would generate about 35 percent less driving and emissions than the comparison sites. The results were so compelling that the development was deemed a transportation control measure by the federal government for the purpose of helping to improve the region's air quality. The Atlantic Station project has become a highly successful reuse of central city industrial land.

Atlantic Station today.
Jacoby Development Company

What Smart Growth Would Look Like

How would this new focus on compact development change U.S. communities? Many more developments would look like the transit-oriented developments and new urbanist neighborhoods already going up in almost every city in the country, and these developments would start filling in vacant lots or failing strip shopping centers, or would revitalize older town centers, rather than replacing forests or farmland. Most developments would no longer be single-use subdivisions or office parks, but would mix shops, schools, and offices together with homes. They might feature ground-floor stores and offices with living space above, or townhomes within walking distance of a retail center. Most developments would be built to connect seamlessly with the external street network.

The density increases required to achieve the changes proposed in this publication would be moderate. Nelson's work shows that the average density of residential development in U.S. urban areas was about 7.6 units per acre in 2003. His predictions of shifting market demand indicate that all housing growth to 2025 could be accommodated by building condominiums, apartments, townhomes, and detached houses on small lots, while maintaining the current stock of houses on large lots. Under this scenario, while new developments would average a density of 13 units per acre, the average density of metropolitan areas overall would rise modestly, to about nine units per acre. Much of the change would result from stopping the sprawling development that has resulted in falling densities in many metropolitan areas.

Several publications provide a glimpse of what this future might look like. Images of compact development are available in *This is Smart Growth* (Smart Growth Network 2006) and *Visualizing Density* (Lincoln Institute of Land Policy 2007).

The Potential of Smart Growth

The potential of smart growth to curb the rise in greenhouse gas emissions will, of course, be limited by the amount of new development and redevelopment that takes place over the next few decades, and by the share of it that is compact in nature. There seems to be little question that a great deal of new building will take place as the U.S. population grows toward 400 million. According to the best available analysis, by Chris Nelson of Virginia Tech, 89 million new or replaced homes—and 190 billion square feet of new offices, institutions, stores, and other nonresidential buildings—will be constructed through 2050. If that is so, two-thirds of the development on the ground in 2050 will be built between now and then. Pursuing smart growth is a low-cost climate change strategy, because it involves shifting investments that have to be made anyway.

Smart Growth Meets Growing Market Demand for Choice

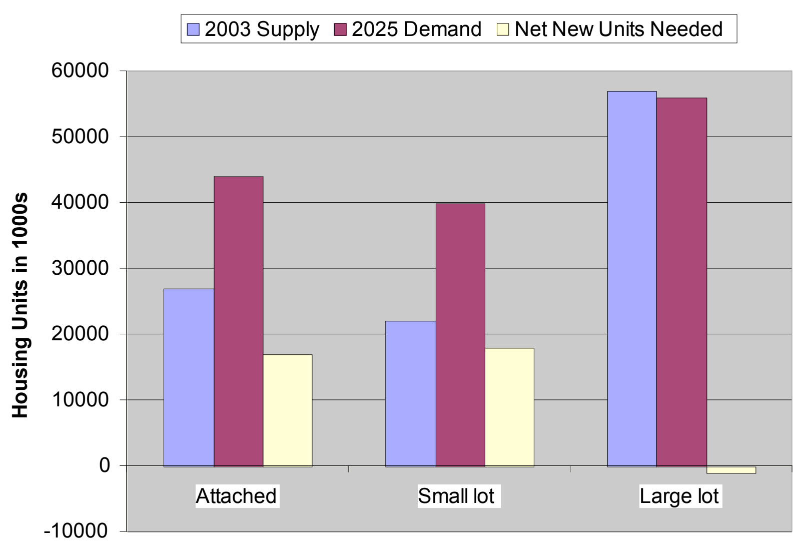
There is no doubt that moving away from a fossil fuel–based economy will require many difficult changes. Fortunately, smart growth is a change that many Americans will embrace. Evidence abounds that Americans are demanding more choices in where and how they live—and that changing demographics will accelerate that demand.

While prevailing zoning and development practices typically make sprawling development easier to build, developers who make the effort to create compact communities are encountering a responsive public. In 2003, for the first time in the country's history, the sales prices per square foot for attached housing—that is, condominiums and townhouses—was higher than that of detached housing units. The real estate analysis firm Robert Charles Lesser & Co. has conducted a dozen consumer preference surveys in suburban and urban locations[1] for a variety of builders to help them develop new projects. The surveys have found that in every location examined, about one-third of respondents prefer smart growth housing products and communities. Other studies by the National Association of Homebuilders, the National Association of Realtors, the Fannie Mae Foundation, high-production builders, and other researchers have corroborated these results—some estimating even greater demand for smart growth housing products. When smart growth also offers shorter commutes, it appeals to another one-quarter of the market, because many people are willing to trade lot or house size for shorter commutes.

Because the demand is greater than the current supply, the price-per-square foot values of houses in mixed-use neighborhoods show price premiums ranging from 40 to 100 percent, compared to houses in nearby single-use subdivisions, according to a study by Chris Leinberger of the Brookings Institution.

This market demand is only expected to grow over the next several decades, as the share of households with children shrinks and those made up of older Americans grows with the retiring of baby boomers. Households without children will account for close to 90 percent of new housing demand, and single-person households will account for a one-third. Nelson projects that the demand for attached and small-lot housing will exceed the current supply by 35 million units (71 percent), while the demand for large-lot housing will actually be less than the current supply.

Figure 0-6 2003 Housing Supply versus 2025 Housing Demand
Source: Nelson 2006.



[1] These locations include Albuquerque, Atlanta, Boise, Charlotte, Chattanooga, Denver, Orlando, Phoenix, Provo, Savannah, and Tampa.

Total Estimated VMT Reduction and Total Climate Impact

When viewed in total, the evidence on land use and driving shows that compact development will reduce the need to drive between 20 and 40 percent, as compared with development on the outer suburban edge with isolated homes, workplaces, and other destinations. It is realistic to assume a 30 percent cut in VMT with compact development.

Making reasonable assumptions about growth rates, the market share of compact development, and the relationship between CO_2 reduction and VMT reduction, smart growth could, by itself, reduce total transportation-related CO_2 emissions from current trends by 7 to 10 percent as of 2050. This reduction is achievable with land-use changes alone. It does not include additional reductions from complementary measures, such as higher fuel prices and carbon taxes, peak-period road tolls, pay-as-you drive insurance, paid parking, and other policies designed to make drivers pay more of the full social costs of auto use.

This estimate also does not include the energy saved in buildings with compact development, or the CO_2-absorbing capacity of forests preserved by compact development. Whatever the total savings, it is important to remember that land use changes provide a permanent climate benefit that would compound over time. The second 50 years of smart growth would build on the base reduction from the first 50 years, and so on into the future. More immediate strategies, such as gas tax increases, do not have this degree of permanence.

The authors calculate that shifting 60 percent of new growth to compact patterns would save 85 million metric tons of CO_2 annually by 2030. The savings over that period equate to a 28 percent increase in federal vehicle efficiency standards by 2020 (to 32 mpg), comparable to proposals now being debated in Congress. It would be as if the fleetwide efficiency for new vehicles had risen to 32 mpg by 2020. Every resident of a compact neighborhood would provide the environmental benefit expected from, say, driving one of today's efficient hybrid cars. That effect would be compounded, of course, if that person also drove such an efficient car whenever he or she chose to make a vehicle trip. Smart growth would become an important "third leg" in the transportation sector's fight against global warming, along with more efficient vehicles and lower-carbon fuels.

A Climate-Sparing Strategy with Multiple Payoffs

Addressing climate change through smart growth is an attractive strategy because, in addition to being in line with market demand, compact development provides many other benefits and will cost the economy little or nothing. Research has documented that compact development helps preserve farmland and open space, protect water quality, and improve health by providing more opportunities for physical activity.

Studies also have confirmed that compact development saves taxpayers money, particularly by reducing the costs of infrastructure such as roads and water and sewer lines. For example, the Envision Utah scenario planning process resulted in the selection of a compact growth plan that will save the region about $4.5 billion in infrastructure spending over a continuation of sprawling development.

Finally, unlike hydrogen-fueled vehicles and cellulosic ethanol, which get a lot of attention in the climate-change debate, the "technology" of compact, walkable communities exists today, as it has in one form or another for thousands of years. We can begin using this technology in the service of a cooler planet right now.

Policy Recommendations

In most metropolitan areas, compact development faces an uneven playing field. Local land development codes encourage auto-oriented development. Public spending supports development at the metropolitan fringe more than in already developed areas. Transportation policies remain focused on accommodating the automobile rather than alternatives.

The key to substantial greenhouse gas (GHG) reductions is to get all policies, funding, incentives, practices, rules, codes, and regulations pointing in the same direction to create the right conditions for smart growth. Innovative policies often are in direct conflict with the conventional paradigm that produces sprawl and automobile dependence.

Here, we outline three major policy initiatives at the federal level that would benefit states, metro regions, cities and towns in their efforts to meet the growing demand for compact development. These initiatives, as well as potential actions on the part of state and local governments, are discussed more fully in Chapter 7.

Federal Actions

Require Transportation Conformity for Greenhouse Gases. Federal climate change legislation should require regional transportation plans to pass a conformity test for CO_2 emissions, similar to those for other criteria pollutants. The Supreme Court ruling in Massachusetts v EPA established the formal authority to consider greenhouse gases under the Clean Air Act, and a transportation planning conformity requirement would be an obvious way for the EPA to exercise this authority to produce tangible results.

Enact "Green-TEA" Transportation Legislation that Reduces GHGs. The Intermodal Surface Transportation Efficiency Act of 1991 (known as ISTEA) represented a revolutionary break from past highway bills with its greater emphasis on alternatives to the automobile, community involvement, environmental goals, and coordinated planning. The next surface transportation bill could bring yet another paradigm shift; it could further address environmental performance, climate protection, and green development. We refer to this opportunity as "Green-TEA."

Provide Funding Directly to Metropolitan Planning Organizations (MPOs). Metropolitan areas contain more than 80 percent of the nation's population and 85 percent of its economic output. Investment by state departments of transportation in metropolitan areas lags far behind these percentages. The issue is not just the amount of funding; it is also the authority to decide how the money is spent. What is necessary to remedy the long history of structural and institutional causes of these inequities is a new system of allocating federal transportation funds directly to metropolitan areas. The amount of allocation should be closer to the proportion of an MPO's population and economic activity compared to other MPOs and non-MPO areas in the same state.

1. Introduction

The phrase "you can't get there from here" has a new application. The United States cannot achieve a 60 to 80 percent reduction in carbon dioxide (CO_2) emissions by 2050 relative to 1990 levels—a commonly accepted target for climate stabilization—unless the transportation sector contributes, and the transportation sector cannot do its fair share through vehicle and fuel technology alone. We have to sharply reduce the growth of vehicular travel across the nation's sprawling urban areas, reversing trends that go back decades.

With regard to urban development and travel demand management, this publication asks and answers three critical questions facing the urban planning profession, the land development community, and federal, state, and local policy makers:

- What reduction in vehicle miles traveled (VMT) is possible in the United States with compact development rather than continuing urban sprawl?
- What reduction in CO_2 emissions will accompany such a reduction in VMT?
- What policy changes will be required to shift the dominant land development pattern from sprawl to compact development?

1.1 Background

The transportation sector accounts for 28 percent of total greenhouse gas (GHG) emissions in the United States and 33 percent of the nation's energy-related CO_2 emissions (EIA 2006, p. xvi; EIA 2007a, p. 15). The United States, in turn, is responsible for 22 percent of CO_2 emissions worldwide and close to a quarter of worldwide GHG emissions (EIA 2007b, p. 93). It is hard to envision a "solution" to the global warming crisis that does not involve slowing the growth of transportation CO_2 emissions in the United States

The transportation sector's CO_2 emissions are a function of vehicle fuel efficiency, fuel carbon content, and VMT, factors sometimes referred to as a "three-legged stool." Energy and climate policy initiatives at the federal and state levels have focused almost exclusively on technological advances in vehicles and fuels, the first two legs. Yet, there is a growing recognition that managing VMT has to be part of the solution, that the third leg is needed to support the stool.

In *A Call for Action*, the U.S. Climate Action Partnership (USCAP)—which is made up of major U.S. corporations and environmental groups—includes promoting "better growth planning" (USCAP 2007). The United Nations Intergovernmental Panel on Climate Change (IPCC 2007c, p. 20) lists "influenc[ing] mobility needs through land use regulations and infrastructure planning" among policies and measures shown to be effective in controlling GHG emissions." California's Climate Action Team (2007) expects "smart land use and intelligent transportation" to make the second-largest contribution toward meeting the state's ambitious GHG reduction goals.

The architects of the principal GHG stabilization framework are banking on major changes in urban development and travel patterns. "The task of holding global emissions constant would be out of reach, were it not for the fact that all the driving and flying in 2056 will be in vehicles not yet designed, most of the buildings that will be around then are not yet built, the locations of many of the communities that will contain these buildings and determine their inhabitants' commuting patterns have not yet been chosen . . ." (Socolow and Pacala 2006).

Alternative futures, circa 2056.
© Scientific American (Socolow and Pacala 2006)

A recent report by the U.S. Environmental Protection Agency (EPA) finds: "By themselves, individual approaches incorporating vehicle technologies, fuels, or transportation demand management (TDM) approaches could moderately reduce, but not flatten, emissions from now until 2050. Most of the system approaches analyzed, by contrast, could . . . nearly flatten the entire U.S. transportation sector emissions, despite the passenger vehicle category representing only half of the sector's emissions" (Mui et al. 2007). In other words, all three legs of the policy stool will be required to flatten transportation CO_2 emission levels.

1.2 The Nature of Compact Development

This publication makes the case for compact development—or its alias, smart growth—rather than continued urban sprawl. It does so in the context of global climate change.

The term "compact development" does not imply high-rise or even uniformly high-density development. A discussion of alternatives to urban sprawl always seems to gravitate toward high-density development, and leads to fears that more compact development will result in the "Manhattanization" of America. That is not what this book is about.

According to data provided by Chris Nelson of Virginia Tech, the blended average density of residential development in the United States in 2003 was about 7.6 units per net acre (see Figure 1-1). This estimate includes apartments, condominiums, and townhouses, as well as detached single-family housing on both small and large lots. A net acre is an acre of developed land, not including streets, school sites, parks, and other undevelopable land.

Because of changing demographics and lifestyle preferences, Nelson projects a significant change in market demand by 2025. The mix of housing stock required to meet this demand would have a blended density of approximately nine units per net acre. Given the excess of large-lot housing already on the ground relative to 2025 demand, all net new housing built between now and then would have to be attached or small-lot detached units (not including replacement of large-lot housing). The density of new and redeveloped housing would average about 13 units per net acre, 75 percent above 2003 average blended density. That is a typical density for a townhouse development. Apartments and condos boost the average, while single-family detached housing lowers it.

Figure 1-1 Projections of Housing Demand and Density in 2025
Source: Nelson 2006.

	Density (Units per Net Acre)	2003 Units (in 1,000s)	2025 Units (in 1,000s)	Difference (in 1,000s)
Attached	20	27,000	44,000	17,000
Small-lot detached	7	22,000	40,000	18,000
Large-lot detached	2	57,000	56,000	-1,000
Average blended density (per net acre)		7.6	9.1	13.3

The role of density, however, should not be overemphasized. As important as density is, it is no more fundamental to compact development than are the mixing of land uses, the development of strong population and employment centers, the interconnection of streets, and the design of structures and spaces at a human scale (see Figure 1-2). Images of compact development are available in *This is Smart Growth* (Smart Growth Network 2006) and *Visualizing Density* (Lincoln Institute of Land Policy 2007).

Figure 1-2 Nature of Compact Development versus Sprawl
Sources: Ewing 1997; Ewing, Pendall, and Chen 2002.

Compact Development	Sprawl
Medium to high densities	*Low densities*
Mixed uses	*Single uses*
Centered development	*Strip development*
Interconnected streets	*Poorly connected streets*
Pedestrian- and transit-friendly design	*Auto-oriented design*

1.3 The High Costs of Urban Sprawl and Automobile Dependence

In 1997, the *Journal of the American Planning Association* (JAPA) carried a pair of articles on the merits of urban sprawl versus compact development (Gordon and Richardson 1997; Ewing 1997). The authors debated the characteristics, causes, and costs of sprawl, and briefly discussed cures. Gordon and Richardson's lead article—titled "Are Compact Cities a Desirable Planning Goal?"—argued that U.S. real estate markets are producing what consumers want; that the social, economic, environmental, and geopolitical impacts of that development are benign; and hence that there is no need for urban planning intervention in markets. Most relevant to concerns over global climate change, the authors contended that a "global energy glut" and vehicle emission controls rendered compact development unnecessary.

Ewing's counterpoint—"Is Los Angeles–Style Sprawl Desirable?"—defined sprawl broadly as 1) leapfrog or scattered development, 2) commercial strip development, or 3) large expanses of low-density or single-use development, as in sprawling bedroom communities, and compact development as the reverse. The article argued that U.S. real estate markets have many imperfections that cause them to "fail," that the social welfare costs of such failure are enormous, and that urban planning interventions therefore are warranted. Particularly relevant to the global climate change debate is the following:

> While the best case envisioned by [Gordon and Richardson] has the real price of gasoline holding steady, it is the worst case that worries others . . . . The fact that the most recent large-scale war fought was in the Persian Gulf is itself a testament to the risk of relying on the political stability of this region for a commodity [oil] so essential to economic activity . . . . Being unregulated, carbon dioxide emissions represent a bigger threat to national welfare than do regulated emissions. There is now a near-consensus within the scientific community that carbon dioxide build-up in the atmosphere is causing global climate change, and that the long-term effects could be catastrophic.

A decade later, there seems to be little doubt that the "worst case" scenario is upon us. The urbanized area of the United States has grown almost three times faster than metropolitan population, as urban development sprawled outwards unchecked (see Figure 1-3). This development pattern has boosted VMT and reduced the amount of forest land available to absorb CO_2.

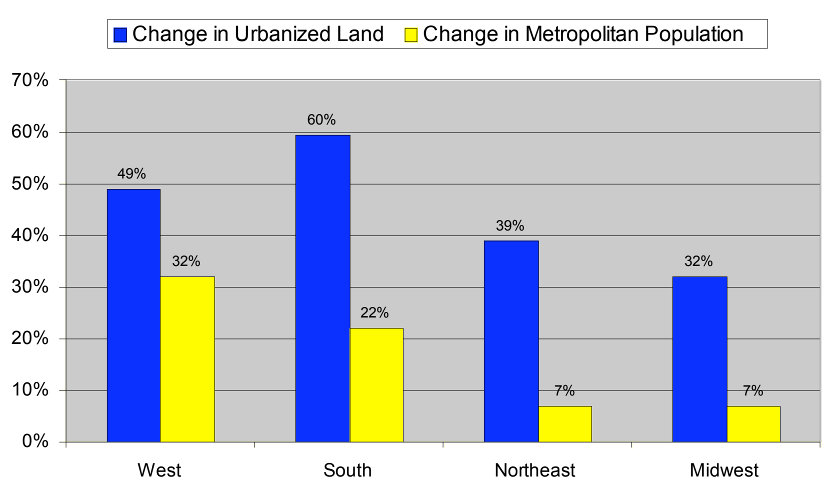
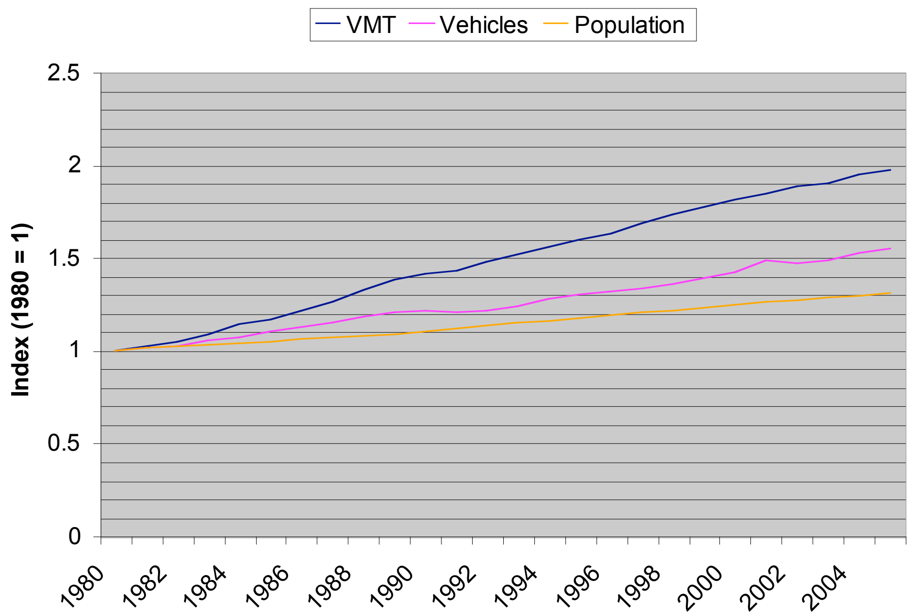


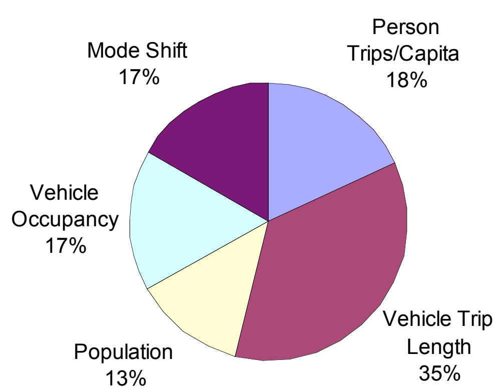
Figure 1-3 Growth of Population and Urbanized Land Area by Census Region between 1982 and 1997
Source: Fulton et al. 2001.

Vehicle miles traveled in the United States have grown three times faster than the population, and almost twice as fast as vehicle registrations (see Figure 1-4). In one analysis, 36 percent of the VMT growth was explained by increasing trip length (see Figure 1-5), which is a function of development patterns. Another 17 percent was explained by shifts to automobile trips from other modes of transportation. Again, development patterns are implicated. Yet another 17 percent was due to lower vehicle occupancy, as rates of carpooling declined. Only 13 percent of the growth in VMT was explained by population growth. Using comparable methodology, we estimate that one-third of the national growth in VMT between 1990 and 2001 was due to longer vehicle trips.[2]

Figure 1-4 Growth of VMT, Vehicle Registrations, and Population in the United States relative to 1980 Values
Source: FHWA 2005.



Vehicle miles traveled have grown more than twice as fast as highway capacity in urbanized areas of the United States. In all 85 urbanized areas for which statistics are available, highways became more congested between 1982 and 2003 (Schrank and Lomax 2005). This is true even in regions that struggled to pave their way out of congestion and appeared to be succeeding for a time (see Figure 1-6). Highway building itself induces more traffic and urban sprawl, in a never-ending spiral. (This will be discussed in greater detail in Chapter 5, Induced Traffic and Induced Development.)



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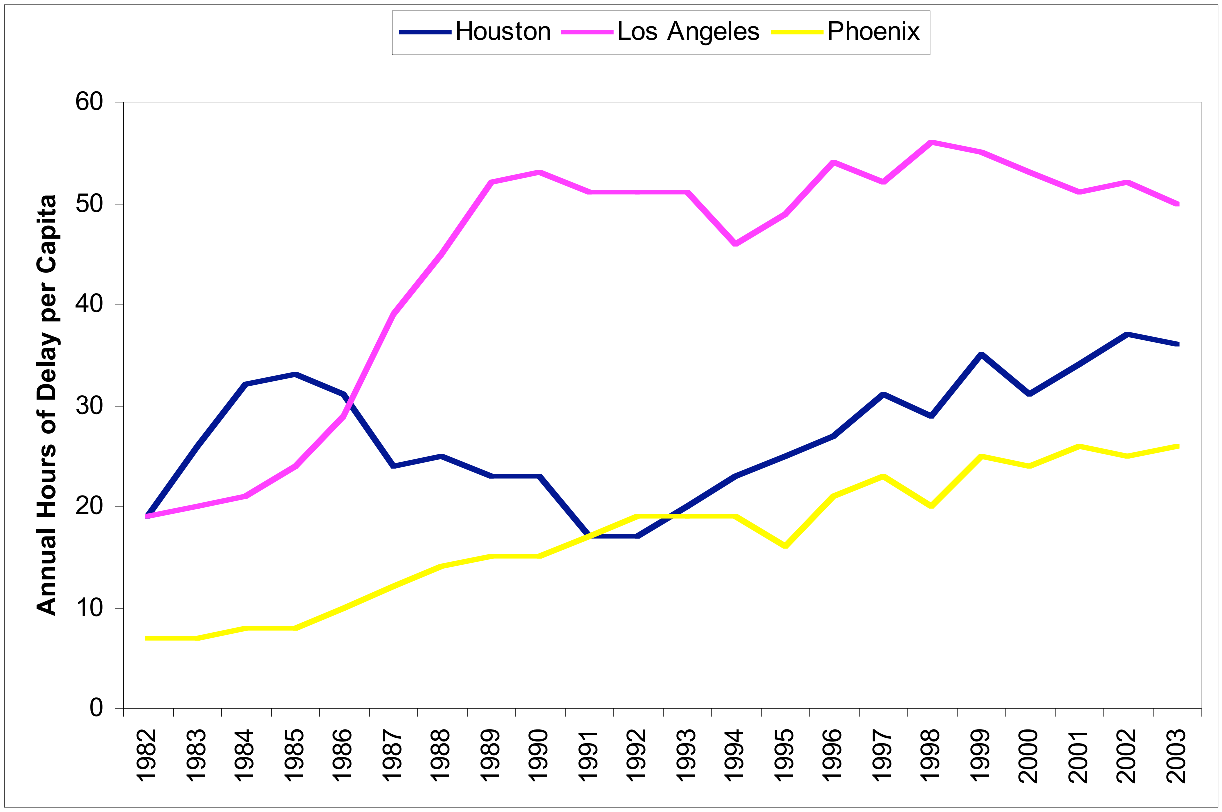
[2] Between 1995 and 2001, total VMT in the United States increased by 34 percent, while average vehicle trip length increased by 11.5 percent (Hu and Reuscher 2004).

Figure 1-6 Growth of Annual Hours of Delay per Capita
Source: Schrank and Lomax 2005.



Carbon dioxide emissions from the transportation sector have grown while regulated pollutant emissions actually declined, thanks to improved fuel and engine technology (see Figure 1-7).[3] Carbon dioxide emissions are proportional to gasoline consumption and, during this period, improvements in vehicle fuel efficiency were overwhelmed by the growth in VMT. Under business-as-usual policies, VMT growth will continue to surpass technology gains. (See Chapter 2, The VMT/CO_2/Climate Connection, for more details.)

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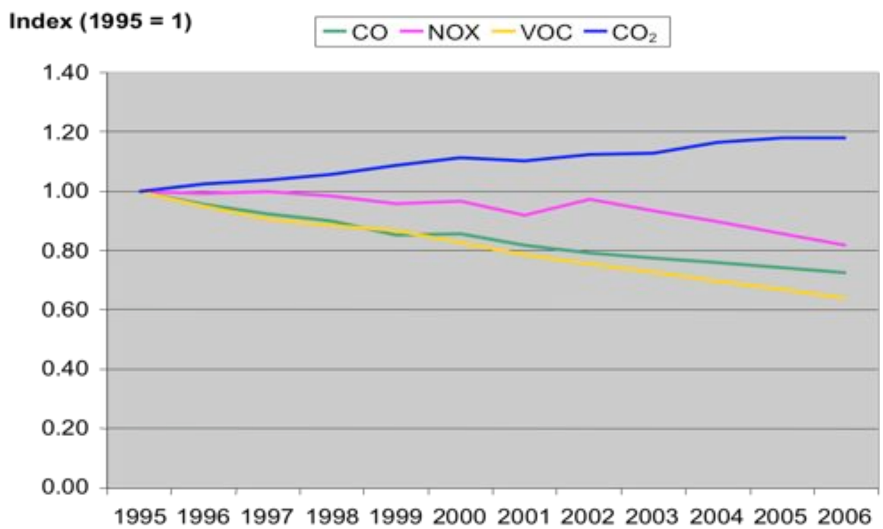
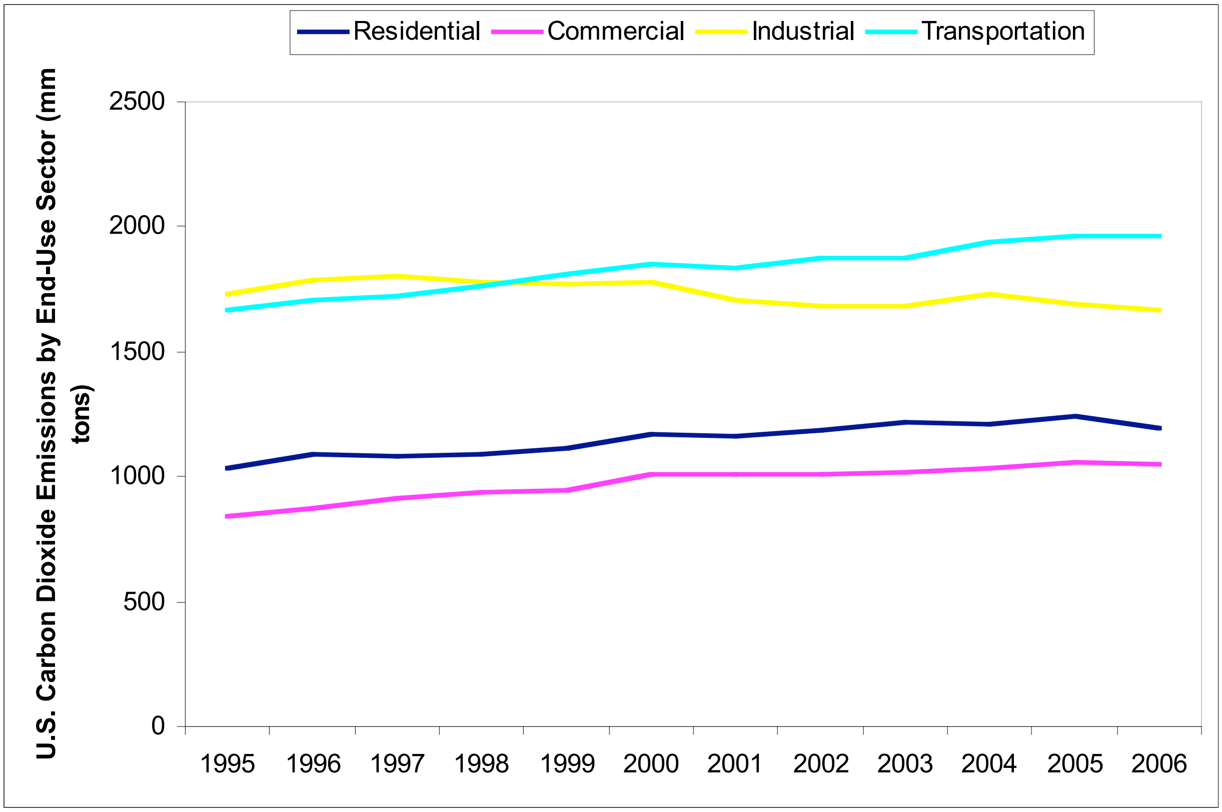
[3] The advent of "first-generation" catalytic converters in 1975 significantly reduced hydrocarbon and carbon monoxide (CO) emissions. Because lead inactivates the catalyst, 1975 also saw the widespread introduction of unleaded gasoline. The next milestone in vehicle emission control technology came in 1980 and 1981. Manufacturers equipped new cars with more sophisticated emission control systems that generally include a "three-way" catalyst (which converts CO and hydrocarbons to CO_2 and water, and also helps reduce nitrogen oxides to elemental nitrogen and oxygen). On-board computers and oxygen sensors help optimize the efficiency of the catalytic converters. Vehicle emissions are being further reduced under 1990 Clean Air Act amendments, which include even tighter tailpipe standards, improved control of evaporative emissions, and computerized diagnostic systems that identify malfunctioning emission controls.

Figure 1-7 Change in Transportation Emissions in the United States Relative to 1995 Values
Source: EPA undated.



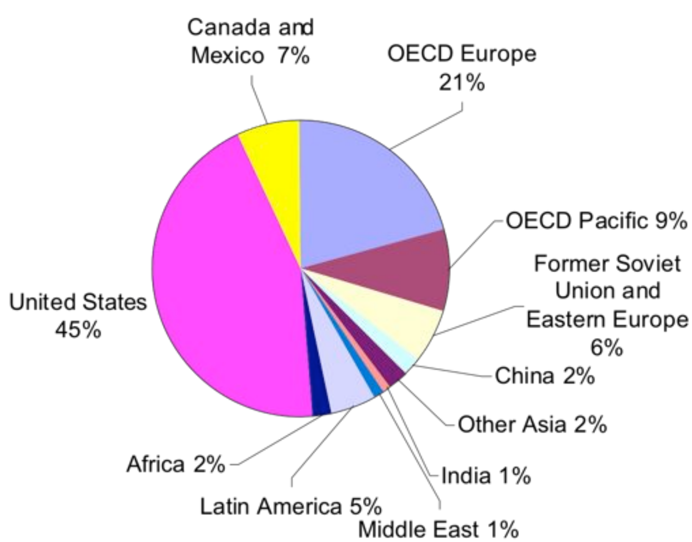
The transportation sector has become the largest source of CO_2 emissions in the United States, surpassing the industrial sector (see Figure 1-8). It now accounts for one-third of the U.S. total. Unless action is taken, the transportation sector's share of CO_2 emissions is expected to increase as VMT outpaces population growth (see Chapter 2).

Figure 1-8 U.S. Carbon Dioxide Emissions by End-Use Sector
Source: EIA 2007a.



The United States is home to only 5 percent of the world's population, but U.S. residents own almost a third of the world's cars, which account for 45 percent of the CO_2 emissions generated by cars worldwide (see Figure 1-9). U.S. cars play a disproportionate role in global warming because they are less fuel efficient than cars elsewhere in the world, and also because they are driven farther.

Figure 1-9 Light-Duty Vehicle Emissions by World Region, 2003
Source: DiCicco and Fung 2006.



1.4 A Perfect Storm in Climate Policy

Author Sebastian Junger coined the expression “a perfect storm” to describe the confluence of different weather conditions that created a powerful 1991 storm in the Atlantic Ocean. The phrase has come to describe the simultaneous occurrence of events which, taken individually, would be far less momentous than the result of their confluence. It seems an appropriate metaphor for what currently is happening in two areas of public policy and in private real estate markets. It also is a good metaphor for what will occur in U.S. urban development generally as these three forces collide.

U.S. climate policy is one area in which a perfect storm is brewing. The issue of climate change has risen to prominence worldwide, and become compelling in the United States, in only 15 years, as the following actions indicate.

- June 1992: The United Nations Framework Convention on Climate Change (UNFCCC), opened for signatures at the “Earth Summit” in Rio de Janeiro, calls for stabilizing GHG concentrations in the atmosphere. The United States is a signatory.

- December 1997: The Kyoto Protocol to the UNFCCC establishes a set of quantified GHG emission targets for developed countries. The United States does not ratify the protocol.

- June 2002: The U.S. government acknowledges for the first time that human activity is contributing to global warming, in a report issued by the U.S. Environmental Protection Agency (EPA) that is challenged by the White House.

- June 2006: A committee convened by the National Academies of Science concludes that human activities are largely responsible for recent global warming.

- September 2006: California becomes the first state to adopt legislation—the Global Warming Solutions Act of 2006 (AB 32)—requiring regulations and market actions to reduce the state’s GHG emissions to 1990 levels by 2020. Eighteen other states later adopt similar targets or mandates.

The pace has accelerated in 2007:

- January 2007: Major U.S. corporations and environmental groups, banding together as the U.S. Climate Action Partnership, call for a 10 to 30 percent reduction in CO_2 emissions within 30 years (USCAP 2007).

- April: The U.S. Supreme Court rules that the EPA has the authority to regulate GHG emissions, and has the duty to do so unless it can provide a scientific basis for not acting.

- May: Tulsa, Oklahoma, becomes the 500th city to sign the U.S. Mayors Climate Protection Agreement to reduce greenhouse gas emissions (U.S. Conference of Mayors 2007).

- June: In the largest international public opinion survey ever taken, most of the world identifies environmental degradation as the greatest danger—above nuclear weapons, AIDS, and ethnic hatred (Pew Research Center 2007). Global warming, in particular, is viewed as a "very serious" problem (see Figure 1-11).

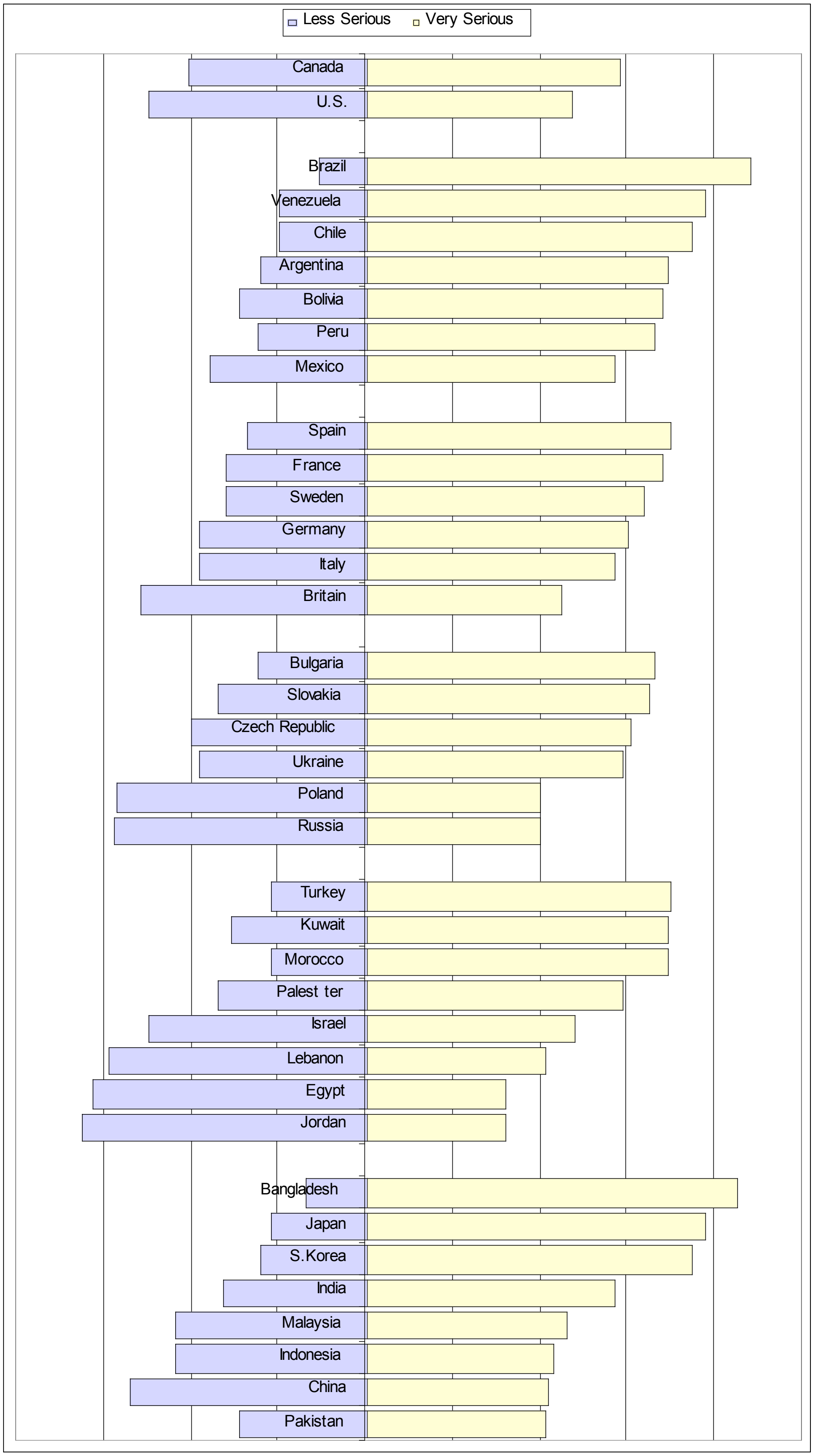
- July: Congressional lawmakers have introduced more than 125 bills, resolutions, and amendments specifically addressing global climate change and GHG emissions, compared with the 106 pieces of relevant legislation introduced during the entire two-year term of the previous Congress (Pew Center on Global Climate Change 2007).

- August: California's attorney general settles his sprawl and carbon emissions case with San Bernardino County. The county agrees to amend its general plan and create a new GHG reduction plan within 30 months to outline opportunities and strategies—especially land use decisions—to reduce GHG emissions.

- August: Russian minisubmarines plant a national flag under the North Pole, claiming the Artic seabed as Russian territory for future oil exploration and thus precipitating an Artic land grab. Arctic oil exploration will become feasible only because global warming is melting and thus shrinking the Artic icecap—and, ironically, the oil and gas extracted will only accelerate the problem as they are burned.

- September: President George W. Bush hosts a climate change summit for top officials from the world's major economies to come to agreement on a framework for lowering global GHG emissions in the post-Kyoto era.

Figure 1-10 World Views on Global Warming: How Serious a Problem?
Source: Pew Research Center 2007



A paradigm shift can occur very rapidly in the physical sciences, as the dominant scientific view changes in response to overwhelming evidence. The 29,000 data series drawn upon by the 2,500 top climate scientists on the U.N. Intergovernmental Panel on Climate Change (IPCC 2007b) constitute that evidentiary base.[4] Since the early 1990s, the scientific community has come to agree on the reality of climate change, on the contribution of human activity to climate change, and on the catastrophic consequences if current trends continue. Social revolutions are slower than scientific revolutions. Public opinion about global warming is changing more slowly than scientific opinion, and political action may be slower still. But they, too, are changing, irrevocably.

1.5 A Perfect Storm in Consumer Demand

There are many reasons why smart growth may be the "low-hanging fruit" for reducing CO_2 emissions in the transportation sector. The most compelling factor is the large and rising consumer demand for homes in neighborhoods that exhibit compact characteristics. The real estate analysis firm Robert Charles Lesser & Co. (RCLCO) has conducted a dozen consumer preference surveys in suburban and urban locations for a variety of builders to help them develop new projects.[5] The RCLCO surveys have found that about one-third of the respondents in every location are interested in smart growth housing products and communities (Logan 2007). Preference varies by geography, economic and demographic fundamentals, and buyer profiles; life stage and income are key variables. Other studies by the National Association of Homebuilders (NAH), the National Association of Realtors (NAR), the Fannie Mae Foundation, high-production builders, and other researchers have corroborated these results, with some estimating even greater demand for smart growth housing products (Myers and Gearin 2001).

Perhaps the best national assessment of the current demand for smart growth is the National Survey on Communities, conducted for Smart Growth America (a nonprofit advocacy group) and the NAR (Belden Russonello & Stewart 2004). In this survey, respondents were given a choice between communities labeled "A" and "B." Community A was described as having single-family homes on large lots, no sidewalks, shopping and schools located a few miles away, commutes to work of 45 minutes or more, and no public transportation. In contrast, community B was described as having a mix of single-family and other housing, sidewalks, shopping and schools within walking distance, commutes of less than 45 minutes, and nearby public transportation.

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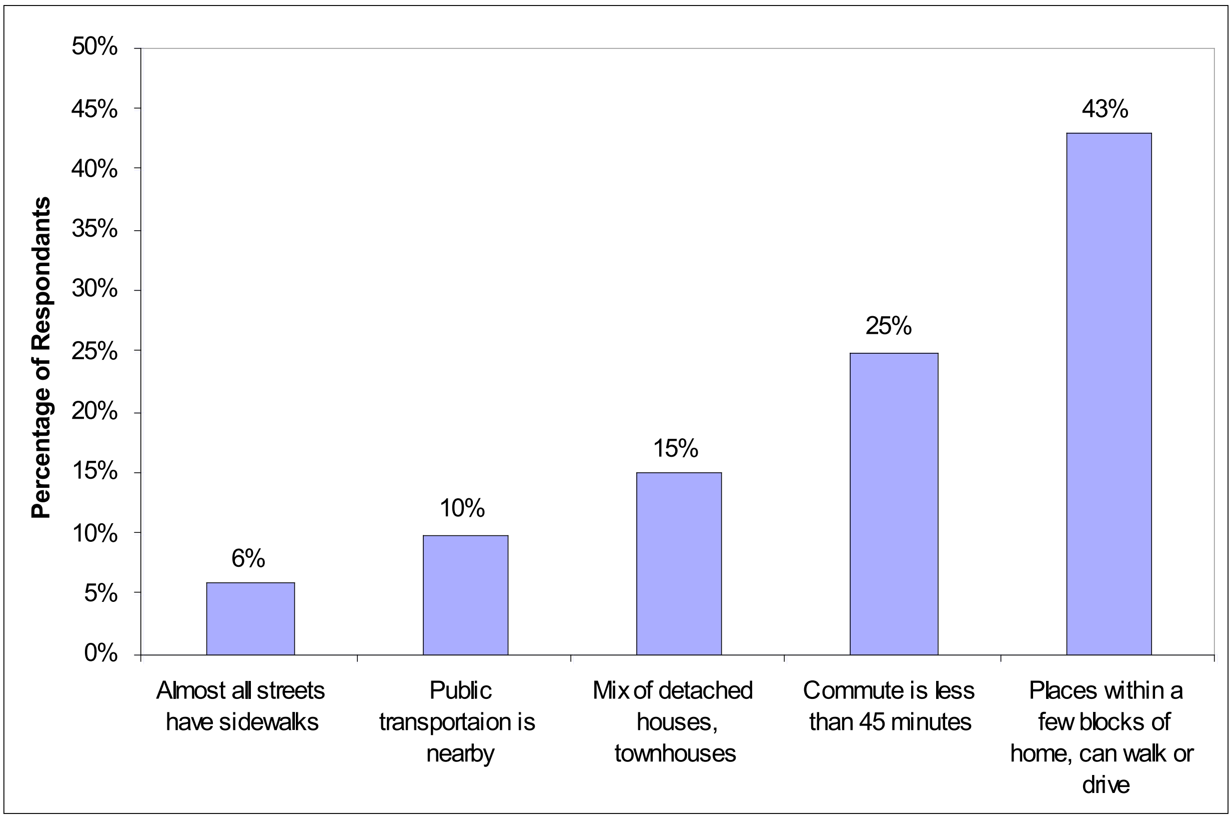
[4] The data series show significant changes in observations of physical systems (snow, ice, and frozen ground; hydrology; and coastal processes) and biological systems (terrestrial, marine, and freshwater biological systems), together with surface air temperature changes over the period 1970 to 2004. A subset of about 29,000 data series was selected from about 80,000 data series from 577 studies. These met the following criteria: 1) ending in 1990 or later; 2) spanning a period of at least 20 years; and 3) showing a significant change in either direction, as assessed in individual studies.

[5] These places include Albuquerque, Atlanta, Boise, Charlotte, Chattanooga, Denver, Orlando, Phoenix, Provo, Savannah, and Tampa.

Overall, 55 percent of Americans indicated a preference for community B, the smart growth community. Of those who said they think they will buy a house within the next three years, 61 percent are more likely to look for a home in a smart growth community than a conventional community. Commute time was a major factor in how respondents chose between A and B. It appears that about a third of the market would choose the smart growth community over the conventional community if commutes were comparable, and more than another quarter would choose the smart growth community if it were located closer to employment than the conventional alternative, thereby reducing commute time.

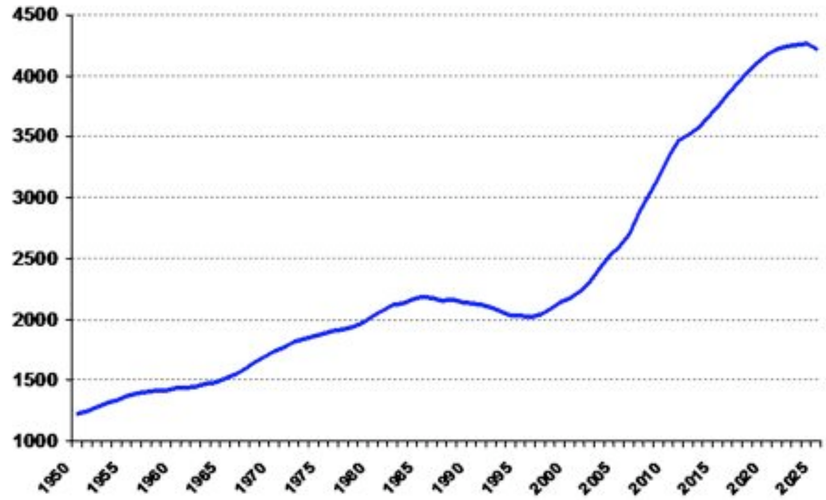
Figure 1-11 Attractions of a Smart Growth Community*
Source: Belden Russonello & Stewart 2004



* For those choosing the smart growth community. The question was "Look at the community you selected and choose the ONE most appealing characteristic of that community for you."

When it comes to housing demand, demographics are destiny. As baby boomers become empty nesters and retirees, they are exhibiting a strong preference for compact, walkable neighborhoods. So are single adults and married couples without children. These trends likely will continue, because the baby boom generation represents America's largest generational cohort. By 2020, the number of individuals turning 65 years of age will skyrocket to more than 4 million per year (see Figure 1-12) Between 2007 and 2050, the share of the U.S. population older than 65 years of age will grow from 11 percent to 15.9 percent (U.S. Census Bureau 2004).

Figure 1-12 Americans Turning 65 Years Old Annually, 1950 to 2025
Source: He et al. 2006

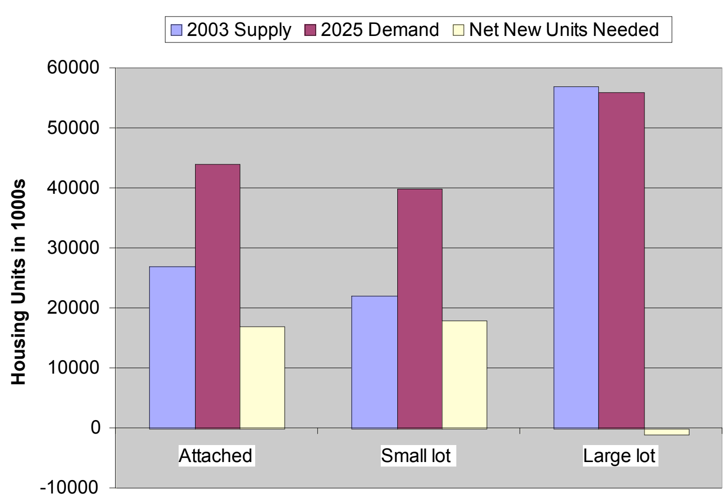


Growth in households without children (including one-person households) also will rise dramatically. From 2000 to 2025, households without children will account for 88 percent of total growth in households. (Thirty-four percent will be one-person households). By 2025, only 28 percent of households will have children (Nelson, 2006).

Some of this change in preferences also appears to be cultural, particularly among Generation Xers who are now fully engaged in the home buying market. According to research by Yankelovich, a leading marketing services consultancy, Gen Xers value traditional face-to-face relationships with neighbors and neighborhood characteristics such as sidewalks and nearby recreational facilities. Yankelovich president J. Walker Smith discussed these findings at the June 2004 NAHB conference, noting that "planned communities that foster togetherness and neighborhood life will resonate with this generation" (NAHB 2004). Another industry analyst, Brent Harrington of DMB Associates, reports that Gen Xers are looking for more diverse and compact communities characterized by smaller but better-designed homes as well as shopping and schools in more central locations, reflecting an "extreme disillusionment with the bland, vanilla suburbs" (Anderson 2004).

This means that the demand for homes located in downtown, in-town, close-in suburban, and other relatively compact locations will continue to rise. The demand for attached and small-lot housing will exceed the current supply by 35 million units (71 percent), while the demand for large-lot housing actually will be less than the current supply (see Figure 1-13).

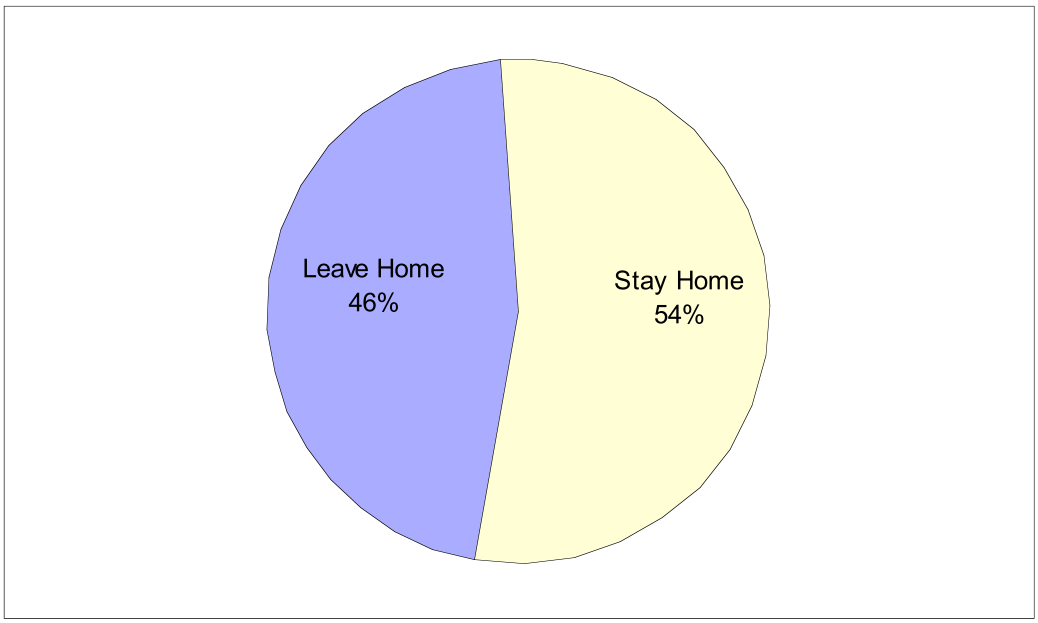
Figure 1-13 2003 Housing Supply versus 2025 Housing Demand
Source: Nelson 2006.



These trends are visible now: Downtown and in-town housing tops the list of hot markets each year in the Urban Land Institute's *Emerging Trends in Real Estate* (ULI 2005, 2006, 2007). In addition, new urban and smart growth communities are in such high demand that they not only command a price premium at the point of purchase, but also hold their premium values over time (Eppli and Tu 1999, 2007; Leinberger 2007).

In addition to changing housing and neighborhood preferences, many stakeholders are carefully watching changes in travel behavior and needs, especially among older Americans. For example, the nonprofit association AARP has made transportation and quality-of-life matters one of its top policy issues to tackle in the next decade. The AARP is concerned because roughly one in five people over 65 years of age do not drive at all, and more than half drive only occasionally; that is, they do not drive on most days (STPP 2004). Older adults who lose their ability to drive tend to lose their independence unless they have other ways of accessing shopping, recreation, medical care, and other basic needs (see Figure 1-14).

Figure 1-14 Average Daily Travel Patterns for Non-drivers over Age 65
Source: STPP 2004.

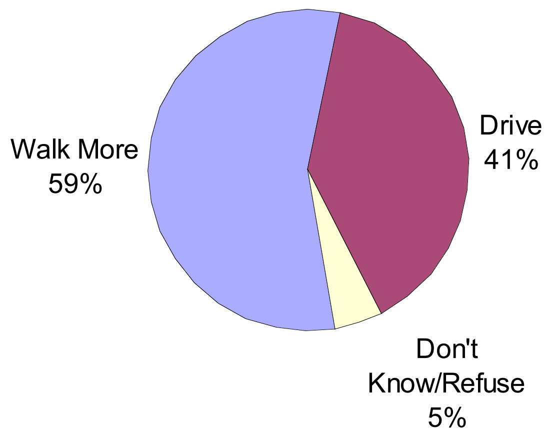


AARP surveys suggest that most people want to "age in place" (Bayer and Harper 2000; Mathew Greenwald & Associates 2003). In most areas where older Americans are aging in place, public transportation services are not available. In fact, according to a national poll, only 45 percent of Americans over 65 live within close proximity to public transportation (Mathew Greenwald & Associates 2003).

Fifty-five percent of respondents to another poll said that they would prefer to walk more throughout the day rather than drive everywhere (see Figure 1-15). The elderly are particularly inclined to walk when conditions are right (Mathew Greenwald & Associates 2003). These results, plus the high cost of special transportation services, are reasons for making sure older people can easily access transit and live in safe, walkable communities. Future community design, development, and transportation decisions will strongly influence their mobility choices.

Figure 1-15 Americans Want to Walk More*
Source: Belden Russonello & Stewart 2003.

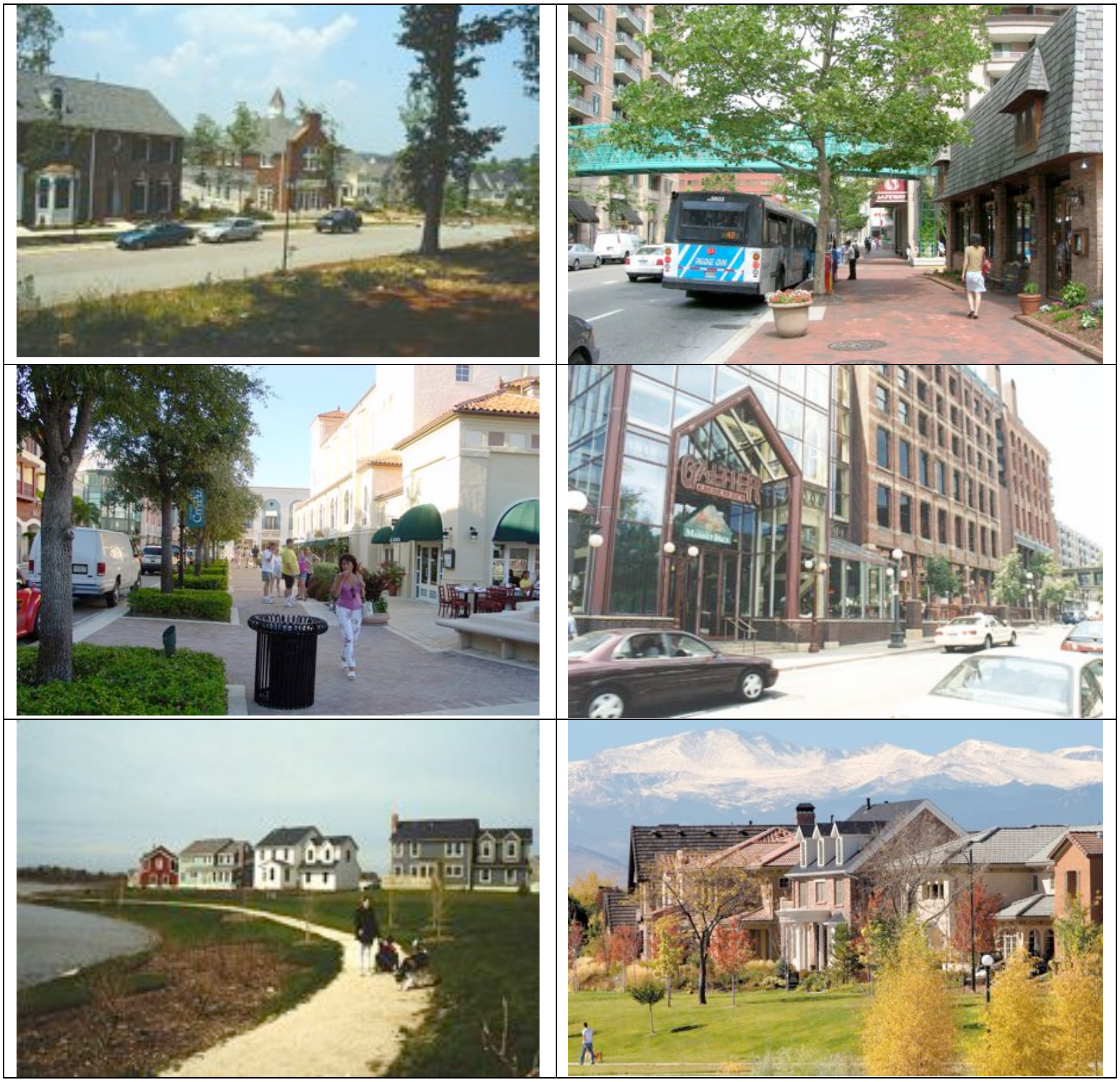
*The question was: Please tell me which of the following statements describe you more: A) If it were possible, I would like to walk more throughout the day either to get to specific places or for exercise, or B) I prefer to drive my car wherever I go?



1.6 And a Perfect Storm in Urban Planning

Yet another perfect storm is brewing in the land use and transportation planning fields. Although it is much less intense, this storm is swirling in the same direction as the ones in climate policy and consumer preferences. The urban planning field has been overtaken by movements promoting alternatives to conventional auto-oriented sprawl. Planners now advocate urban villages, neotraditional neighborhoods, transit-oriented developments (TODs), mixed-use activity centers, jobs/housing balance, context-sensitive highway designs, and traffic calming.

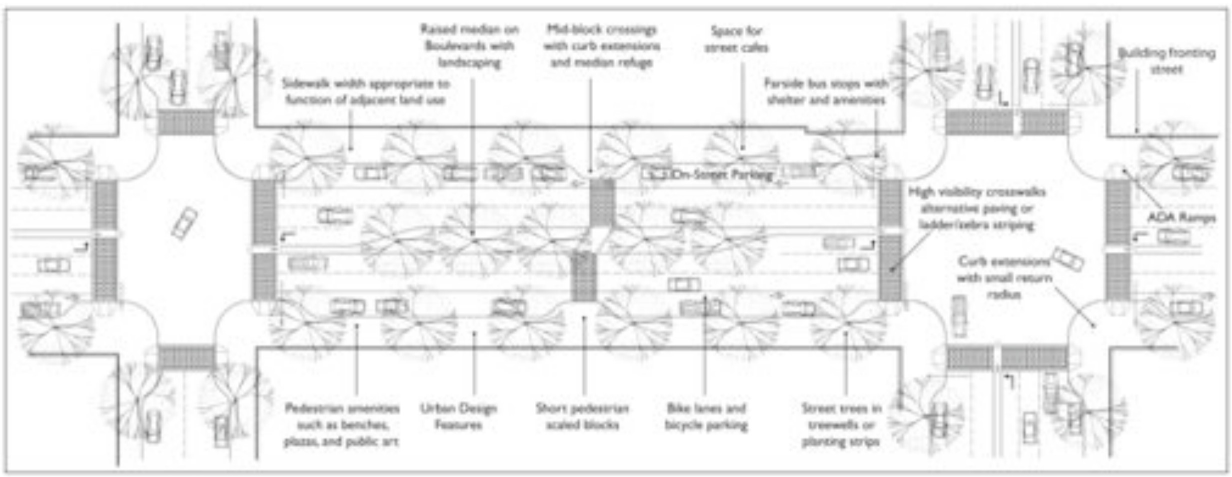
Alternative models of land development are everywhere. A 2003 listing shows 647 new urbanist developments in some state of planning or construction (New Urban News 2003), even though the new urbanist movement began only 12 years earlier. *Transit-Oriented Development in the United States: Experiences, Challenges, and Prospects* identifies 117 TODs on the ground or substantially developed as of late 2002 (Cervero et al. 2004). The first TOD guidelines were issued about a decade earlier. In 2004, there were more than 100 lifestyle centers (open-air shopping centers fashioned after main streets) in the United States, a 35 percent increase from 2000 (Robaton 2005). The U.S. Green Building Council's new rating and certification system for green development, LEED (Leadership in Energy and Environmental Design) for Neighborhood Development, generated 370 applications from land developers, many more than expected by the program sponsors.



This series of photographs illustrates alternative models of land development. Top left: Southern Village, a new urbanist village in North Carolina; top right: transit-oriented development in Bethesda, Maryland; middle left: CityPlace, a lifestyle center in West Palm Beach, Florida; middle right: infill/redevelopment (so-called "refill") in St. Paul, Minnesota; bottom left: green development in Prairie Crossing, Illinois; bottom right: Stapleton, a "new town in town" in Denver, Colorado.

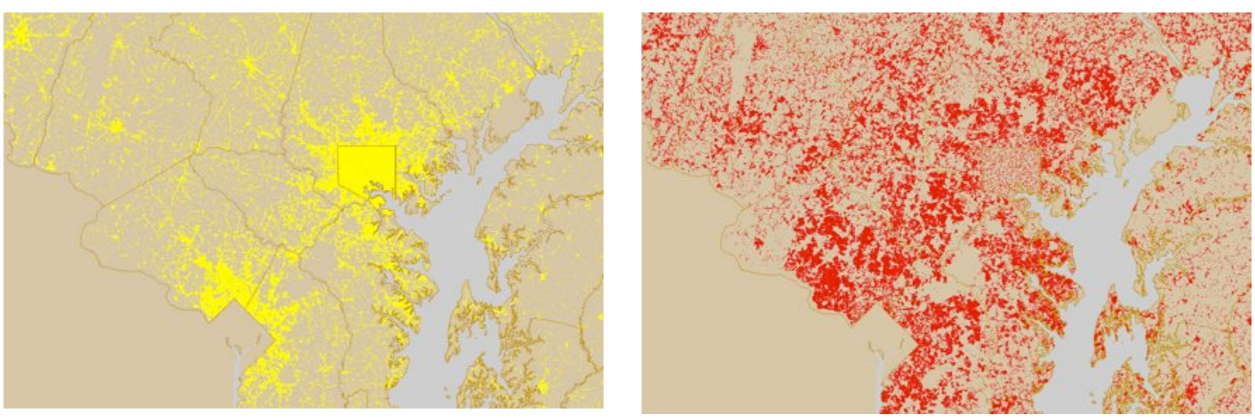
Recognizing the unsustainable growth in driving, the American Association of State Highway and Transportation Officials, representing state departments of transportation, recently called for VMT growth to be cut by half during the next 50 years (AASHTO 2007). Such unlikely allies as the Institute of Transportation Engineers and the Congress for the New Urbanism have teamed up to develop new context-sensitive street standards for walkable communities (see the illustration below). At the local level, several hundred traffic-calming programs have been created in the past decade; the term traffic calming was not even used in the United States until the mid-1990s (Ewing, Brown, and Hoyt 2005).

Elements of a context-sensitive urban highway.
Kimley-Horn and Associates et al. 2006



Loss of farmlands and natural areas—and the public benefits they provide—are behind a number of planning initiatives. The Maryland Smart Growth Program was motivated primarily by the rate at which the urban footprint was expanding into resource areas (see Figure 1-16). Nationally, most urbanized areas have seen their land area expand several times faster than their population (Fulton et al. 2001).

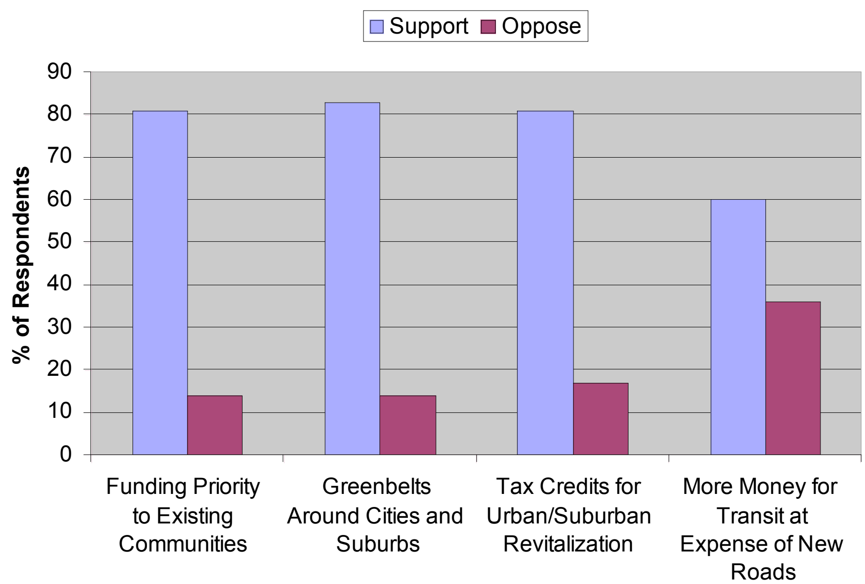
Figure 1-16 Parcel Development in Maryland, 1900 to 1960 (left) and 1961 to 1997 (right)



Fiscal constraints at the state and local levels are prompting governments to look for less expensive ways to meet infrastructure and service needs. Compact growth is less expensive to serve than sprawl, by an estimated 11 percent nationally for basic infrastructure (Burchell et al. 2002). The per capita costs of most services decline with density and rise as the spatial extent of urbanized land area increases (Carruthers and Ulfarsson 2003). The Envision Utah scenario planning process resulted in the selection of a compact growth plan that will save the region about $4.5 billion (17 percent) in infrastructure spending compared with a continuation of sprawling development (Envision Utah 2000). A major impetus for growth management is the desire to hold down public service costs.

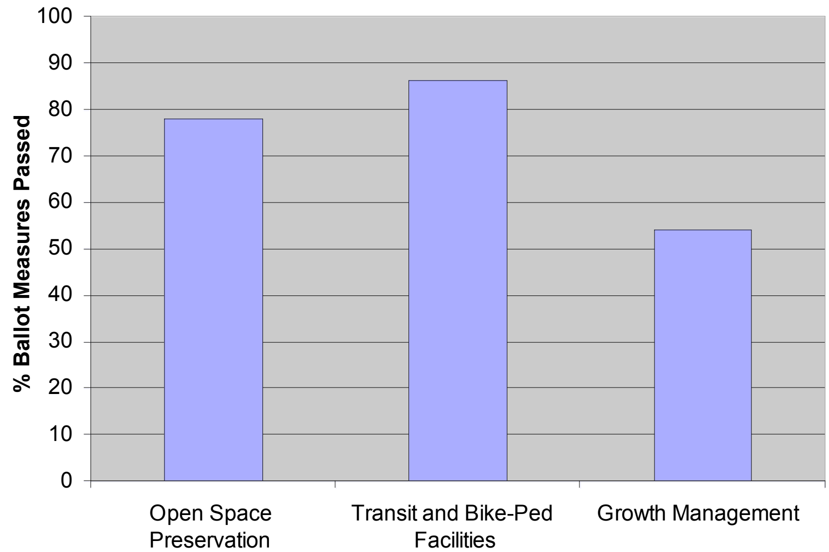
The U.S. obesity epidemic and associated mortality, morbidity, and health care costs have added to the momentum for walkable communities. Circa 2000, a new collaboration between urban planning and public health advocates, began under the banner of active living. Out of this came the Active Living by Design Program of the Robert Wood Johnson Foundation, the Active Community Environments initiative of the Centers for Disease Control and Prevention (CDC), numerous Safe Routes to School programs, and dozens of Mayors' Healthy City initiatives. A recent literature review found that 17 of 20 studies, all dating from 2002 or later, had established statistically significant relationships between some aspect of the built environment and the risk of obesity (Papas et al. 2007).

Figure 1-17 National Opinion Poll Results
Source: Belden Russonello & Stewart 2000.



Public support for smart growth policies appears to be strong and growing (Myers 1999; Myers and Puentes 2001; American Planning Association 2002; Kirby and Hollander 2005). In a 2000 national survey, a majority of respondents favored specific policies under the general heading of smart growth (see Figure 1-17). In the 2000 election, 553 state or local ballot initiatives in 38 states focused on "issues of planning or smart growth" and high percentages passed (see Figure 1-18). In 2004, voters approved 70 percent of ballot measures supporting public transit and rejected three out of four ballot initiatives on "regulatory takings" that could have significantly crimped planning efforts (Goldberg 2007).

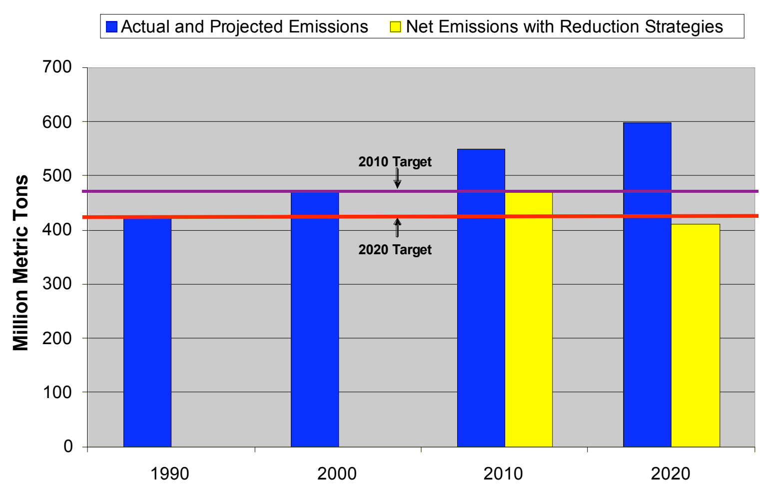
Figure 1-18 State and Local Ballot Measures Passed, 2000 Election
Source: Myers and Puentes 2001.



1.7 The Impact of Compact Development on VMT and CO_2 Emissions

California's landmark Global Warming Solutions Act of 2006 (AB 32) calls for restoring California's GHG emissions to 1990 levels by 2020, a 25 percent reduction relative to current emissions (see Figure 1-19). AB 32 also requires the Air Resources Board (ARB) to identify a list of "discrete early action greenhouse gas reduction measures." Once on the list, these measures are to be developed into regulatory proposals, adopted by the ARB, and made enforceable by January 1, 2010.

Figure 1-19 California's Projected GHG Emissions and Targets
Source: Climate Action Team 2007.



Pursuant to the act, the ARB released *Proposed Early Actions to Mitigate Climate Change in California* (ARB 2007). At the same time, the California Environmental Protection Agency's Climate Action Team recommended 21 additional actions for which GHG emission reductions have been quantified (Climate Action Team 2007). Of all the actions on the original list, those expected to achieve the second-largest reduction (originally 18 million metric tons per year CO_2 equivalent by 2020, since lowered to 10 million metric tons) fell under the heading of "smart land use and intelligent transportation." No details were provided as to what this category of actions might entail, or how the targeted reduction might be achieved.

How much could a transition from sprawl to compact development reasonably reduce U.S. transport CO_2 levels relative to current trends? The answer is the product of the following six factors:

- market share of compact development;
- reduction in VMT per capita with compact development;
- increment of new development or redevelopment relative to the base;
- proportion of weighted VMT within urban areas;
- ratio of CO_2 to VMT reduction for urban travel; and
- proportion of transport CO_2 due to motor vehicle travel.

Each factor is discussed below and quantified in turn.

1.7.1 Market Share of Compact Development

The first factor that will determine CO_2 reduction with compact development is market penetration during the forecast period, 2007 to 2050. The market share of compact development in the United States is growing but probably still small (Sobel 2006). No comprehensive inventory exists.

Two factors, however, suggest that whatever the market share is today, it will increase dramatically during the forecast period. One factor is the current undersupply of compact development relative to demand (see section 1.5). "A review of existing studies on consumer demand for smart growth products as well as consumer surveys . . . consistently find that at least one third of the consumer real estate market prefers smart growth development" (Logan 2007). The other factor is changing demographics (also discussed in section 1.5). "The aging of the baby boomers is an inexorable force likely to increase the number of households desiring denser residential environments" (Myers and Gearin 2001). The question is, how fast will the supply of compact development respond to this demand?

Over the long run, it is reasonable to assume that what is supplied by the development industry will roughly equal what is demanded by the market, with a time lag. This will be true, provided government policies allow and encourage it. If a third of the market currently wants the density, diversity, and design of smart growth, and almost another third wants the destination accessibility of smart growth (see section 1.5), the market will be inclined to provide these product types.

Changing demographics and lifestyles will increase these proportions. The policy recommendations presented in Chapter 7 will facilitate market changes as well as make a contribution of their own to growing market shares. We will assume that between now and 2050, the *lower bound on the proportion of compact development is six-tenths and the upper bound is nine-tenths*, consistent with demographic trends and the current undersupply. As discussed in subsection 1.7.3, this still leaves more than 40 percent of development as it is today, largely sprawling and auto oriented.

1.7.2 Reduction in VMT per Capita with Compact Development

Based on the urban planning literature reviewed in this publication, it appears that compact development has the potential to reduce VMT per capita by anywhere from 20 to 40 percent relative to sprawl. The actual reduction in VMT per capita will depend on two factors: how bad trend development patterns are in terms of the so-called "five Ds" (density, diversity, design, destination accessibility, and distance to transit); and how good alternative growth patterns are in terms of these same five Ds. The five Ds, which are described in Chapter 3, are qualities of the urban environment that urban planners and developers can affect, which in turn affect travel choices.

Considering all the evidence presented in Chapter 3, it is reasonable to assume an *average reduction in VMT per capita with compact development relative to sprawl of three tenths*. This fraction applies to each increment of development or redevelopment but does not affect base development.

1.7.3 Increment of New Development or Redevelopment Relative to the Base

The cumulative effect of compact development also depends on how much new development or redevelopment occurs relative to a region's existing development pattern. The amount of new development and redevelopment depends, in turn, on the time horizon and the area's growth rate. The longer the time horizon and the faster the rate of development or redevelopment, the greater will be the regionwide percentage change in VMT per capita.

A recent article in the *Journal of the American Planning Association* began with the following words: "More than half of the built environment of the United States we will see in 2025 did not exist in 2000, giving planners an unprecedented opportunity to reshape the landscape" (Nelson 2006). Between 2005 and 2050, the number of residential units of all types may grow from 124 million to 176 million, or a total of 52 million.[6] In addition, each decade, roughly 6 percent of the housing stock of the previous decade is replaced,[7] with about two-thirds being rebuilt on site and another third consisting of new units built elsewhere because of land use conversions (such as a strip mall replacing houses, with the displaced homes rebuilt elsewhere).[8] Counting compounding effects, perhaps 37 million homes will need to be replaced entirely through conversion processes between 2005 and 2050. The number of new plus replaced residential units

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[6] The American Housing Survey reports about 124 million residential units in 2005 while the Census reports a population of about 296 million for the same year, for a ratio of 0.42 units per capita. As household size is not projected to change substantially over the next generation, the Census projected population for 2050 is multiplied by the ratio of residential units to population in 2005 to estimate future residential demand (see http://www.census.gov/hhes/www/housing/ahs/ahs.html).
[7] The 1990 Census reports 102 million residential units while the 2000 Census reports that 96 million survived to 2000, indicating a loss rate of about 6 percent per decade (see www.census.gov).
[8] There is no consensus on the actual rate of loss of residential units through demolition and conversion to another land use. The one-third figure is conservative based on Delphi consensus of experts (see Nelson 2006).

may reach 89 million units between 2005 and 2050, or more than 70 percent of the stock that existed in 2005.

Even more dramatic is the construction of nonresidential space, largely because, on average, about 20 percent of such space turns over each decade.[9] Nonresidential space includes retail, office, industrial, government, and other structures. From 2005 to 2050, nonresidential space will expand from about 100 billion square feet[10] to about 160 billion square feet, or by 60 billion square feet.[11] However, about 130 billion square feet will be rebuilt; some structures will be rebuilt two or more times because their useful life is less than 20 years. Perhaps a total of 190 billion square feet of nonresidential space will be constructed between 2005 and 2050, or nearly twice the volume of space that existed in 2005.

The magnitude of development ahead suggests there may be unprecedented opportunities to recast the built environment in ways that reduce a variety of emissions, especially CO_2. Furthermore, as noted in section 1.5, a very large share of this new development will be driven by emerging market forces that desire compact development, not because it reduces CO_2 emissions but rather because it is responsive to changing tastes and preferences.

Much of the built environment existing in 2005 will remain, of course, including most existing residential stock, institutional buildings, and high-rise structures. Nonetheless, we may assume that easily *two-thirds of development on the ground in 2050* will be developed or redeveloped between now and then.

1.7.4 Proportion of Weighted VMT within Urban Areas

A shift to compact development will affect *urban* VMT, not *rural* VMT. Put another way, compact development policies will affect travel within cities, not travel between cities. Two-thirds of the total VMT in the United States currently is urban. Heavy vehicles produce about four times more CO_2 emissions per mile than light vehicles, and heavy vehicles represent a higher proportion of rural VMT. Weighting VMT accordingly, 62 percent of the nation's VMT is presently urban. This estimate includes cars, trucks, and buses.

The proportion of urban VMT is growing as the United States becomes ever more urbanized. Projecting current trends out to 2050, about *four-fifths of the weighted VMT in 2050 will be urban*.

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[9] The U.S. Department of Energy's Energy Information Administration conducts the Commercial Buildings Energy Consumption Survey (CBECS) about every five years. The 1992 survey reported 68 billion square feet of nonresidential space excluding industrial space. The 1999 survey (the most compatible in format) reported 58 billion nonresident square feet existing in 1992 surviving to 1999, or an imputed loss rate of slightly more than 20 percent per decade (see http://www.eia.doe.gov/emeu/cbecs/).

[10] This figure includes industrial space (see Nelson 2006).

[11] This figure assumes about 580 square feet of space per full- and part-time worker. It is the quotient of total nonresidential space (see Nelson 2006) and workers. The U.S. Department of Commerce's Bureau of Economic Analysis reported there were 173 million total full- and part-time workers in 2005 (see www.bea.gov.) In contrast, the CBECS for 2003 estimates 1,000 square feet per full time worker. The more conservative figure is used.

1.7.5 Ratio of CO_2 to VMT Reduction

Compact development may not reduce CO_2 emissions by exactly the same proportion as VMT. The reasons, discussed in Chapter 2, are the CO_2 penalties associated with cold starts and lower operating speeds in compact areas. For the project-level simulations presented in section 3.4, the ratio of CO_2 to VMT reduction for compact development projects is around 0.95.

The material presented in section 2.3.3 indicates that a reduction in VMT of 30 percent would be expected to produce a reduction in CO_2 of about 28 percent. This figure factors in CO_2 penalties associated with cold starts and reduced vehicle operating speeds. Thus the ratio of CO_2 to VMT reduction would be around 0.93.

Given these three pieces of evidence, and weighting the second most heavily, we will conservatively assume a *CO_2 reduction equal to nine-tenths of the VMT reduction*.

1.7.6 Proportion of Transportation CO_2 from Motor Vehicles

Motor vehicles (automobiles, light- and heavy-duty trucks, and buses) contributed 79 percent of transportation CO_2 emissions in 2005 (EPA 2007, Table 3-7). This percentage is increasing over time, largely because of the growth of heavy-vehicle traffic. We will assume that *motor vehicles contribute four-fifths of transportation CO_2 emissions*, with the balance coming from aircraft, ships, and trains.

1.7.7 Net CO_2 Reduction in Comparison to Other Actions

Projecting out to 2050, the net CO_2 reduction is estimated to be as follows:

6/10 to 9/10 (market share of compact development)

x

3/10 (reduction in VMT per capita with compact development)

x

2/3 (increment of new development or redevelopment relative to base)

x

4/5 (proportion of weighted VMT within urban areas)

x

9/10 (ratio of CO_2 to VMT reduction)

x

4/5 (*proportion of transportation CO_2 from motor vehicles).*

Doing the math, compact development has the potential to reduce U.S. transportation CO_2 emissions by 7 to 10 percent, when compared to continuing urban sprawl.

A 7 to 10 percent reduction in CO_2 emissions should be put into perspective. The long-term elasticity of VMT with respect to fuel price is around –0.3 (see review by Victoria Transport Policy Institute 2007). The price of gasoline would have to double to produce an equivalent (30 percent) reduction in VMT. If one-quarter of the projected gasoline use were replaced with petroleum diesel, biodiesel, or electricity (a replacement rate viewed as “reasonable” within a 25-year time frame), transportation CO_2 emissions would decline by an estimated 8 to 11 percent (Pickrell 2003). This does not include an adjustment for CO_2 from sources other than motor vehicles. The CO_2 savings through 2030 would be at least as large as a 31-mile-per-gallon (mpg) corporate average fuel economy (CAFE) standard (2020 combined mpg for cars and light trucks), or one-third of the savings expected from the Senate's 35-mpg CAFE standard.

The 7 to 10 percent reduction is an end-year estimate. During the 43-year period, the cumulative drop in CO_2 emissions would be about half this amount. Yet, the very phenomenon that limits the short- and medium-term impacts of compact development—the long-lived nature of buildings and infrastructure—makes the reduction essentially permanent and compoundable. The next 50 years of compact development would build on the base reduction from the first 50 years, and so on into the future. More immediate strategies, such as gas tax increases, do not have the same degree of permanence.

The 7 to 10 percent reduction only relates to the transportation sector. Compact development, however, would reduce CO_2 emissions for other sectors as well. An order-of-magnitude estimate for the residential sector is provided in Chapter 6. Controlling for socioeconomic and climatic variables, an equivalent household uses 20 percent less primary energy for space heating and cooling in a compact area than in a sprawling one. This savings is primarily due to less exterior wall area in attached and multifamily housing, and less floor area consumed at higher densities.

The 7 to 10 percent reduction does not consider the impact of intelligent transportation systems, congestion pricing, pay-as-you-drive insurance, or other complementary strategies. These might be used to better manage existing roads and public transportation, supporting smart growth or, alternatively, could be used to accelerate highway capacity expansion, undermining the smart growth impacts documented in this publication.

1.8 The Organization of this Book

Chapter by chapter, this book addresses the impacts of the following:

- vehicular travel on greenhouse gas emissions;
- urban development on vehicular travel;
- residential preferences on urban development and travel;
- highway building on urban development and travel;
- urban development on residential energy use; and, finally,
- policy options for encouraging compact development and reducing vehicular travel.

2. The VMT/CO_2/Climate Connection

There is now a scientific consensus that greenhouse gas accumulations due to human activities are contributing to global climate change (Greenough et al. 2001; Barnett and Adger 2003; Hegerl et al. 2007; IPCC 2007a). The Fourth Assessment Report of the U.N. Intergovernmental Panel on Climate Change (IPCC 2007a, p. 2) concludes that: "Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed preindustrial values determined from ice cores spanning many thousands of years." Greenhouse gas concentrations have risen from preindustrial levels of approximately 280 parts per million (ppm) CO_2 equivalent (CO_2e) to 430 ppm CO_2e (Stern 2006).[12]

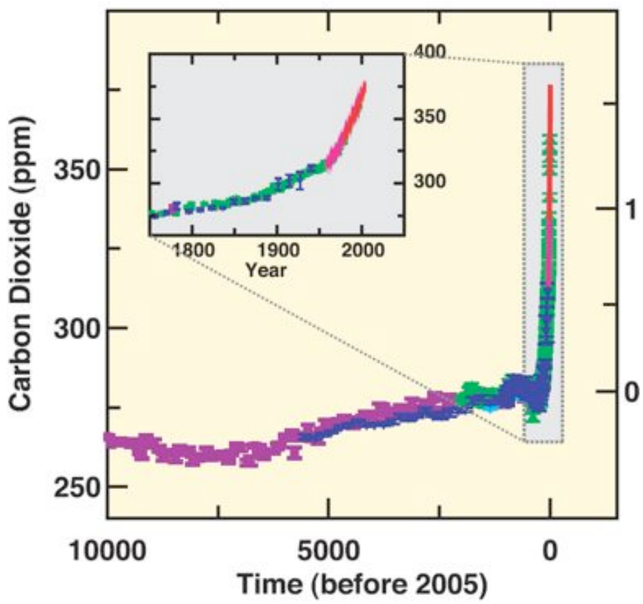


Figure 2-1 Atmospheric Concentration of Carbon Dioxide (CO_2) over the Last 10,000 Years
Source: IPCC 2007a, p. 3.

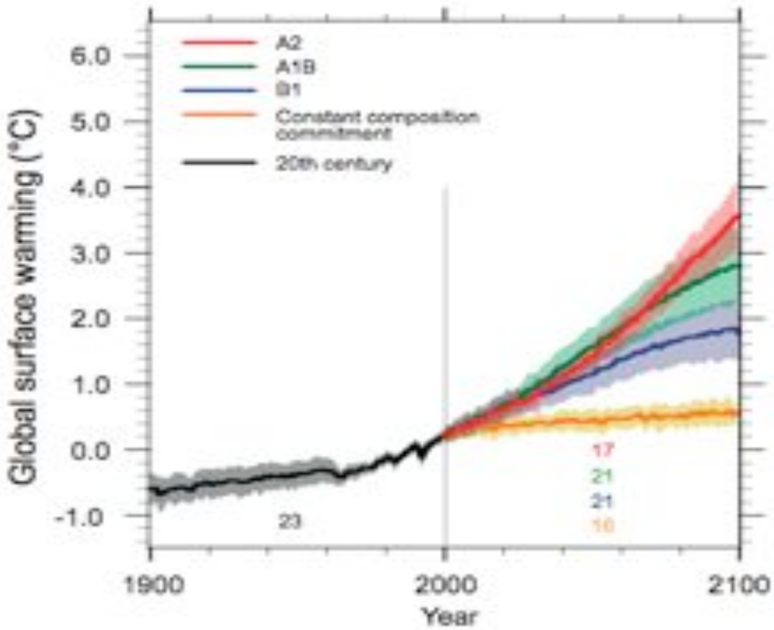
The result is climate change. "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level" (IPCC 2007a, p. 5). Eleven of the last 12 years are among the 12 warmest globally since the instrumental record began in 1850 (IPCC 2007a, p. 5).[13] Long-term changes have been observed in Arctic temperatures and ice formations, ocean salinity, droughts, heavy precipitation, heat waves, and tropical cyclone intensity.

With current trends, the atmospheric concentration of CO_2e is expected to rise from 430 ppm to 630 ppm by 2050. Even if GHG emissions were held at year 2000 levels, the planet would warm by 1°C over the next 100 years. Under a variety of scenarios with differing assumptions about growth, technology, and climate feedback, the likely range of warming by 2100 is between 1.1°C and 6.4°C, with a best estimate of 1.8°C to 4.0°C (IPCC 2007a, p. 12).

[12] Carbon dioxide equivalent (CO_2e) is an internationally accepted measure of the amount of global warming of greenhouse gases (GHGs) in terms of the amount of carbon dioxide (CO_2) that would have the same global warming potential.

[13] NASA's Goddard Institute for Space Studies identifies the five warmest years for global temperatures as (in descending order): 2005, 1998, 2002, 2003, and 2006 (Goddard 2007). Five of the last nine years have been the warmest on record in the United States (in descending order: 1998, 2006, 1999, 2001, 2005) (National Climate Data Center 2007).

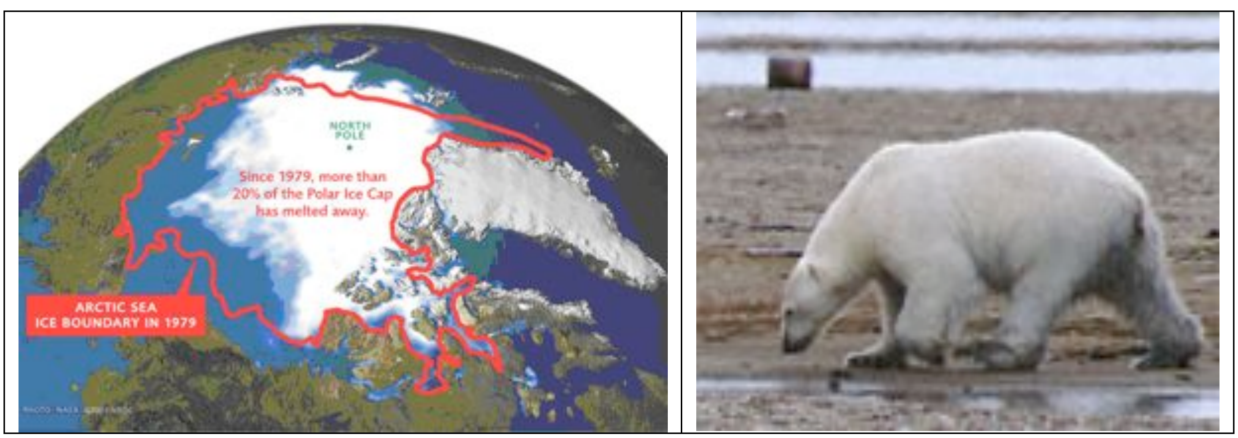
Figure 2-2 Global Average Surface Temperature Warming under Different Scenarios
Source: IPCC 2007a, p. 14.



International and domestic climate policy discussions have gravitated toward the goal of limiting the temperature increase to 2°C to 3°C (European Commission 2007). Stabilization at 450 ppm CO_2e is expected to produce a 50/50 chance of keeping warming to + 2°C above preindustrial levels, whereas 550 ppm would result in a 50/50 chance of keeping warming to +3°C (Meinshausen 2006).

With a 2°C increase in global average temperature, all coral reefs are at risk of being bleached. At 3°C, more than one-third of all species will be at risk of eventual extinction. With an increase of 2°C to 3°C, coastal flooding threatens to harm or displace 70 million to 250 million people, respectively, and hundreds of millions of people face an increased risk of hunger. In this same range of temperature increase, the Amazon rainforest and Great Lakes ecosystems are at risk of collapse (Meinshausen 2006). From 1°C to 4°C, a partial deglaciation of the Greenland Ice Sheet will occur, with the sea level destined to increase by four to six meters over centuries to millennia (IPCC 2007b, p. 17; DEFRA 2006).

A shrinking Arctic icecap threatens many species, including the polar bear.
NRDC undated



Stabilization at 450 ppm CO_2e would require global GHG emissions to peak around 2015 and be reduced 30 to 40 percent below 1990 levels by 2050 (Höhne, Phylipsen, and Moltmann 2007; Meinshausen and den Elzen 2005). The British government's review and the IPCC report show that the less we limit GHG emissions globally in the near term, the harder it will be to stabilize them at the target concentrations later (HM Treasury 2006; IPCC 2007c, p.15). For each five years that the peak in global emissions is delayed beyond 2015, the annual rate by which emissions must decline will increase by an additional 1 percent (Meinshausen and den Elzen 2005). One percent per year is a substantial level of effort, comparable to the reduction the United Kingdom achieved nationally after it switched all of its coal-fired power plants to natural gas in the 1990s (Helme and Schmidt 2007).

Determining the necessary GHG reductions in the United States to meet global targets requires assessment of and assumptions about expected GHG reductions in other countries. The emerging consensus is that industrialized countries will need to reduce their GHG emissions by 60 to 80 percent below 1990 levels by 2050 (European Commission 2007; Helme and Schmidt 2007; Höhne, Phylipsen, and Moltmann 2007; Meinshausen and den Elzen 2005; New England Governors/Eastern Canadian Premiers 2001; Schwarzenegger 2005). To meet this long-term goal, industrialized countries must reduce GHG emissions 15 to 30 percent below 1990 levels by 2020 (European Commission 2007; Höhne, Phylipsen, and Moltmann 2007; Meinshausen and den Elzen 2005). In August 2007, industrial nations agreed to GHG cuts 25 to 40 percent below 1990 levels by 2020 as a nonbinding starting point for a new round of international climate negotiations (Reuters 2007).

2.1 Prospects for the U.S. Transportation Sector

The transportation sector is responsible for 33 percent of U.S. CO_2 emissions (28 percent of U.S. GHG emissions), and its emissions are projected to grow faster than the average rate for all sectors of the economy (EIA 2007, Table A18). Passenger vehicles (cars and light trucks) are responsible for more than three-fifths of transportation sector CO_2 emissions.

The GHG reduction "required" from U.S. transportation is a function of the level of reductions that can be expected in other sectors of the economy to meet the 60 to 80 percent reduction target. While certain sectors of the economy may be able to reduce GHG emissions more than others, it is unlikely that they will be able to sufficiently overcompensate for limited progress in the transportation sector. As discussed below, current policy proposals on vehicle technology and fuels would leave passenger vehicle CO_2 emissions well above 1990 levels in 2030, significantly off course for meeting the 2050 target. Reduction in travel demand will be an important element of effective climate policy.

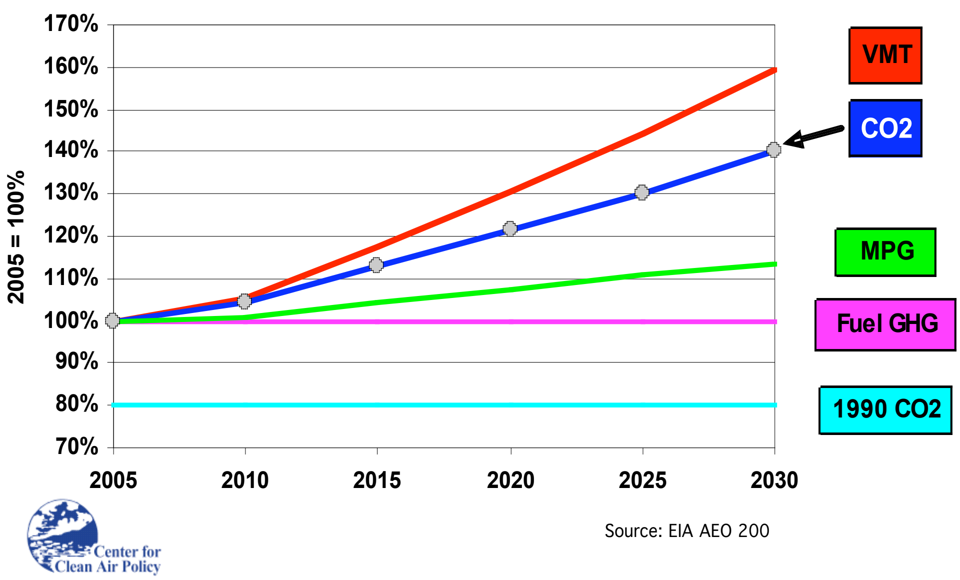
There is a popularly held expectation that electricity or hydrogen fuels will provide long-term solutions to energy security and transportation GHG concerns, essentially shifting transportation GHG emissions upstream to other sectors of the economy. Biofuels also could potentially play an important role, but their use will be limited because of land use constraints, high costs, and ecological and social concerns. A shift to electric or hydrogen cars could certainly reduce petroleum use if major technological breakthroughs and cost reductions are achieved on battery and fuel cell technologies. (Plug-in hybrid vehicles currently carry a cost premium on the order of $10,000, and the cost premium for hydrogen fuel cell vehicles is on the order of $500,000 to $1 million.)

Achieving significant GHG reductions also will require significant investments and political will. Since electricity and hydrogen are energy carriers, they result in GHG savings only if their production and transportation processes are relatively more carbon efficient than the current approach. Thus, for electricity or hydrogen to result in GHG reductions, they must be generated via low-emitting processes. Three primary energy sources could generate low-GHG electricity or hydrogen. First, renewable sources such as solar, biomass, and wind have significant but limited potential. Although these sources could potentially provide a large amount of energy, issues such as intermittent generation and local resource availability present difficulties. Second, nuclear power has great potential as a low-GHG energy source, but faces significant cost and political barriers. Third, carbon capture and sequestration (CCS)—in which CO_2 is removed from a coal (or other) power plant smokestack and injected underground into geological formations such as oil fields, gas fields, or saline formations—offers the possibility of continued use of coal resources with a much improved GHG profile. There is active research on CCS to assess costs, permanence, and storage capacity. Each of these three low-GHG energy sources holds significant promise but can offer no guarantees.

2.2 VMT and CO_2 Projections

The U.S. Department of Energy's Energy Information Administration (EIA) forecasts VMT to increase by 59 percent from 2005 to 2030 (the red line in Figure 2-3), outpacing projected population growth of 23 percent (EIA 2007, Table A7). The projected VMT increase represents a slowdown relative to historic VMT growth rates, but is within the likely range for future VMT growth (Polzin 2006). Over this time period, the EIA projects fuel economy for new passenger vehicles to increase by 16 percent (from 25 to 29 mpg) and the fuel economy of the full stock of vehicles (the green line in Figure 2-3) to increase by l3.3 percent as more efficient vehicles penetrate the fleet. CO_2 emissions would increase by 40 percent[14] over the same time frame (the dark blue line in Figure 2-3). In this case, transportation CO_2 emissions in 2030 would be 75 percent above 1990 levels (the turquoise line in Figure 2-3).

Figure 2-3 Projected Growth in CO_2 Emissions from Cars and Light Trucks
Source: EIA 2007.



U.S. fuel economy has been flat for almost 15 years, as the upward spiral of car weight and power has offset more efficient technology (Schipper 2007). In June 2007, the U.S. Senate passed new CAFE standards that would increase new passenger vehicle fuel economy (cars and light trucks combined) to 35 mpg by 2020 (U.S. Congress 2007). The state of California is implementing a low carbon standard for transportation fuels that calls for a 10 percent reduction in fuel carbon intensity by 2020 (Schwarzenegger 2007). If California's low carbon fuel standard were applied at the national level (the purple line in Figure 2-4), in conjunction with the Senate's CAFE standard of 35 mpg by 2020 (the green line in Figure 2-4), passenger vehicle CO_2 emissions in 2030 would be 12 percent above 2005 levels, or 40 percent above 1990 levels. In other words, projected growth of VMT would still overwhelm the CO_2 savings from vehicle and fuel regulations.[15]

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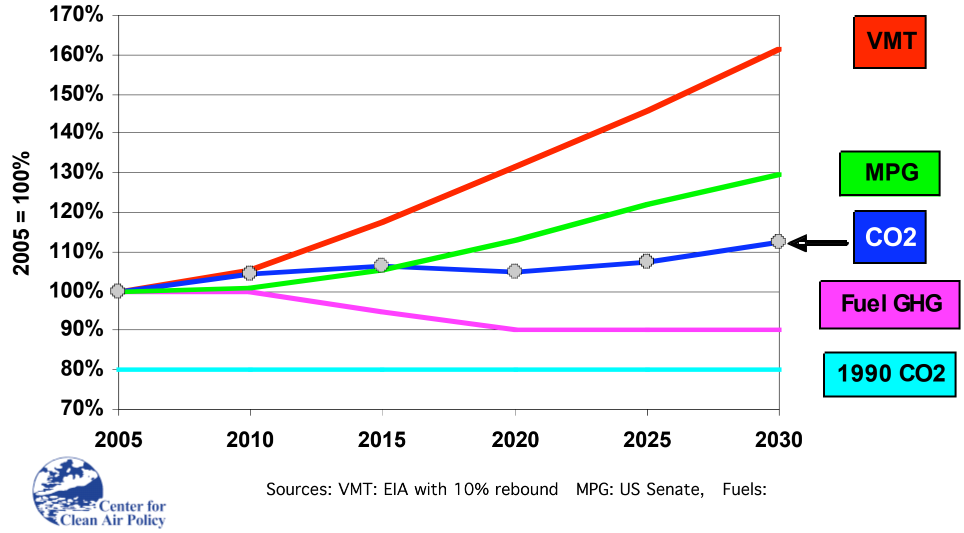
[14] 159% [vehicle miles traveled] / 1.133 [mpg] = 140% [CO_2] with constant fuel carbon content.
[15] In this scenario, VMT growth increases by 2 percentage points (61 percent growth by 2030) due to the "rebound effect" whereby driving increases as fuel economy increases (10 percent short-run elasticity).

Figure 2-4 Projected Growth in CO_2 Emissions from Cars and Light Trucks, Assuming Stringent Nationwide Vehicle and Fuel Standards*
Sources: EIA 2007; U.S. Congress 2007; Schwarzenegger 2007.

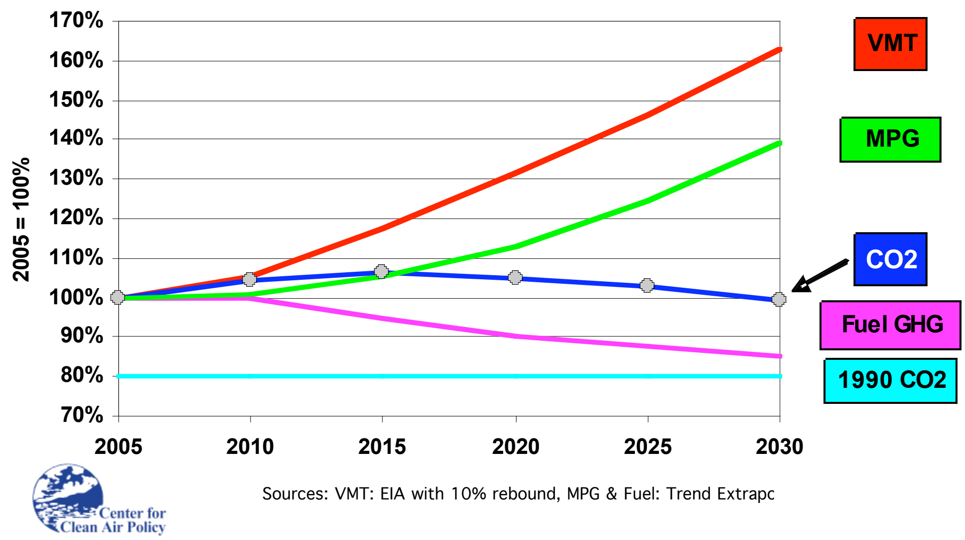
* With Senate new passenger vehicle fuel economy of 35 mpg and California low carbon fuel standard of –10 percent in 2020, applied nationally. Assumes a 10 percent rebound.



If the fuel economy and fuel carbon content trends represented in Figure 2-4 were extended through to 2030, so that new vehicle fuel economy would increase to 45 mpg and fuel carbon content would decrease to 15 percent below current levels, then 2030 CO_2 emissions would be reduced to 1 percent below 2005 levels, or 24 percent above 1990 levels (Figure 2-5).

Figure 2-5 Projected Growth in CO2 Emissions from Cars and Light Trucks, Assuming Even More Stringent Nationwide Vehicle and Fuel Standards*
Sources: EIA 2007; U.S. Congress 2007; Schwarzenegger 2007.

*Extrapolating trends from Figure 2-4 with new passenger vehicle fuel economy of 45 mpg in 2030 and low carbon fuel standard of –15 percent in 2030.



Clearly, lowering transportation CO_2 emissions to 60 to 80 percent below 1990 levels by 2050 would require even greater improvements in vehicles, fuels and, almost certainly, reductions in VMT per capita.

2.3 Other Influences on CO_2 Emissions

Carbon dioxide emissions are a function not only of VMT but also of numbers of vehicle trips (VT) and vehicle operating speeds. The number of vehicle trips is directly related to the number of vehicle starts, while average vehicle operating speed is a proxy for the entire driving cycle (starts, acceleration, cruising speed, deceleration, and stops). Both affect vehicle operating efficiency and CO_2 emissions per vehicle mile.

2.3.1 Vehicle Trip Frequencies

Starting a vehicle when it is cold uses more energy and emits more CO_2 than does starting the vehicle after it has warmed up. For an average car in California, the California Air Resources Board EMFAC model shows cold start emissions of 213 grams CO_2 after a 12-hour soak.[16] To put this in context, an average passenger car emits 386 grams of CO_2 per mile when traveling at an average speed of 30 miles per hour.[17]

Still, any cold start penalty associated with compact development is likely to be small. From the EMFAC model, CO_2 emissions from *all* vehicle starts (cold, intermediate, and hot) account for just 3.3 percent of total annual passenger vehicle CO_2 emissions in California.[18] Moreover, while there has been some speculation in the literature that compact development could increase trip frequencies, the weight of evidence suggests otherwise. Overall trip rates appear to depend largely on household socioeconomics and demographics. Controlling for these influences, vehicle trip rates are lower in compact areas because some of a household's daily trips shift from the automobile to other modes (Ewing, DeAnna, and Li 1996; Ewing and Cervero 2001).

2.3.2 Vehicle Operating Speeds

Compact development policies could have secondary effects on CO_2 emissions by lowering (or raising) average vehicle speeds. Motor vehicles with internal combustion engines are most efficient at an average speed of about 45 miles per hour, with lower efficiency and higher CO_2 emission rates for speeds above and below this "sweet spot" (see Figure 2-6). The data in Figure 2-6 come from the California Air Resources Board EMFAC model and represent average speed for vehicle trips that have been calibrated to reflect real-world driving behavior, including acceleration, starts, idling, and so forth.

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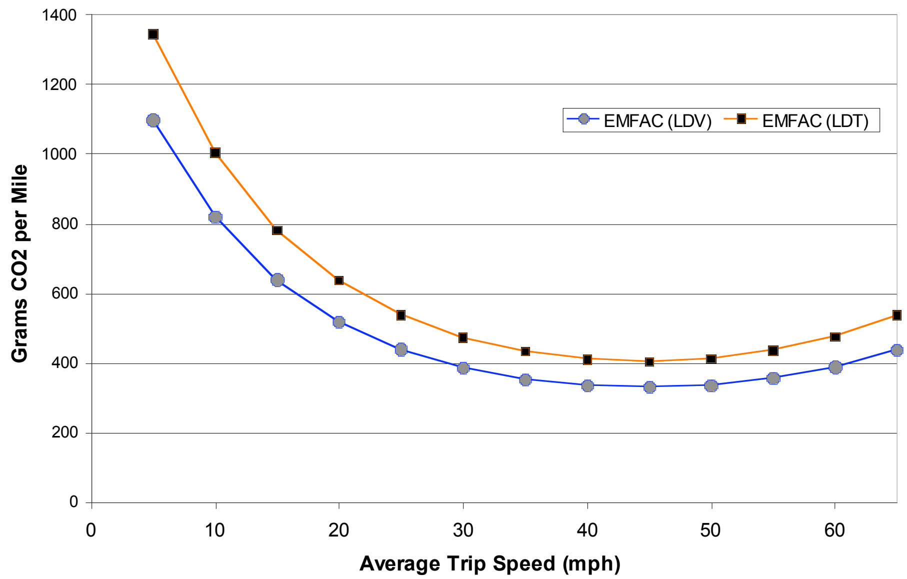
[16] Authors' calculations based on data from EMFAC 2007, V2.3 Nov. 1, 2006, provided by Jeff Long, California Air Resources Board, July 24, 2007.
[17] Authors' calculations based on data from EMFAC 2007, V2.3 Nov. 1, 2006, provided by Jeff Long, California Air Resources Board, April 25, 2007.
[18] Authors' calculations based on data from EMFAC 2007, V2.3 Nov. 1, 2006, provided by Jeff Long, California Air Resources Board, July 9, 2007.

Figure 2-6 CO_2 Emission Rate versus Average Vehicle Speed*
Source: Jeff Long, California Air Resources Board



*Data from EMFAC 2007, V2.3 Nov. 1, 2006, provided by Jeff Long, California Air Resources Board, April 2007. Data include all model years in the range 1965 to 2007. The magnitude of the curve (not the shape) is a function of temperature and humidity assumptions, in this case 80°F and relative humidity of 50 percent.

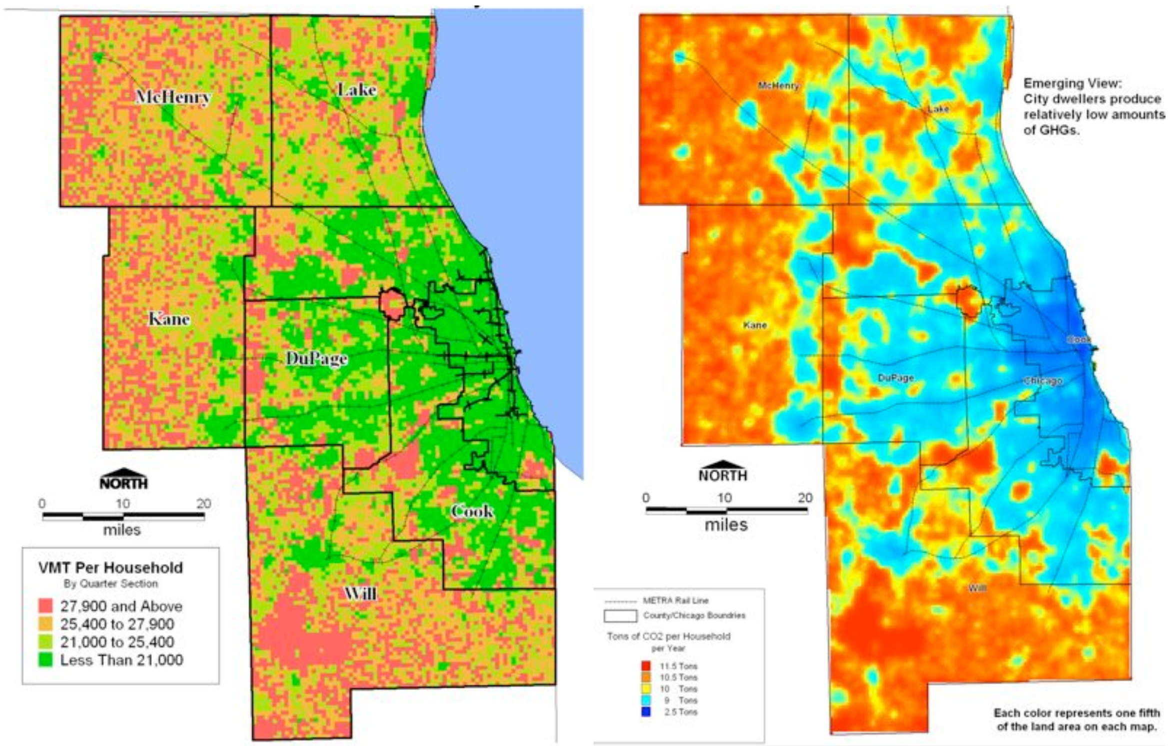
Can we therefore conclude that it would be most efficient to design cities and roadways to maximize vehicle operating efficiency? No, because the efficiency gained by designing roads for high average speeds would be negated by an increase in miles traveled. Development can and would become ever more dispersed. The phenomena of induced traffic and induced development are discussed in Chapter 5. Moreover, the most efficient speed for today's cars is probably higher than the most efficient speed for tomorrow's cars. Emission rate curves for hybrid vehicles, in particular, look different, because these vehicles experience less of a low-speed emissions penalty.

2.3.3 Synthesis

With the transition from sprawl to compact development, both VMT and VT would be expected to decline, though by different percentages. The result would be a drop in CO_2 emissions per capita. Vehicle trips will decline as travelers shift from the automobile to alternative modes, and VMT will decline as mode shifts occur and as automobile trips get shorter. Vehicle operating speeds also may decline, and would have an opposite effect on CO_2 emissions per capita. Compact development may mean lower cruising speeds and more stop-and-go driving, hence higher emissions per mile traveled (assuming conventional vehicle technology).

We can get a sense of the magnitude of these effects based on available information. All else being equal, there is a one-to-one relationship between VMT and CO_2 emissions; a 30 percent reduction in VMT will result in a 30 percent reduction in CO_2 emissions.

Figure 2-7 Close Relationship between VMT per Household and CO_2 Emissions in the Chicago Metropolitan Area
Source: Center for Neighborhood Technology undated.



Let us posit that regional density will be 50 percent higher in 2050 under compact development than with current trends, a not unreasonable assumption, given the data presented in section 1.7. Given an elasticity of peak hour speed with respect to density of –0.15 (see subsection 3.1.4), the average peak hour vehicle operating speed might decline by 0.15 times 50 percent, or 7.5 percent, with compact development. If so, average daily speed would decline by about 3 percent, since the morning and afternoon peak periods represents two-fifths of average daily traffic in metropolitan areas. Such a decline would cause a 1 to 2 percent increase in CO_2 emissions per mile at typical urban speeds (see subsection 2.3.2). Therefore, if compact development reduced VMT by 30 percent, lowered average vehicle operating speed by 3 percent, and had no effect on vehicle trips, the net impact would be a 28 percent drop in CO_2 emissions.[19]

The next chapter addresses the extent to which compact urban development can reduce VMT and associated CO_2 emissions.

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[19] 100% – (70% [VMT] x 102% [CO_2 per mile] x 96.7% [running emissions] + 3.3% [start emissions]).

3. The Urban Development/VMT Connection

Four different rich empirical literatures inform the discussion of urban development and its impacts on VMT, the primary determinant of transportation-related CO_2 emissions:

- aggregate travel studies, such as sprawl index research conducted for Smart Growth America;
- disaggregate travel studies, such as Smart Growth Index elasticity estimates;
- regional simulation studies, such as Portland's LUTRAQ (Land Use, Transportation, Air Quality) study; and
- project simulation studies, such as the EPA's Atlantic Steel study.

In this chapter, we review each literature in turn and present order-of-magnitude effect sizes. For two literatures—disaggregate travel studies and regional simulation studies—the sample of studies is large enough to permit meta-analyses of study results. A meta-analysis is a special kind of literature synthesis, conducted most often in scientific fields. It is more than a literature review, as it generalizes across studies quantitatively, taking individual studies as units of analysis and combining study results to arrive at average effect sizes and confidence intervals.

The different literatures provide a consistent picture. Compact development has the potential to reduce VMT per capita by anywhere from 20 to 40 percent relative to sprawl. The actual reduction in VMT per capita will depend on the specific form of compact development, as outlined in the following sections.

3.1 Aggregate Travel Studies

For decades, it has been known that compact areas have lower levels of automobile use per capita and greater use of alternative modes of transportation than do sprawling areas. They also tend to generate shorter trips. The combined effect is significantly less VMT per capita in compact areas (see Figure 3-1). This fact has been documented most famously by Newman and Kenworthy (1989a, 1989b, 2006, 2007), Holtzclaw (1991, 1994), and Holtzclaw et al. (2002). This same-shaped exponential decline in vehicular travel with density is found in many data series (see Figures 3-2 and 3-3 for communities in the Baltimore area and for higher-income cities worldwide).

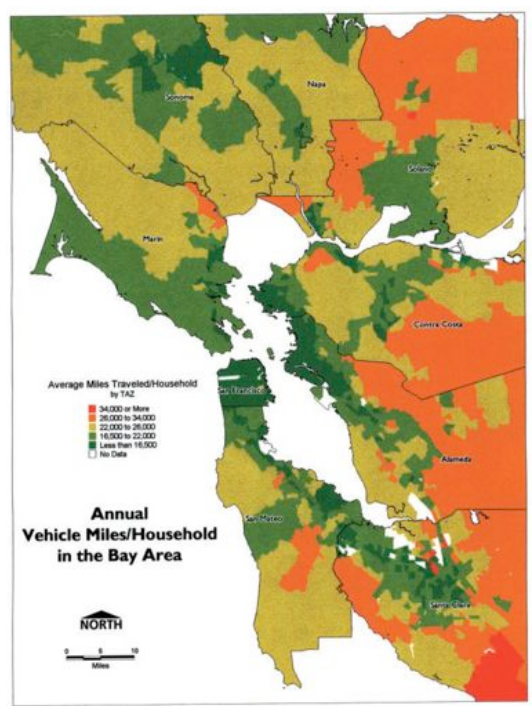


Figure 3-1 Vehicle Miles Traveled per Household for Neighborhoods in the San Francisco Metropolitan Area
Source: Holtzclaw et al. 2002.

Figure 3-2 Vehicle Miles Traveled per Capita versus Residential Density for Baltimore Neighborhoods
Source: Baltimore Metropolitan Council, 2001 Travel Survey.

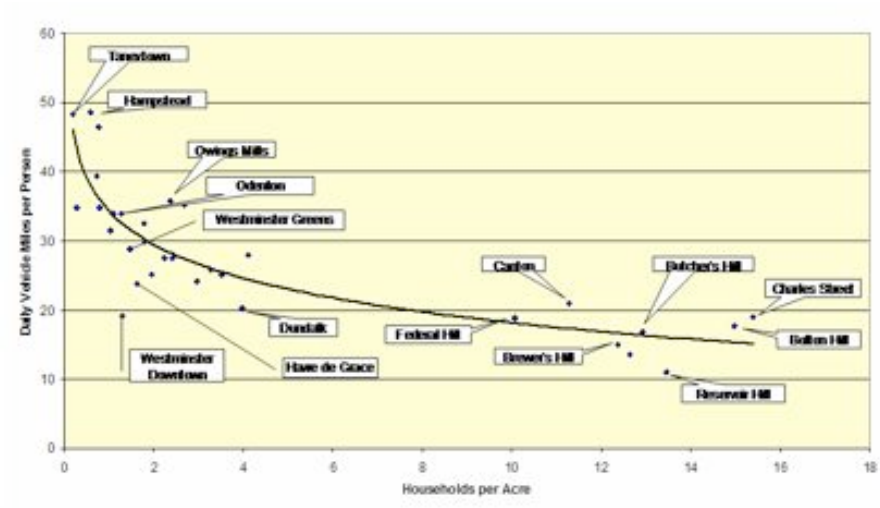
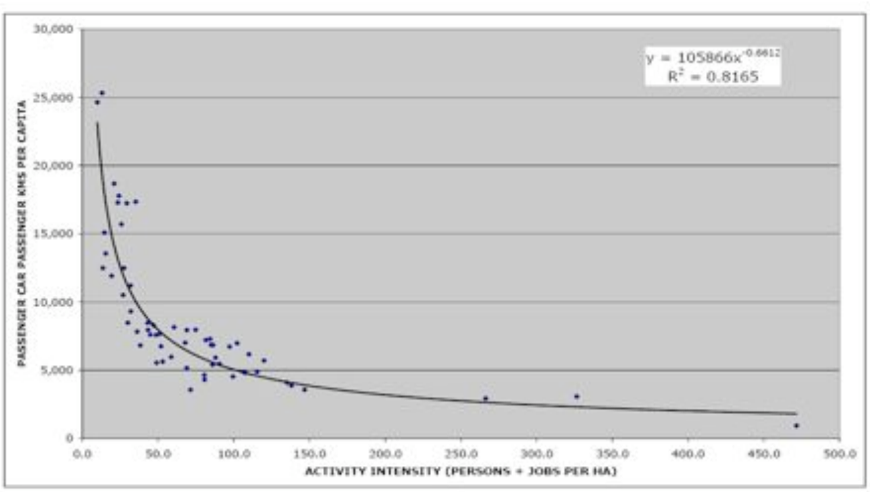


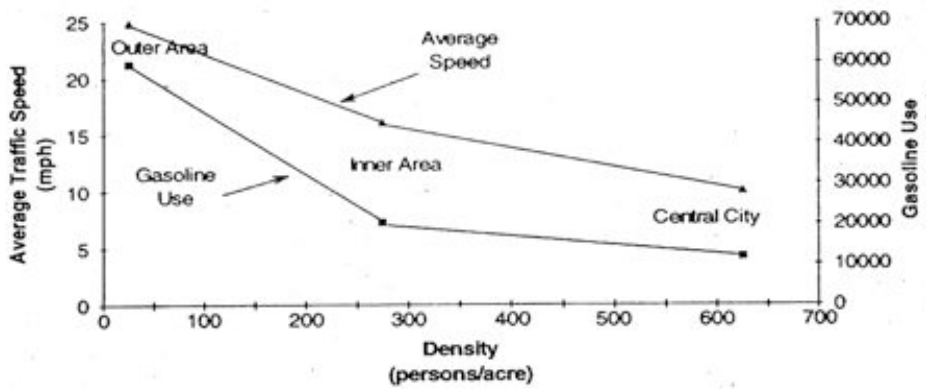
Figure 3-3 Vehicle Kilometers Traveled per Capita versus Activity Intensity for 58 Higher- *Income Cities Source: Newman and Kenworthy 2006.*



Four facts, however, preclude broad generalizations about urban development patterns and fuel consumption or CO_2 emissions. First, dense areas may experience more congestion and lower travel speeds than sprawling areas, hence lower vehicle fuel economy for whatever VMT they produce. Second, dense areas may have different population characteristics than sprawling areas, differences that could confound urban development and travel relationships. Third, density is only one aspect of urban form, albeit an important one. Urban sprawl is defined more broadly as any development pattern in which homes, workplaces, stores, schools, and other activities are widely separated from one another. Fourth, any relationships that appear in aggregate statistics for neighborhoods, cities, or metropolitan areas would not necessarily apply to individual households, the ultimate travel decision makers.[20]

In a paper entitled "The Transport Energy Trade-Off: Fuel-Efficient Traffic versus Fuel-Efficient Cities," Newman and Kenworthy (1988) addressed the first of these qualifiers. They concluded that the lower VMT in compact areas overwhelms any effect of lower vehicle fuel economy (see Figure 3-4). They subsequently substantiated this relationship for many other places (Newman 2006; Newman and Kenworthy 2006, 2007).

Figure 3-4. Per Capita Gasoline Consumption in Inner and Outer Portions of the New York Metropolitan Area
Source: Newman and Kenworthy 1988.



The second qualifier is not so easily dismissed. In Figures 3-2 through 3-4, residential density is not the only characteristic that distinguishes Taneytown from Charles Street in the Baltimore metropolitan area, or one higher-income city from another, or the inner and outer areas of the New York metropolitan area. Culture, socioeconomics, demographics, transit availability, and even gas prices could account for most or all of the differences in per capita vehicle use. Critics of these early studies argued, correctly, that until these other factors were controlled, the independent effect of urban development patterns would be unknown and unknowable (Gomez-Ibanez 1991; Gordon and Richardson 1989).

Likewise, the third qualifier also is not easily dismissed. If poor accessibility is the common denominator of sprawl, then sprawl is more than low-density development. The term also encompasses scattered or leapfrog development, commercial strip development, and single-use development such as bedroom communities. In scattered or leapfrog development, residents and service providers must pass vacant land on their way from one developed area to another. In classic strip development, consumers must pass other uses on the way from one store to the next; this is the antithesis of multipurpose travel to an activity center. In a single-use development, of course, different uses are located far apart as a result of the segregation of land uses. Poor accessibility also could be a product of fragmented street networks that separate urban activities more than need be (see the photos below of sprawling development patterns).

[20] This is due to the so-called ecological fallacy. The ecological fallacy is a widely recognized error in the interpretation of statistical data, whereby inferences about individuals are based solely upon aggregate statistics for the group to which those individuals belong.

Sprawling development patterns include low-density and single-use development (top left), uncentered strip development (top right), scattered and leapfrog development (bottom left), and sparse street networks (bottom right).

The fourth qualifier has led to a host of studies using disaggregate travel data; that is, data for individuals or households. Such studies are summarized in section 3.2. For now, the focus is on aggregate relationships, where the unit of analysis is the place.

3.1.1 Measuring Urban Sprawl

Around 2000, researchers began to measure the extent of urban sprawl. Their initial attempts were crude. For example, *USA Today*—on the basis of an index presented in its February 22, 2001, issue—declared: “Los Angeles, whose legendary traffic congestion and spread-out development have epitomized suburban sprawl for decades, isn’t so sprawling after all. In fact, Portland, OR, the metropolitan area that enacted the nation’s toughest antigrowth laws, sprawls more.” Indeed, according to *USA Today*’s index, even the New York metropolitan area sprawls more than Los Angeles (Nasser and Overberg 2001).

The most notable feature of these early studies was their failure to define sprawl in all its complexity. Population density is relatively easy to measure, and hence served as the sole indicator of sprawl in several studies. Judged in terms of average population density, Los Angeles looks compact; it is the endless, uniform character of the city's density that makes it seem so sprawling. Another notable feature of these studies was the wildly different sprawl ratings given to different metropolitan areas by different analysts. With the exception of Atlanta, which always seems to rank among the worst, the different variables used to measure sprawl led to very different results. In one study, Portland was ranked as most compact and Los Angeles was way down the list. In another, their rankings were essentially reversed.

Meanwhile, others were developing more complete measures of urban sprawl. Galster et al. (2001) characterized sprawl in eight dimensions: density, continuity, concentration, clustering, centrality, nuclearity, mixed use, and proximity. The condition—sprawl—was defined as a pattern of land use that has low levels in one or more of these dimensions. Each dimension was operationally defined, and six of the eight were quantified for 13 urbanized areas. New York and Philadelphia ranked as the least sprawling of the 13, and Atlanta and Miami as the most sprawling.

Since then, Galster and his colleagues have extended their sprawl measures to 50 metropolitan areas, and are closing in on 100. Their recent work confirms the multidimensional nature of sprawl. In one study, metropolitan areas were ranked in 14 dimensions, some related to population, others to employment, and still others to both (Cutsinger et al. 2005). The 14 dimensions were reduced to seven factors through principal components analysis. Metropolitan areas ranking near the top on one factor were likely to rank near the bottom on another. Los Angeles, for example, ranked second on both "mixed use" and "housing centrality," but 48th on "proximity" and 49th on "nuclearity." With so many variables and esoteric names, this type of analysis can get very confusing.

Building on this work, Cutsinger and Galster (2006) identified four distinct sprawllike patterns among the 50 metropolitan areas: 1) deconcentrated, dense areas; 2) leapfrog areas; 3) compact, core-dominant areas with only moderate density; and 4) dispersed areas. Since none of the 50 metropolitan areas exhibited uniform sprawllike patterns in all dimensions, the authors judged it incorrect to treat sprawl as a single phenomenon.

Multidimensional sprawl indices also were developed for the U.S. EPA and Smart Growth America. They defined sprawl as any environment with 1) a population widely dispersed in low-density residential development; 2) a rigid separation of homes, shops, and workplaces; 3) a lack of major employment and population concentrations downtown and in suburban town centers and other activity centers; and 4) a network of roads marked by very large block size and poor access from one place to another. These indices were used to measure sprawl for 83 of the nation's largest metropolitan areas (Ewing, Pendall, and Chen 2002, 2003).

Principal components analysis was used to reduce 22 land use and street network variables to four factors representing these four dimensions of sprawl, each factor being a linear combination of the underlying operational variables.[21] The four factors represent a balanced scorecard of sprawl indicators. "Density" and "mix," while correlated, are very different constructs, as are "centeredness" and "street accessibility." The four factors were combined into an overall metropolitan sprawl index.

A simpler county sprawl index also was developed to measure the built environment at a finer geographic scale, the individual county. This index is a linear combination of six variables from the larger set, these six being available for counties, whereas many of the larger set were available only for metropolitan areas.[22] Initially calculated for 448 metropolitan counties (McCann and Ewing 2003), the index is now available for 954 metropolitan counties or county equivalents representing 82 percent of the nation's population (Ewing, Brownson, and Berrigan 2006).

All sprawl indices were standardized, with mean values of 100 and standard deviations of 25. The way the indices were constructed, the bigger the value of the index, the more compact the metropolitan area or county; the smaller the value, the more sprawling the metropolitan area or county. Thus, in the year 2000, the New York metropolitan statistical area had an index value of 178, while Atlanta had a value of 58. Manhattan had an index value of 352, while Geauga County (outside Cleveland) had a value of 63 (see photographs below).

[21] "Residential density" was defined in terms of gross and net densities and proportions of the population living at different densities; seven variables made up the metropolitan density factor. "Land use mix" was defined in terms of the degree to which land uses are mixed and balanced within subareas of the region; six variables made up this factor. "Degree of centering" was defined as the extent to which development is focused on the region's core and regional subcenters; six variables made up this factor. "Street accessibility" was defined in terms of the length and size of blocks; three variables made up this factor.

[22] The six variables are as follows: 1) gross population density (persons per square mile); 2) percentage of the county population living at low suburban densities, specifically, densities between 101 and 1,499 persons per square mile, corresponding to less than one housing unit per acre; 3) percentage of the county population living at moderate to high urban densities, specifically, more than 12,500 persons per square mile, corresponding to about eight housing units per acre, the lower limit of density needed to support mass transit; 4) the net density in urban areas, which was derived from the estimated urban land area for each county; 5) average block size; and 6) percentage of blocks with areas less than 1/100 of a square mile, the size of a typical traditional urban block bounded by sides just over 500 feet in length.

Satellite photographs show the nation's most compact county—New York County, also known as Manhattan—at left and its most sprawling county—Geauga County, Ohio—at right. Both photographs are presented at the same scale.
Source: www.maps.google.com

3.1.2 Relating Urban Sprawl to Travel Outcomes

The study for the EPA and Smart Growth America analyzed relationships between sprawl and various travel outcomes. The overall sprawl index showed strong and statistically significant relationships to six outcome variables. All relationships were in the expected directions. As the index increases (that is, as sprawl decreases), average vehicle ownership, daily VMT per capita, the annual traffic fatality rate, and the maximum ozone level decrease to a significant degree. At the same time, shares of work trips by transit and walk modes increase to a significant degree.

The significance of these relationships rivaled or, in some cases, actually exceeded that of the sociodemographic control variables. The index was the only variable that rose to the level of statistical significance for walk share of work trips and maximum ozone level, and had the strongest association to daily VMT per capita and the annual traffic fatality rate. It had secondary, but still highly significant, associations with average vehicle ownership and transit share of work trips.

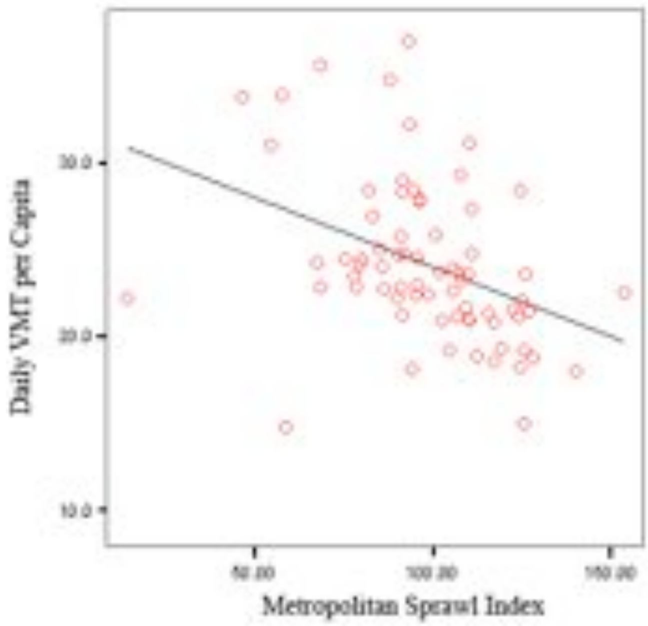
Obviously, these relationships are not independent of each other. The lower level of vehicle ownership in dense metropolitan areas contributes to higher mode shares for alternatives to the automobile. These, in turn, contribute to lower VMT, which contributes to lower traffic fatalities and ozone levels. Because of the different data sources, units of analysis, and sample sizes, it would be treacherous to model the causal paths among these outcome variables. But, intuitively, they should be related as indicated.

3.1.3 Sprawl versus VMT

The relationship between the overall metropolitan sprawl index and VMT per capita is plotted in Figure 3-5. The simple correlation is significant. The more compact an area (the larger the index value), the lower the VMT per capita.

Figure 3-5 Simple Correlation between Daily VMT per Capita and Metropolitan Sprawl Index*
Source: Ewing, Pendall, and Chen 2002.

*Larger index values = less sprawl.



Recall that the overall sprawl index is composed of four factors: density, mix, centeredness, and street accessibility (as discussed in section 3.1.1). The density factor has the strongest and most significant relationship to travel and transportation outcomes (see Figure 3-6). It has a significant inverse relationship to average vehicle ownership, VMT per capita, traffic fatality rate, and maximum ozone level, and a significant direct relationship to public transportation and walk shares of commute trips. With the exception of the traffic fatality rate, all relationships are significant at the 0.01 probability level or beyond.

To illustrate the strength of density relationships, a 50-unit increase in the density factor (from one standard deviation below average to one standard deviation above average) is associated with a drop of 10.75 daily VMT per capita (50 x –0.215). That is, controlling for metropolitan population, per capita income, and other factors, the difference between low- and high-density metropolitan areas is more than 10 VMT per capita per day, or 40 percent. Fifty units is roughly the difference in density between San Francisco (denser) and Washington, D.C. (less dense), or between Chicago (denser) and St. Louis (less dense).

The centeredness factor has the next most significant environmental influence on travel and transportation outcomes. It is inversely related to annual delay per capita and traffic fatality rate, and is directly related to public transportation and walk shares of commute trips. These associations are in addition to—and independent of—those of density, which is controlled in the same equations.

The relationship between degree of centering and VMT per capita is just short of significant at the 0.05 level. A 50-unit increase in the centeredness factor (from one standard deviation below the average to one standard deviation above) is associated with a 2.3 daily VMT per capita (50 x –0.0462), about one-quarter the change associated with the density factor. The two effects are additive. Fifty units is roughly the difference in degree of centering between New York (more centered) and Philadelphia (less centered), or between Portland (more centered) and Los Angeles (less centered).

Figure 3-6 Transportation Outcomes versus Sprawl Factors*
Source: Ewing, Pendall, and Chen 2002

	Transportation Outcomes							
	Vehicles per Household	***Transit Share of WorkTrips***	***Walk Share of WorkTrips***	***Mean Travel Time to Work***	***Annual Delay per Capita***	***VMT per Capita***	***Fatalities per 10,0000 Population***	***Peak Ozone Level***
Density factor	– –	++	++			– –	–	– –
Mix factor				–			–	+
Centers factor	– –	++	++	–	–	–	–	–
Streets factor				++	++			
Metro population		+		++	+			++
Average household size	+			++	++			
Percentage of working age	++				++	+		
Per capita income		++		++			–	
Adjusted R^2	0.56	0.67	0.36	0.61	0.63	0.28	0.44	0.40

*+ indicates a positive relationship significant at the 0.05 probability level; ++ a positive relationship significant at the 0.01 probability level; – a negative relationship significant at the 0.05 probability level; and – – a negative relationship significant at the 0.01 probability level.

The mix factor is significant for only three transportation outcomes: as a mitigating influence on travel time to work and fatal accidents and an aggravating influence on the maximum ozone level. The big surprise is that land use mix does not significantly affect other outcomes, including VMT per capita. It may be that land use mix has not been successfully operationalized because of problems with the underlying data sets (Ewing, Pendall, and Chen 2002).

The streets factor is significant for two transportation outcomes, albeit just barely and with unexpected signs. Average travel time for commute trips and annual traffic delay per capita are directly related to the streets factor. Perhaps the reason for this counterintuitive result is that the additional intersections in metro areas with dense street grids translate into more total delay, since most delays occur at intersections rather than on the stretches between them. This is the conventional wisdom among traffic engineers. In any case, street patterns appear to be much less important than land use patterns as correlates of travel and transportation outcomes.

3.1.4 Sprawl versus Congestion

It has been argued that the dispersal of jobs and housing allows residents to live closer to their workplaces than they could if jobs were concentrated in downtown and other centers. It also has been argued that the dispersal of jobs and housing eases traffic congestion by dispersing origins and destinations. These effects, if dominant, would lead to shorter trips and less congestion in sprawling metro areas. But the dispersal of jobs and housing also may result in jobs/housing imbalances across the region, cross commuting, and significantly more VMT per capita than with more compact urban development. The average commute has been getting steadily longer in miles and minutes (Hu and Reuscher 2004). The net effect of sprawl on traffic congestion is unclear a priori.

Evidence from aggregate travel studies suggests that density aggravates congestion, but not much. One study found that congestion rises with population density for counties in California (Boarnet, Kim, and Parkany 1998). Urbanized counties as a group are more congested than rural counties. However, this same study found “surprisingly congested counties that are either rural or on the fringe of urban areas.” These fringe counties generate a lot of VMT. We reanalyzed congestion data from that study and, excluding one outlier, computed an elasticity of congestion with respect to density of 0.14.

Another study found little relationship between density and commute time in the largest urban areas (Gordon, Kumar, and Richardson 1989). “Travel times may be long in high- or low-density cities (e.g., New York or Houston) or short (e.g., Los Angeles or Dallas).” Basically, shorter trips and mode shifts in dense areas largely offset any effect of lower speeds.

The Texas Transportation Institute’s Urban Mobility database for 85 urbanized areas also shows a weak relationship between density and congestion (Schrank and Lomax 2005). TTI measures congestion in terms of a travel time index; that is, the ratio of travel time in the peak period to travel time at free-flow conditions. A value of 1.35 indicates that a 20-minute free-flow trip takes, on average, 27 minutes in the peak period. In a cross-sectional analysis for 2003, the last year in the series, the elasticity of travel time with respect to population density is 0.085. This elasticity estimate controls for population size because bigger cities have more congestion regardless of their urban form. In a longitudinal analysis for the same 85 urbanized areas using the full TTI data series (1982 to 2003), the elasticity of change in travel time with respect to change in density is 0.107. This elasticity estimate controls for population growth because fast-growing areas have more congestion regardless of how they grow.

Such studies have been criticized for focusing on only one dimension of sprawl: “Other land use dimensions are less well studied in a comparative framework . . . while it is believed that land use patterns may play an important role in mitigating or slowing the growth of congestion in urban areas, few studies have explored the relationship between land use and congestion across more than a small number of urban areas or examined multiple measures of land use beyond population density” (Sarzynski et al. 2006).

In the Smart Growth America study, sprawl factors pulled in opposite directions (Ewing, Pendall, and Chen 2002, 2003). The overall sprawl index was not significantly related to either average commute time or annual traffic delay per capita. Both outcomes were a function primarily of metropolitan area population, and secondarily of other sociodemographic variables. Big metro areas generate longer trips to work and higher levels of traffic congestion. After controlling for population size and other sociodemographic variables, sprawl (overall) did not appear to have an effect on average commute time or annual traffic delay per capita.

Using the same overall metropolitan sprawl index as Ewing, Pendall, and Chen (2002), Kahn (2006) divided metropolitan areas into four categories and found that, relative to workers in compact metro areas, workers in sprawling ones commute an extra 1.8 miles each way. But their commute is still 4.3 minutes shorter; the extra commute distance is more than offset by higher travel speeds. Indeed, commute speed is estimated to be 9.5 mile per hour higher in the sprawling metro areas.

Why is there a difference in the sprawl/commute time relationship between two studies that test the same overall sprawl index? The first study uses U.S. Census commute data, the second American Housing Survey commute data. The first study treats sprawl as a continuous variable, the second as a categorical variable. Whatever their differences, both studies suggest higher VMT in sprawling metro areas than in compact ones.

Another recent study, by Galster and colleagues, related seven dimensions of sprawl to traffic congestion for 50 large metropolitan areas in 2000 (Sarzynski et al. 2006). Controlling for 1990 levels of congestion and changes in an urban area's transportation network and relevant demographics, the study found that density and housing centrality were positively related to year 2000 delay per capita and that housing/job proximity was negatively related to year 2000 commute time.

Differences between this and earlier studies may be due to the use of a lagged model structure, different land use measures, or a different sample of metropolitan areas. Since Sarzynski et al. were unable to study the effect of land use changes between 1990 and 2000 (for lack of sprawl indices for 2000), it is hard to interpret the coefficients of a lagged model. Relationships to delay could be bogus in all of these studies, since the delay measure used by everyone comes from the Texas Transportation Institute and is imputed rather than actually measured in the field. Considering all the evidence from aggregate travel studies, it is reasonable to assume some drop in average travel speeds with rising density. From this literature, we cannot draw any conclusions about travel speeds versus land use mix or other dimensions of sprawl.

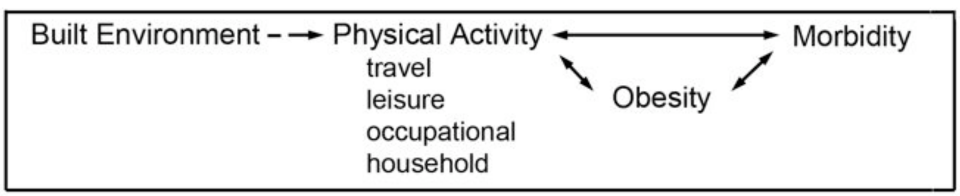
3.2 Disaggregate Travel Studies

Land use/travel studies date from the early 1960s, when urban density was first shown to affect auto ownership, trip rates, and travel mode shares. Around 1990, researchers began to use disaggregate travel data for individuals or households; made some effort to control for other influences on travel behavior, particularly the socioeconomic status of travelers; and tested a wider variety of local land use variables than had earlier studies.

The relationship between urban development patterns and individual or household travel has become the most heavily researched subject in urban planning. There are now close to 100 empirical studies conducted with a degree of rigor—that is, with decent sample sizes, sociodemographic controls, and statistical tests to determine the significance of the various effects (see literature reviews by Badoe and Miller (2000); Crane (2000); Ewing and Cervero (2001); Saelens, Sallis, and Frank (2003); and Heath et al. (2006)). The vast majority of these studies show significant relationships between development patterns and travel behavior. Today, only the direction of causality and strength of effects seems to be seriously debated.

When funding from public health sources became available after 2000, planning researchers morphed into physical activity researchers, and the literature grew even further (see reviews by Frank (2000), Frank and Engelke (2001, 2005), Lee and Moudon (2004), Owen et al. (2004), Badland and Schofield (2005), and Handy (2006)). Both types of physical activity—for transportation and for exercise—were studied together for the first time, and the physical environment was measured comprehensively in terms of development patterns and physical activity settings (see Figure 3-7). Again, nearly all studies show significant relationships. And, again, the debate is mainly over the direction of causality and effect sizes. A special Winter 2006 issue of the *Journal of the American Planning Association* was devoted to this new research.

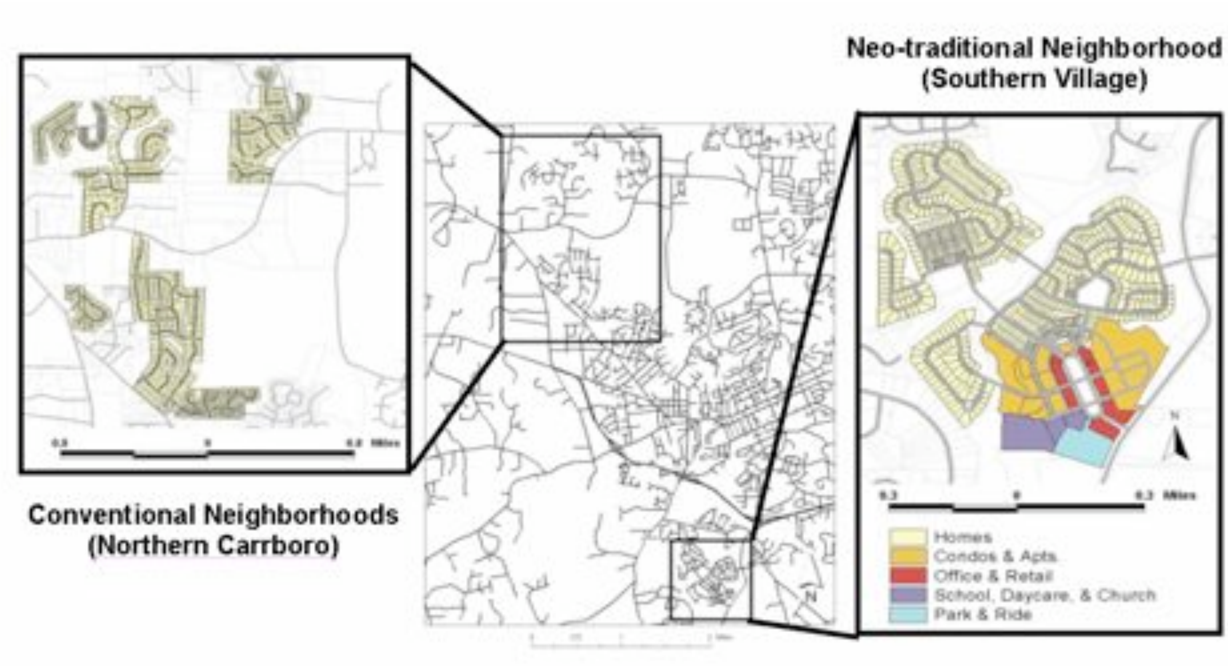
Figure 3-7 Causal Pathways Linking the Built Environment to Health
Source: Ewing et al. 2003.



3.2.1 Accessibility Again

The concept of sprawl seems particularly tailored to large areas such as metropolitan areas and their component counties. The degree to which employment is concentrated in central business districts or suburban centers, for example, is a characteristic of an entire metro area, not of an individual community or neighborhood. Yet there are analogous measures for subareas as small as neighborhoods (see Figure 3-8), and these analogous measures have been studied in depth for their relationships to trip frequency, trip distance, and mode choice.

Figure 3-8 Neighborhoods with Different Designs and Travel Characteristics in Chapel Hill, North Carolina
Source: Khattak and Rodriquez 2005.



Accessibility influences the way household needs are met through travel. Two types of accessibility have been shown to be significant. One is ease of access to activities from one's place of residence, the other ease of access to activities from other activities.

Residential accessibility affects the destination, mode and, arguably, even the frequency of home-based trips. It has been the focus of nearly all travel and physical activity research. However, the relevant environment for many trips is someplace other than home. Non–home based trips account for 25 to 30 percent of trips in most urban areas, and the percentage is growing as people's complex lives cause them to link trips into complex tours.

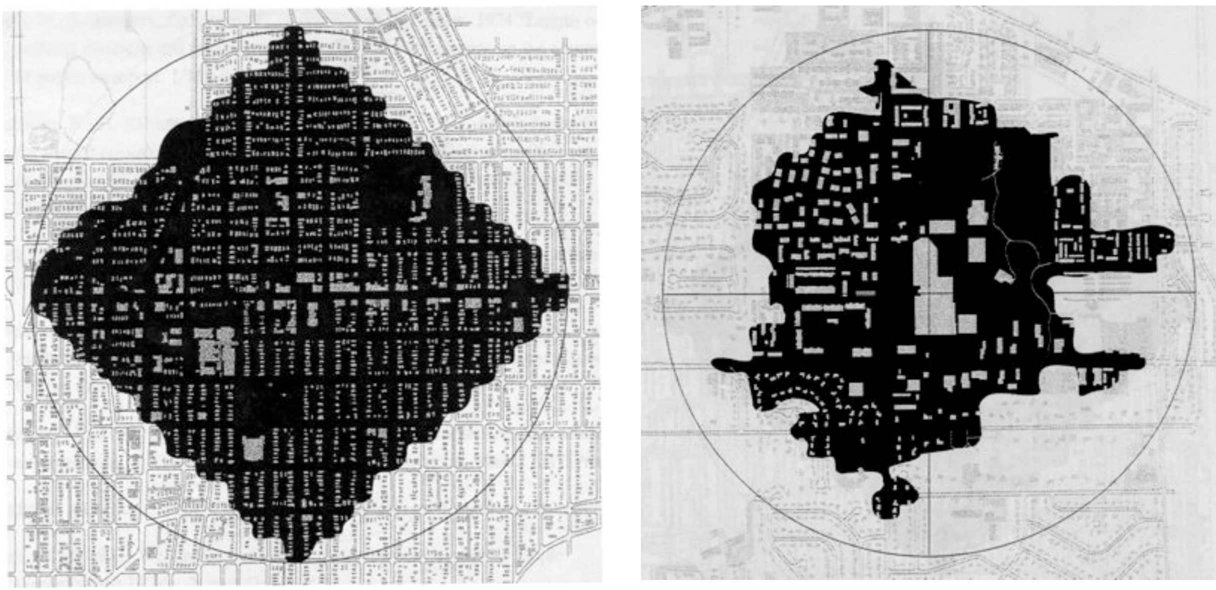
Trip chaining, or the linking of trips into tours, has been increasing over time (Levinson and Kumar 1995; McGuckin, Zmud, and Nakamoto 2005). Trips are more likely to be linked into long tours in areas of poor residential accessibility, simply because this is a way for households living in sprawl to economize on travel (Ewing, Haliyur, and Page 1994; Ewing 1995; Krizek 2003; Limanond and Niemeier 2004; Noland and Thomas 2006). The more sprawling the area, the more important it becomes to concentrate common destinations in centers, so a single auto trip can meet multiple needs. Conservatively, the ability to link trips in tours cuts overall household travel by 15 to 22 percent relative to separate trips for the same purposes (Oster 1978).

3.2.2 Measuring the Five Ds

In travel research, urban development patterns have come to be characterized by "D" variables. The original "three Ds," coined by Cervero and Kockelman (1997), are density, diversity, and design. The Ds have multiplied since then, with the addition of destination accessibility and distance to transit. If we could think of an appropriate label, parking supply and cost might be characterized as a sixth D.

Density usually is measured in terms of persons, jobs, or dwellings per unit area. Diversity refers to land use mix. It often is related to the number of different land uses in an area and the degree to which they are "balanced" in land area, floor area, or employment. Design includes street network characteristics within a neighborhood (see Figure 3-9). Street networks vary from dense urban grids of highly interconnected, straight streets to sparse suburban networks of curving streets forming "loops and lollipops." Street accessibility usually is measured in terms of average block size, proportion of four-way intersections, or number of intersections per square mile. Design also is measured in terms of sidewalk coverage, building setbacks, streets widths, pedestrian crossings, presence of street trees, and a host of other physical variables that differentiate pedestrian-oriented environments from auto-oriented ones.

Figure 3-9 Destinations within One-Quarter Mile of Center for Contrasting Street Networks in Seattle
Source: Moudon et al. 1997.



Destination accessibility is measured in terms of the number of jobs or other attractions reachable within a given travel time, which tends to be highest at central locations and lowest at peripheral ones. Distance to transit usually is measured from home or work to the nearest rail station or bus stop by the shortest street route.

3.2.3 D Variables versus VMT and VT

The D variables have a significant effect on the overall VMT and VT of individuals and households, mostly through their effect on the distance people travel and the modes of travel they choose (Ewing and Cervero 2001). Trip frequencies appear to be primarily a function of travelers' socioeconomic and demographic characteristics and secondarily a function of the built environment; trip lengths are primarily a function of the built environment and secondarily of socioeconomic and demographic characteristics; and mode choices depend on both, though probably more on socioeconomics.

Trip lengths are generally shorter at locations that are more accessible, have higher densities, or feature mixed uses. This holds true for both the home end (that is, residential neighborhoods) and nonhome end (activity centers) of trips. Alternatives to the automobile claim a larger share of all trips at higher densities and in mixed-use areas. Walk mode shares can rise to 20 percent or more in mixed-use neighborhoods even without high-quality transit service (see Figure 3-10).

These studies indicate that transit use varies primarily with local densities and secondarily with the degree of land use mixing (see Figure 3-11). Some of the density effect is, no doubt, due to shorter distances to transit service. Walking varies as much with the degree of land use mixing as with local densities (see Figure 3-12). An unresolved issue is whether the relationship of density to travel behavior is due to density itself or to other variables with which density co-varies, such as good transit service, limited parking, and so forth.

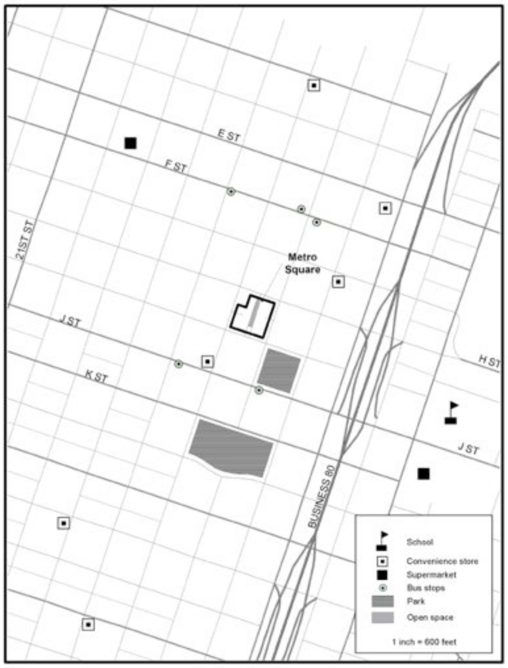


Figure 3-10 Built Environment and Mode Shares of Metro Square in Sacramento, California
Source: NRDC 2000.

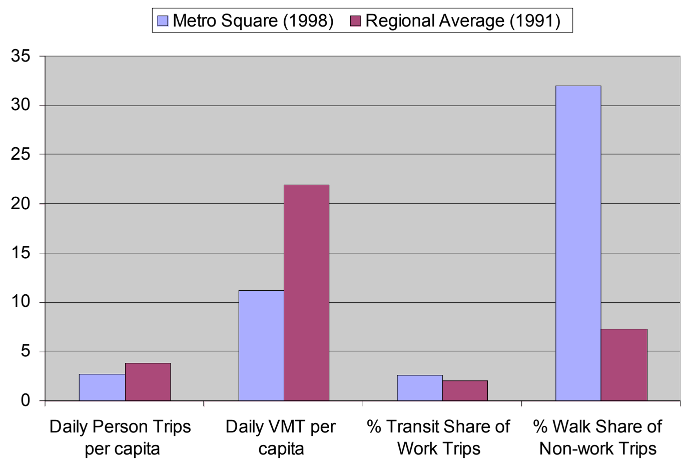
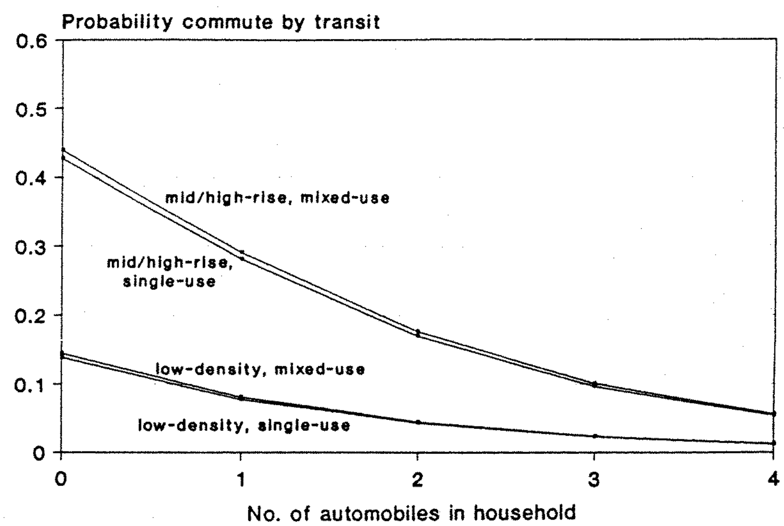


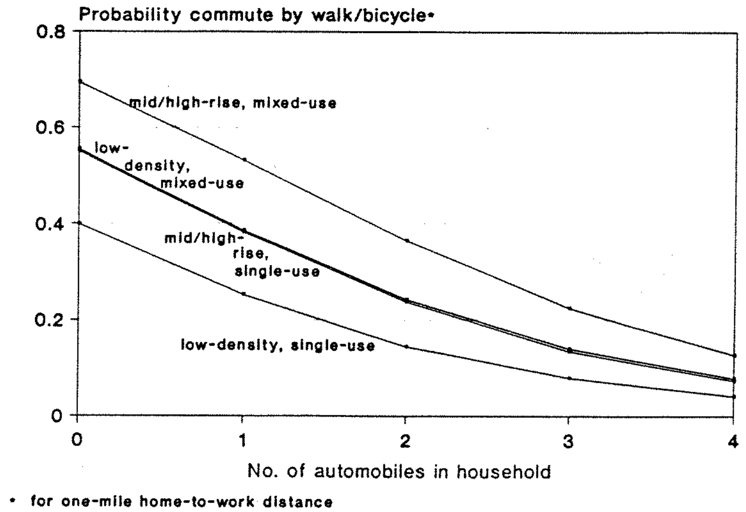
Figure 3-11 Effects of Density and Mixed Use on Choice of Transit for Commutes*
Source: Cervero 1996.



*Data for more than 45,000 U.S. households showed transit use primarily dependent on density of development. At higher densities, the addition of retail uses in neighborhoods was associated with several percentage point higher levels of transit commuting across 11 U.S. metropolitan areas.

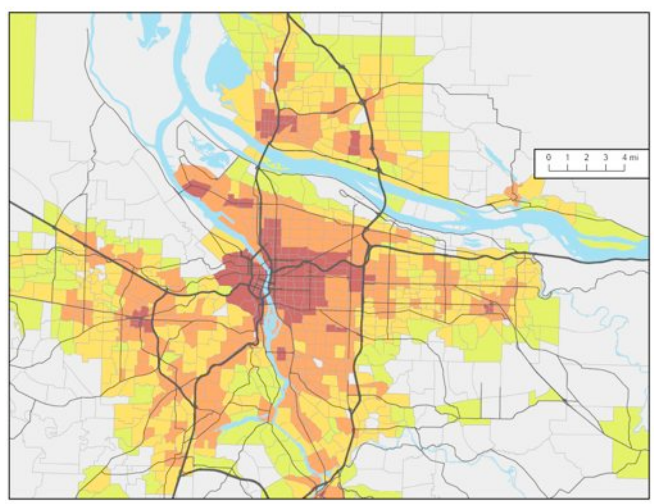
Figure 3-12 Effects of Density and Mixed Use on Choice of Walk/Bike for Commutes*
Source: Cervero 1996.

*Rates of walk and bicycle trips (for a one-mile home-to-work trip) are comparable for low-density, mixed-use neighborhoods as compared with high-density, single-use ones, controlling for vehicle ownership levels.



The third D—design—has a more ambiguous relationship to travel behavior than do the first two. Any effect is likely to be a collective one involving multiple design features. It also may be an interactive effect involving land use and transportation variables. This is the idea behind composite measures such as Portland, Oregon's "pedestrian environment factor" and Montgomery County, Maryland's "transit serviceability index" (see Figure 3-13). Portland's pedestrian environment factor is the sum of four variables related to 1) ease of street crossing, 2) sidewalk continuity, 3) street network connectivity, and 4) topography. Because of the subjective nature of these variables, the pedestrian environment factor has been replaced with an "urban design factor," which is a function of intersection density, residential density, and employment density.

Figure 3-13 Values of the Urban Design Factor across the Portland Metropolitan Area
Source: Portland Metro.



For 14 carefully controlled travel studies, Ewing and Cervero (2001) synthesized the literature by computing elasticities of VMT and VT with respect to the first four Ds—density, diversity, design, and destination accessibility. These summary measures were incorporated into the EPA's Smart Growth Index (SGI) model, a widely used sketch planning tool for travel and air quality analysis. In the SGI model, density is measured in terms of residents plus jobs per square mile; diversity in terms of the ratio of jobs to residents relative to the regional average; and design in terms of street network density, sidewalk coverage, and route directness (two of three measures relating to street network design). These are just a few of the many ways in which the 3Ds have been operationalized at the neighborhood level (see literature review, Ewing and Cervero 2001).

Figure 3-14 presents elasticities of VT and VMT with respect to the four Ds. An elasticity is a percentage change in one variable with respect to a 1 percent change in another variable. Hence, from the elasticities presented in Figure 3-14, we would expect a doubling of neighborhood density to result in approximately a 5 percent reduction in both VT and VMT, all other things being equal. The effects of the four Ds captured in this table are cumulative. Doubling all four Ds would be expected to reduce VMT by about one-third. Note that the elasticity of VMT with respect to destination accessibility is as large as the other three combined, suggesting that areas of high accessibility—such as center cities—may produce substantially lower VMT than dense mixed-use developments in the exurbs.

Figure 3-14 Typical Elasticities of Travel with Respect to the Four Ds
Source: Ewing and Cervero 2001.

	Vehicle Trips (VT)	Vehicle Miles Traveled (VMT)
Local Density	– .05	– .05
Local Diversity (Mix)	– .03	– .05
Local Design	– .05	– .03
Regional Accessibility	– –	– .20

3.2.4 Meta-Analysis of Disaggregate Travel Studies

Since Ewing and Cervero's 2001 literature review, the published literature on the built environment and travel has mushroomed. A more recent review identified 40 published studies of the built environment and travel, and selected 17 that met minimum methodological and statistical criteria (Leck 2006). While the analysis stopped short of estimating average effect sizes, it did evaluate the statistical significance of relationships between the built environment and travel. Residential density, employment density, and land use mix were found to be inversely related to VMT at the $p < 0.001$ significance level.

The number of rigorous studies now exceeds 100, including studies examining four or five D variables at once, studies comparing travel behavior across nations, studies focusing on children, and studies accounting for residential preferences that may confound results. The EPA is funding a full-blown meta-study of this ever-expanding literature, which will summarize the most pertinent literature qualitatively and, using standard methods of meta-analysis, will combine individual study results into average elasticities or percentage point adjustments of VMT, VT, and transit use and walking with respect to the D variables. Confidence intervals will be computed for the average values. These summary measures will become available for sketch planning applications.

3.3 Regional Growth Simulations

In the "old days," metropolitan planning organizations (MPOs) developed their plans by testing different transportation alternatives against a single future land use forecast. One alternative might have more highways, another more transit or a new beltway or more arterial street improvements. But future land use patterns were always assumed to be fixed.

Future land use projections typically were extrapolations of recent trends, assumed to be unaffected by additions to urban infrastructure, most importantly by transportation improvements. In other words, future land use patterns were treated as fixed inputs into the analysis, not as variables or possible outcomes.

All that changed in the early 1990s with the advent of regional scenario planning, which matches alternative land use plans with alternative transportation plans. These plans are run through simulation models to project impacts on VMT, land consumption rates, air pollutant emission levels, housing affordability indexes, and other outcome measures. In theory, the most cost-effective plan is adopted.

3.3.1 The Rise of Scenario Planning

Scenario planning got a major boost from the well-publicized success of Portland, Oregon's Land Use, Transportation, Air Quality (LUTRAQ) study, which called for combining light-rail investments with transit-oriented development and travel demand management policies (1000 Friends of Oregon 1997). Portland Metro, the regional government, turned down a proposed western bypass beltway in favor of the LUTRAQ plan when regional travel forecasts showed the LUTRAQ alternative would produce significantly fewer VMT and lower levels of congestion than would trend development with the new freeway (see Figure 3-15).

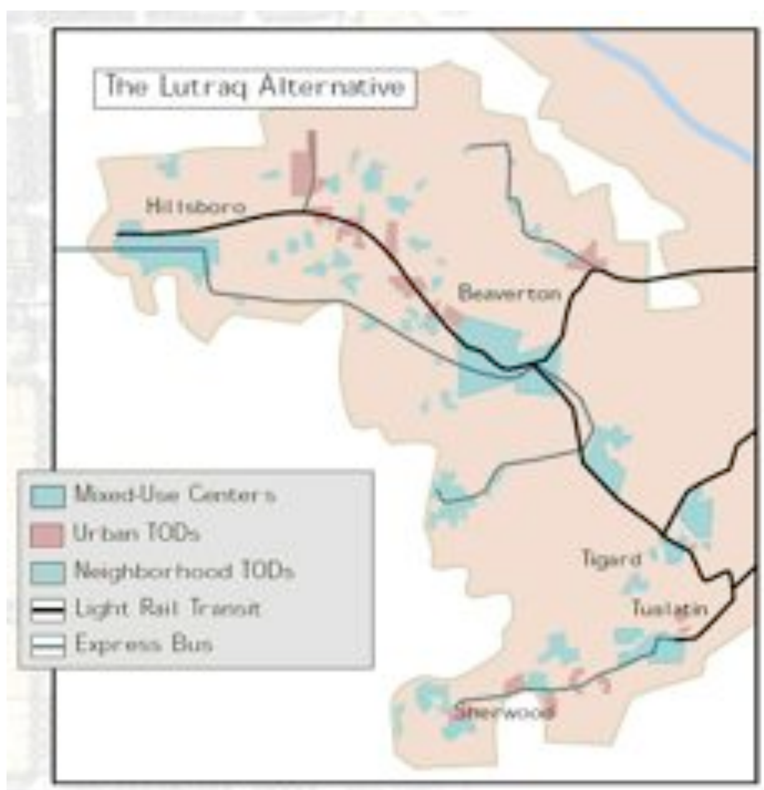
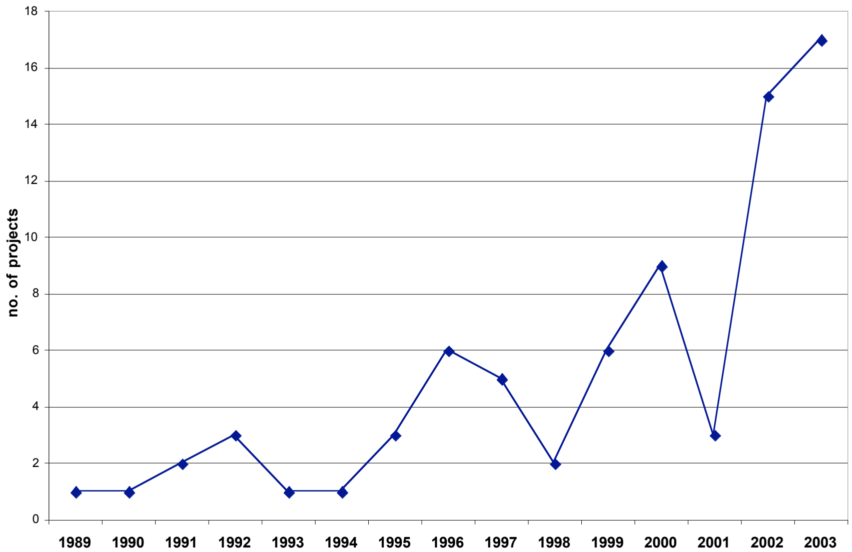


Figure 3-15 The LUTRAQ Plan for the Western Portland Metro
Source: 1000 Friends of Oregon 1997.

The number of scenario planning studies undertaken in the United States has grown dramatically since LUTRAQ (see Figure 3-16). Regional scenario planning has transitioned from state-of-the-art to state-of-the-practice at MPOs (Ewing 2007). Such studies also have become common outside the United States (Johnston 2006). In fact, many advances in integrated land use/transportation modeling have come from outside the United States.

Figure 3-16 Number of Scenario Planning Projects by Completion Date
Source: Bartholomew 2007.



3.3.2 The Scenario Planning Process

The typical scenario planning process compares a "trend" scenario to one or more alternative future "planning" scenarios. In the trend scenario, urban development and transportation investment patterns of the recent past are assumed to continue through the planning horizon (20 to 50 years in the future). The trend scenario—usually some version of urban sprawl—is assessed for its impacts on VMT and other regional outcomes.

This is followed by the formulation of one or more alternative futures that vary with respect to land use and transportation. Compared to the trend scenario, the planning alternatives usually have higher gross densities, mix land uses to a greater extent, and/or channel more development into urban centers. They may incorporate a variety of transportation infrastructure investments and pricing policies. One alternative may invest more in transit lines, another might invest more in high-occupancy-vehicle (HOV) lanes.

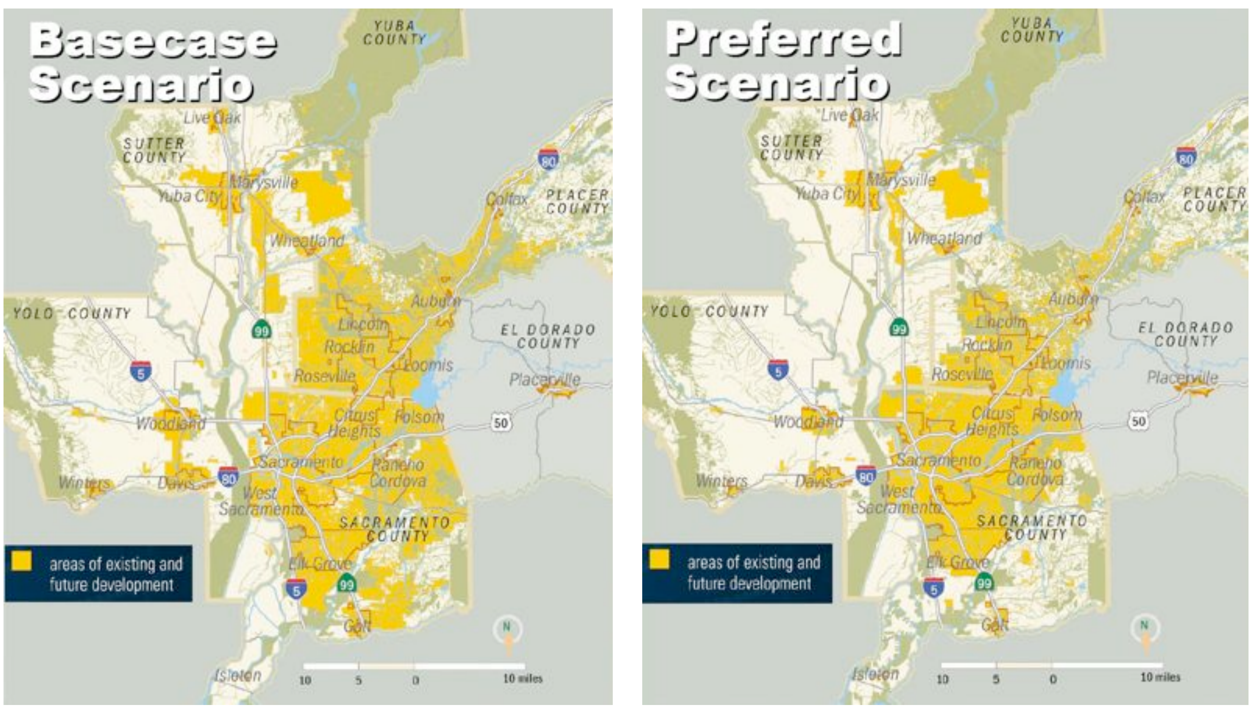
These alternative scenarios are then assessed for their impacts using the same travel forecasting models and same set of outcome measures as with the trend scenario. Vehicle miles traveled is almost always among the outcomes forecasted. The resulting comparison of scenarios can provide the basis for rational urban policy development.

3.3.3 Case Study: The Sacramento Region Blueprint Study

A leading example of scenario planning technique comes from the Sacramento region. Concerned about dispersed future growth patterns, housing, transportation, and air quality, the Sacramento Area Council of Governments initiated the Sacramento Region Blueprint Transportation–Land Use Study to craft a future growth strategy for the region (SACOG undated). Scenarios were constructed through a bottom-up process, starting at the neighborhood level. At a series of 25 neighborhood workshops, citizen participants were shown future “business as usual” development scenarios for their neighborhoods. Participants then were asked to develop a series of smart growth alternative scenarios, which were fed into a geographic information systems (GIS) modeling program that provided real-time assessments of each scenario’s land use and transportation impacts.

The neighborhood scenarios provided the basis for countywide scenarios. Four scenarios were crafted for each of the region’s six counties—a trend scenario plus three alternatives that combined different growth rates, land use mixes, housing types, densities, and infill/redevelopment proportions. These scenarios were analyzed for their land use and transportation impacts, creating information for several countywide workshops. The output of those workshops provided the basis for four regional-scale scenarios. Regionwide workshops then led to the creation of a fifth scenario—with a substantially smaller urban footprint than the so-called base case or trend—that ultimately was selected as the preferred option (see Figure 3-17).

Figure 3-17 Urban Footprints of Base Case and Preferred Scenarios for the Sacramento, California, Region
Source: SACOG (2005).



As illustrated in Figure 3-18, transit use and walking/bicycling increase and VMT decreases in the Sacramento region as the levels of density and infill development increase. The preferred scenario from the blueprint project is now being implemented through amendments to local government land use plans and through the region’s long-range transportation plan.

Figure 3-18 Selected Data for Scenarios from the Sacramento Region Blueprint Study
Source: SACOG (2005).

Scenarios	Single-Family: Multifamily Hou	% Housing Growth throu Infill	% Auto Trips	% Transit	% Walk/Bi	Daily VM per House
A: Business as usual (trend)	75:25	27.0	91.0	1.6	7.3	51.08
B: Higher housing densities A, with growth focused at th urban fringe	67:33	39.0	83.2	4.0	12.7	37.60
C: Higher housing densities A, with growth focused on central infill sites	65:35	38.3	81.8	4.8	13.4	36.70
D: Higher housing and employment densities, with growth focused on central in sites	64:36	44.0	79.9	4.8	15.3	35.70
Preferred Scenario	65:35	41.0	83.9	3.3	12.9	34.90

3.3.4 A Sample of Regional Scenario Studies

An open-ended survey was conducted in 2003/2004 to gather information on current and past scenario planning practices (Bartholomew 2007). The survey initially was sent to the planning directors of 658 member organizations in the National Association of Regional Councils (NARC). Additional surveys were sent to members of the Association of Metropolitan Planning Organizations that were not also NARC members. Responses to the two surveys were supplemented by hundreds of e-mails, telephone calls, and Internet searches, resulting in an initial data pool of 153 studies.

This initial pool was subjected to a threshold analysis to determine whether the studies actually used land use/transportation scenario planning techniques. The primary discriminating criterion was whether future land use inputs—such as the density, diversity, design, and destination accessibility of growth—varied across scenarios. Those that held land use patterns static were excluded from the data set. This left a total of 80 studies, spread geographically across the country. Large and fast-growing regions are overrepresented in the sample.

Most studies test three or four scenarios (including a trend scenario) that vary in density, mix, and arrangement of future land uses. Half of the studies also test alternative transportation infrastructure investments. Twelve incorporate a transportation pricing element. Three-quarters of the studies evaluate scenarios for transportation impacts; more than half for impacts on open space and resource lands; 33 for impacts on criterion air pollutants; 18 for impacts on fuel use; and ten for greenhouse gas emissions (Bartholomew 2005).

A subset of 23 studies was selected for this publication, based on three criteria: simulations conducted at the regional scale, consistent population and employment totals across the scenarios, and availability of data for all scenarios on density, population growth, and VMT. Together, these studies tested a total of 85 regional development scenarios—one trend scenario per study, plus 62 planning scenarios that could be compared to trend.

3.3.5 Differences across Scenarios

The percentage difference in regional VMT for each planning scenario, relative to its respective trend scenario, is shown in Figure 3-19. Each bar represents a different planning scenario; the value shown is the percentage difference between that scenario and the study's trend scenario. Across studies, the median reduction in regional VMT is 5.7 percent, none too impressive. However, there is wide variation in values across scenarios, from + 5.2 percent to –31.7 percent, which suggests that regional growth patterns may have a substantial impact in the best case scenario.

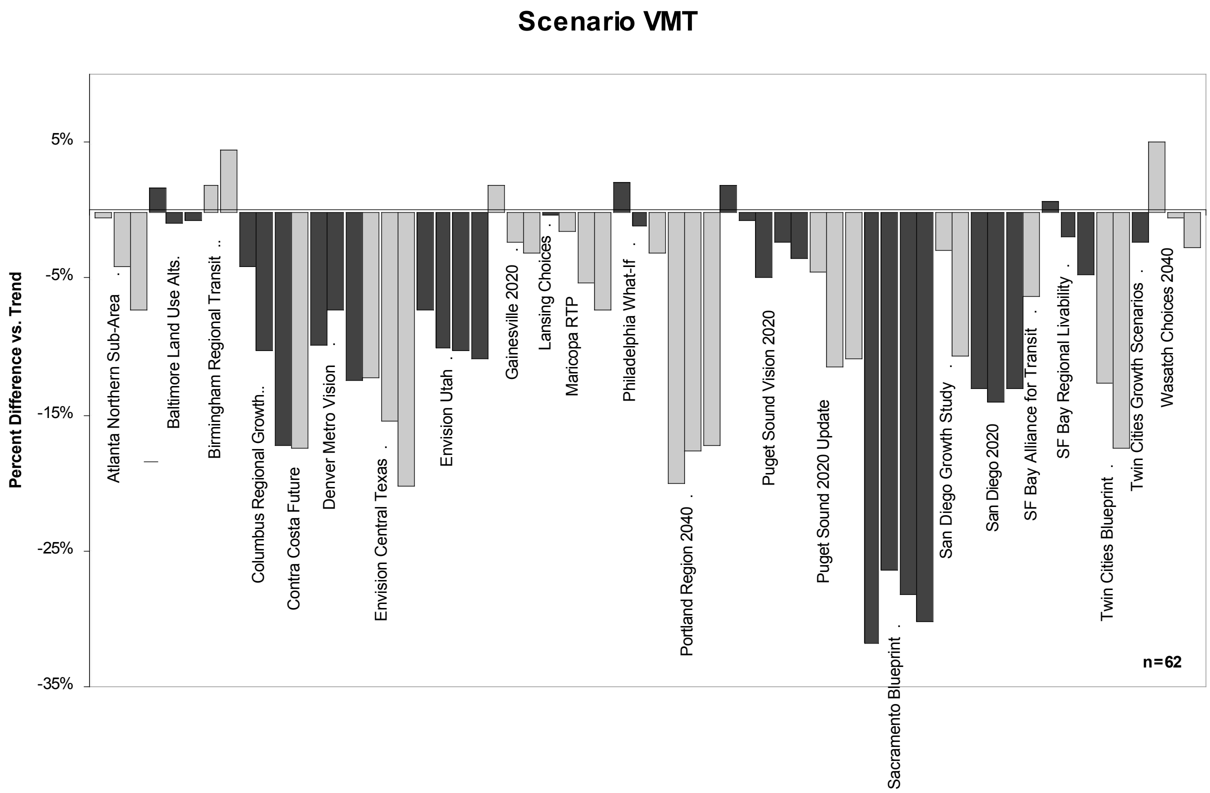
Why is there so much difference in VMT across scenarios? Bartholomew identifies many of the potential sources of variation that could be considered in a meta-analysis. These, with their presumed impact on VMT, include the following:

- nature of the scenarios (denser, more mixed, and more centered ones result in bigger VMT reductions);
- planning time horizon (longer horizons result in bigger VMT reductions);
- rate of growth (more growth that can be redirected results in bigger VMT reductions);
- reallocation of transportation dollars (higher transit investments result in bigger VMT reductions); and
- addition of travel demand management strategies (higher costs of automobile travel result in bigger VMT reductions).

While a few planning scenarios are more dispersed than trend, the great majority are more compact (see Figure 3-20). The median increase in regional density of planning scenarios over trend is 13.8 percent. Here, again, there is wide variation across scenarios, from a 14.8 percent lower density for the most dispersed scenario to a 64.3 percent higher density for the most compact scenario.

The two variables are plotted against one another in Figure 3-21. As anticipated, this simple scatter plot shows that higher scenario densities are associated with greater VMT reductions relative to the trend. The relationship appears strong and linear.

Figure 3-19 VMT Differences for 62 Scenarios Relative to the Trend Scenario*
Source: Bartholomew 2005.



*Additional information about most of these projects is available through a digital library on scenario planning maintained by the University of Utah (http://www.lib.utah.edu/digital/collections/highways/).

Figure 3-20 Scenario Densities for 62 Planning Scenarios Relative to the Trend Scenario
Source: Bartholomew 2005.

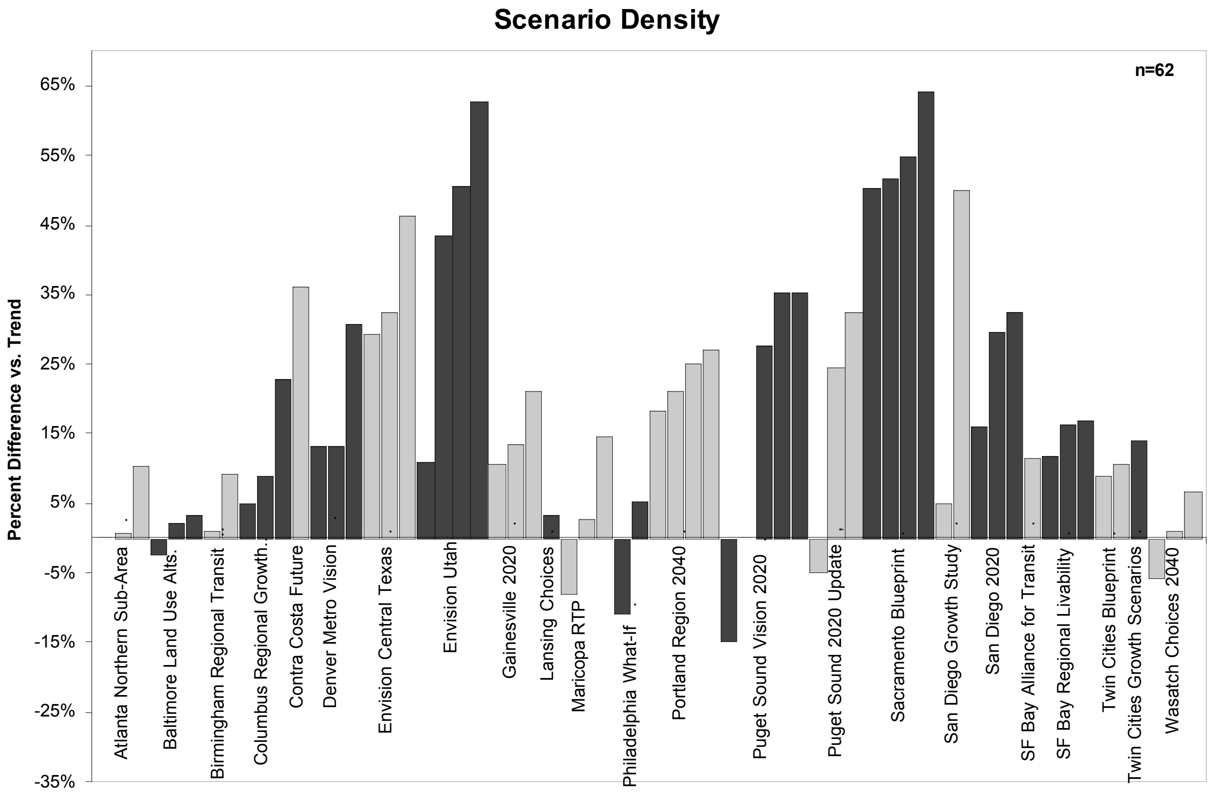
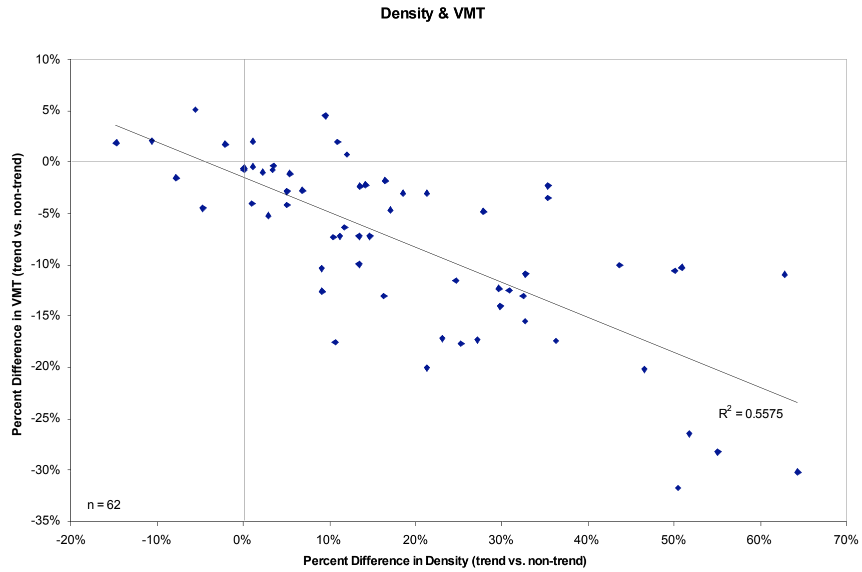
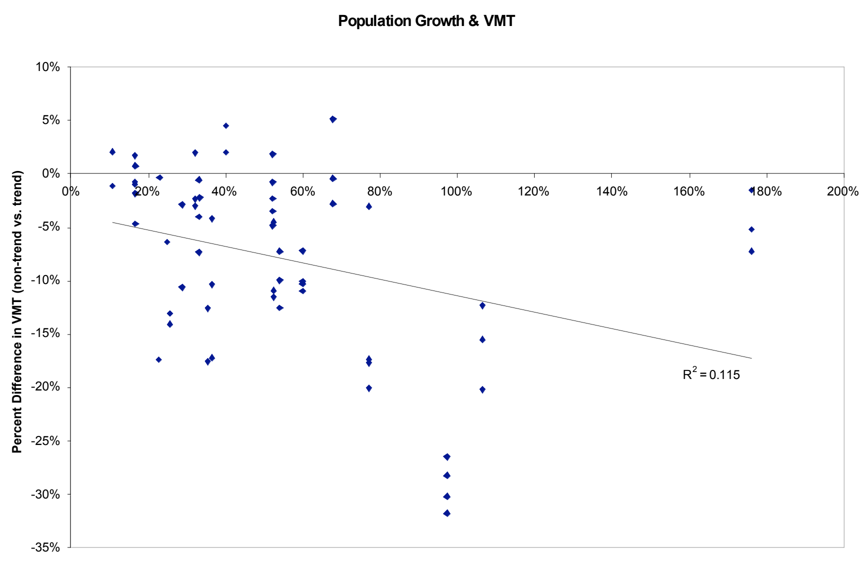


Figure 3-21 VMT versus Density for 62 Planning Scenarios Relative to the Trend
Source: Bartholomew 2005.



While much VMT reduction may be accounted for by higher densities, the scatter around the regression line in Figure 3.21 suggests that other factors also are at work. Figure 3-22 plots the percent difference in VMT for each planning scenario relative to trend against the percent population growth during the planning period for the metropolitan region as a whole (from base year to target year). Again, a correlation is apparent. The greater the increment of population growth that can be redirected in a planning scenario, the greater the difference in VMT. The growth increment is a function of both planning horizon (the further out, the more growth can be reallocated) and growth rate (the higher the growth rate, the more growth can be reallocated).

Figure 3-22 Percent Difference in VMT versus Percent Increase in Population for Planning Scenarios Relative to the Trend
Source: Bartholomew 2005.



Other variables may contribute to VMT changes as well. Several were represented by dummy variables in this meta-analysis. A dummy variable is a variable that assumes a value of one or zero, depending upon whether a condition is met. Dummies are regularly used to represent categorical variables in analyses such as this.

Lacking numeric data on these variables, we relied on narrative descriptions of scenarios in study documents to create dummy variables. For example, one dummy variable was used to distinguish between scenarios that mix and balance residential and commercial land uses to a high degree (assigned a value of one), and scenarios that mix and balance land uses only to the same degree as in trend development (assigned a value of zero). Some of the dummies were specific to scenarios; others were specific to regions and/or studies.

3.3.6 Meta-Analysis of Regional Simulation Studies

With so many independent variables, it becomes hard to discern relationships from simple scatter plots. This is a multivariate problem that requires a multivariate analysis to isolate the effect of each independent variable on the dependent variable, holding the other variables constant.

The analysis is further complicated by the multilevel nature of the data structure. Scenarios are “nested” within regions, with the typical region having two or three alternatives to the trend. Scenarios for the same region are not independent of each other, as they share the characteristics of their respective regions. Thus, standard (ordinary least squares) regression analysis cannot be used to analyze this multivariate data set. Rather, a hierarchical or multilevel modeling technique is required.[23]

A hierarchical linear model was estimated for the continuous outcome, percent difference in VMT relative to trend. Independent variables tested were at two levels, those specific to scenarios and those specific to studies (the latter common to all scenarios for a given region). Independent variables specific to scenarios were as follow:

- percent difference in gross density relative to trend development (–15 percent to +64 percent);
- development centralized/infill emphasized (one if yes, zero if no); and
- land uses highly mixed (one if yes, zero if no).

Independent variables common to scenarios for a given region but different across regions/studies are as follow:

- percent population growth increment relative base population (10 percent to 176 percent);
- auto use priced higher (one if yes, zero if no); and
- transportation investments coordinated with land uses (one if yes, zero if no).

[23] For region-level characteristics, ordinary least squares (OLS) regression analysis would underestimate standard errors of regression coefficients and would produce inefficient regression coefficient estimates. Hierarchical modeling overcomes these limitations, accounting for the dependence of scenarios for the same region and producing more accurate regression coefficient and standard error estimates (Raudenbush and Byrk 2002). Within a hierarchical model, each level in the data structure is represented by its own submodel. Each submodel captures the structural relations occurring at that level and the residual variability at that level. To represent such complex data structures, this study relied on HLM 6 (Hierarchical Linear and Nonlinear Modeling) software.

The best-fit model is presented in Figure 3-23. For theoretical reasons, the model was estimated with no constant term (as a regression through the origin). If nothing changes from trend, there should be no reduction in regional VMT. There are three significant influences on VMT: the population growth increment, centralized development, and mixed land use. All three are associated with decreases in VMT relative to trend. The increase in density relative to trend has the expected sign but falls just short of significance. Coordinated transportation investment also has the expected sign but is not significant.

The elasticity of VMT with respect to the population growth is –0.068, meaning that there is a 0.068 percent decrease in VMT per capita for every 1 percent increase in population relative to the base year. This does not argue for population growth per se, but simply indicates that regions that are growing rapidly have more opportunity to evolve toward a compact urban form than regions that are growing slowly.

Centralization of regional development and mixing of land uses both are inversely related to VMT at the 0.05 probability level. From their coefficients, we would expect a 1.5 percent drop in regional VMT with centralized development, and a 4.6 percent drop in regional VMT with mixed-use development (after controlling for other variables).

While the regional density variable is not statistically significant, our best guess at the elasticity of VMT with respect to regional density is –0.075, meaning that there would be a 0.075 percent decrease in VMT for every 1 percent increase in population density. This is a little higher than the elasticity estimate from the disaggregate travel studies in section 3.2. The density variable likely is soaking up some of the effect of other D variables that are not adequately represented in the regional growth simulations.

The coordinated transportation investment variable also is not statistically significant. Again, our best estimate of the impact of coordinated transportation investments, controlling for other variables, is a 2.1 percent reduction in regional VMT.

When forced into the model, the imposition of transportation pricing policies has a positive coefficient, suggesting that it would lead to higher VMT. This counterintuitive result is discussed in section 3.3.9.

Plugging realistic numbers into the best-fit model in Figure 3-23, we can estimate the VMT reduction associated with a shift to compact development. If such a shift increases average regional density by 50 percent in 2050, emphasizes infill, mixes land uses to a high degree, and has coordinated transportation investments, it would be expected to reduce regional VMT by about 18 percent over 43 years at an average metropolitan growth rate of 1.3 percent annually.[24]

[24] Computed as –0.074*50 – 1.50*1 – 4.64*1 – 0.068*73 – 2.12*1. The 73 in the preceding formula represents a growth increment of 73 percent, or 43 years at an average growth rate of just over 1.28 percent per year.

Figure 3-23 Best-Fit Model of Percent VMT Reduction Relative to Trend (with Robust Standard Errors)

	Coefficient	t	P
Difference in density (% above trend)	–0.074	–1.48	0.15
Development centralized	–1.50	–2.13	0.037
Land uses mixed	–4.64	–2.15	0.036
Population growth increment (% over base)	–0.068	–2.02	0.056
Transportation coordinated	–2.12	–1.01	0.33

3.3.7 The Conservative Nature of Scenario Forecasts

This forecasted reduction in regional VMT with compact development is almost surely an underestimate due to limitations of the travel demand models used in these studies. It is widely known, and oft-stated, that conventional regional travel models of the type used in most regional scenario studies are not sensitive to the effects of the first three Ds—density, diversity, and design (Walters, Ewing, and Allen 2000; Johnston 2004; Cervero 2006; DKS Associates and University of California 2007; Beimborn, Kennedy, and Schaefer undated). Conventional models can simulate land use and transportation system effects on travel at the gross scale of a region, but not at the fine scale of a neighborhood. In particular, they cannot account for the micromixing of land uses, interconnection of local streets, or human-scaled urban design. Most do not even consider walk or bike trips, adjust vehicle trip rates for car shedding at higher densities, or estimate internal trips within mixed-use developments.[25]

[25] What is missing from conventional travel demand models are five D variables. The following is true of nearly all conventional four-step models: 1) Only trips by vehicle are modeled, and trip rates are related only to characteristics of people, not characteristics of place. The possibility of households in urban settings making fewer vehicle trips—and instead using nonmotorized modes—is not considered. 2) Households, jobs, and other trip generators are assumed to be located at a single point, the zone centroid, and the entire local street network is reduced to one or more centroid connectors to the regional street network. This precludes the modeling of intrazonal travel in terms of the local built environment. 3) The choice between transit and auto modes is modeled solely in terms of characteristics of travelers and modes. The characteristics of origins and destinations—their transit-friendliness and walkability—are disregarded. 4) Trips are treated as unlinked, when a majority of trips nowadays are part of tours (trip chains) in which each trip depends on the trips preceding and following it, in a linked fashion. Destinations doubtless are chosen based not only on the attractions they contain, but also based on their accessibility to other trip attractions. 5) Trip attractions are summed for component land uses in a given zone, with each use treated as independent of the others. Yet mixed-use development is known to generate fewer vehicle trips than the component uses individually. 6) Daily travel is allocated to the peak hour based on fixed factors, disregarding the tendency for peak spreading when land uses become concentrated enough to produce serious peak-hour congestion. Peak spreading is the rescheduling of trips from the peak hour to the shoulders of the peak.

These failings and others have prompted:

- the U.S. Department of Transportation to spend millions of dollars developing a new generation of travel demand models under the Travel Model Improvement Program;
- the U.S. EPA to develop the Smart Growth Index model;
- leading MPOs such as Portland Metro (for the LUTRAQ study) to enhance their conventional "four-step" models with additional steps and feedback loops; and
- other leading MPOs to post-process model outputs or develop direct transit ridership models.

How much additional VMT reduction might be achieved with compact development, beyond that forecasted in regional growth simulations? To a first approximation, we can think of conventional travel models as accounting for one of the D variables, destination accessibility. The effects of the other D variables, outlined in section 3.2, are largely neglected. Were they factored into the analyses, one could easily reach VMT reductions of 20 percent or more.

3.3.8 Regional Growth and Vehicle Emissions

Our sample of regional growth studies is not large enough, and the studies themselves are not sophisticated enough, to support meta-analyses of impacts of smart growth on other outcomes (beyond VMT). At most, they support qualitative statements and inferences.

Vehicle emissions, including CO_2, are not merely a function of VMT, but also reflect the numbers of cold starts plus vehicle operating speeds (see section 2.3). Figure 3-24 shows that for many scenarios, an increase in density is associated with a drop in average peak hour operating speeds—an outcome that could result in increased emissions because gasoline engines function more efficiently at higher speeds.

Figure 3-24 Percent Differences in Peak Hour Average Speed versus Density for Planning Scenarios Relative to Trend

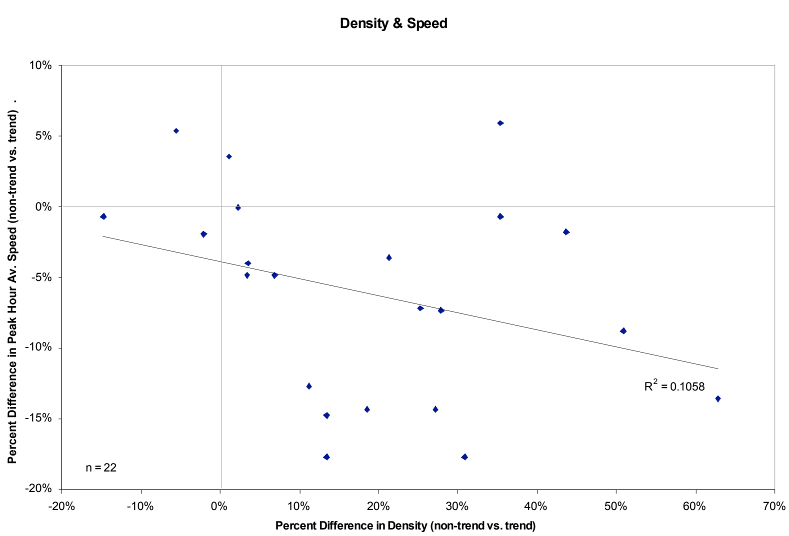


Figure 3-25. Percent Difference in NOx Emissions versus Percent Difference in Density for Planning Scenarios Relative to the Trend

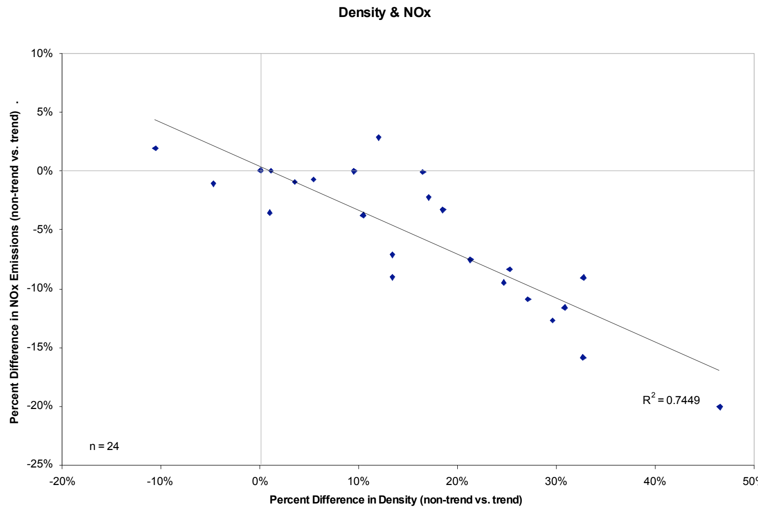
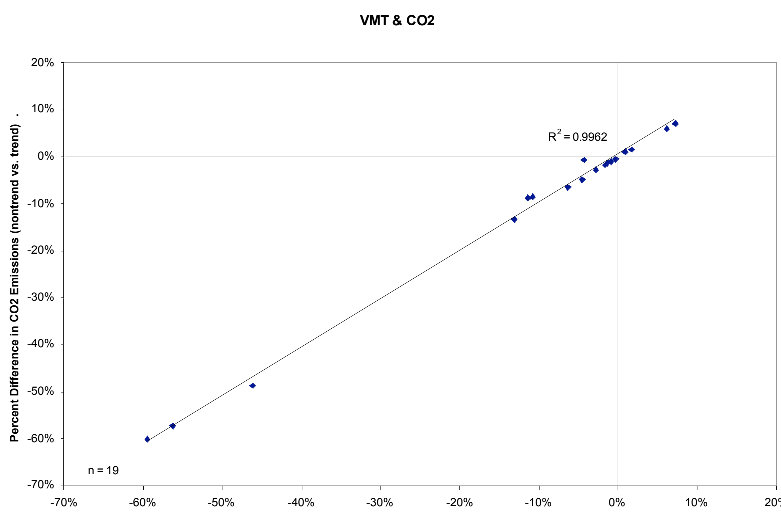


Figure 3-25 plots nitrogen oxide (NOx) emissions versus density differences for 24 planning scenarios. The scatter plot shows a strong association between the two variables. The strength of the association appears equivalent to that between VMT and density. Because most or all of these studies use vehicle emission models that account for differences in vehicle operating speeds, we can reasonably conclude from these data that any effect of density on emissions through vehicle operating speeds is overwhelmed by the effect of density on emissions through VMT. As with the observations above on energy consumption and speed (Figure 3-4), compact development is associated with lower emissions, notwithstanding possible reductions in vehicle speeds.

Data on regional CO_2 emissions are more limited. The scarcity of the forecasts indicates that the agencies undertaking scenario planning studies—primarily MPOs—have not focused on carbon emissions as a planning issue. Figure 3-26 plots VMT versus CO_2 differences for 19 planning scenarios. The near-perfect correlation and the elasticity value close to 1.0 suggest the multiplication of VMT by some constant factor to arrive at CO_2 forecasts.

Figure 3-26 Percent Difference in VMT and CO_2 Emissions for Planning Scenarios Relative to Trend



3.3.9 Regional Growth and Transportation Pricing

The meta-analysis in section 3.3.6 produced one anomalous result. When forced into the model, the imposition of transportation pricing policies has a positive coefficient, suggesting that it would lead to higher VMT. This is probably explained by confounding variables and the small sample of studies that actually test pricing policies.

In theory, the impact of pricing schemes on land development patterns could be positive or negative, depending on the pricing scheme. Increasing the price of driving (roads or parking) in only one part of a metropolitan region or along only a limited number of corridors could shift future economic and development activity away from the priced area or corridors and toward areas that are unpriced (Deakin et al. 1996). This could increase overall driving and VMT. Using an areawide pricing approach, however, could result in a concentration of future growth. This would occur as households and businesses seek to reduce or avoid the extra costs (Komanoff 1997). Some simulation-based evidence supports this conclusion (Gupta, Kalmanje, and Kockelman 2006).

If transportation pricing is ultimately adopted as a strategy to reduce VMT and CO_2, compact development could prove useful in both cushioning the blow to household budgets and enhancing the travel reduction effects (see Cambridge Systematics 1994). The LUTRAQ project, which was not included in the meta-analysis, provides data that support this conclusion. The project compared three scenarios: 1) a trend scenario that assumed the continuation of recent development practices and transportation investments, including a new highway; 2) the same scenario with an areawide parking pricing/free transit pass policy added;[26] and 3) a transit-oriented development scenario (LUTRAQ) with two additional rail lines and the same parking/transit pass component. Adding the LUTRAQ land use/transit element to the pricing/subsidy package tripled reductions in NOx and nearly quadrupled reductions in VMT and CO_2 emissions (see Figure 3-27).

Figure 3-27 Percentage Reduction in Transportation Outcomes with Transportation Pricing, and Pricing and Compact Development Combined
Source: 1000 Friends of Oregon 1996.

	Pricing/Subsidy	LUTRAQ w/ Pricing/Subsidy
Daily VMT	– 2%	– 7.9%
NOx Emissions (kg/day)	– 2.9%	– 8.7%
CO_2 Emissions (kg/day)	– 2%	– 7.9%

[26] The pricing policy assumed an areawide $3.00 per day parking charge for drive-alone work trips. The income was used to provide free transit passes to all commuters in the study area.

3.4 Project-Level Simulations

We also can assess the effects of the built environment through comparisons of VMT and vehicle emissions generated by individual land developments. These comparisons may be based on actual travel diaries or odometer readings for residents of existing developments. Or they may be based on simulations using conventional travel models calibrated and validated for the study region and, in some cases, enhanced to capture the effects of localized variations in density, diversity, and design.

Unlike regional scenario studies, project-level simulations have the advantage of focusing on the subset of the regional population for whom the built environment actually varies. Site plans can vary in density, diversity, or design, without differences in regional location or proximity to transit. Regional location can vary from transit-served brownfields to auto-only greenfields, without any difference in site plans. Or both can vary. The amount of development (housing and employment) generally is held constant in project-level simulations, but acreage may differ across site plans.

3.4.1 Case Study: Atlantic Steel Project XL

The 1999 study of the Atlantic Steel project—now known as Atlantic Station—is a prominent example of project-level simulation with both types of variation. The redevelopment project is on a 138-acre former steel mill and brownfield site in Midtown Atlanta. A developer proposed converting the vacant site into a “new town in town.” Its location—close to primary regional destinations and to rapid transit—and its dense, mixed-use design made the proposed Atlantic Steel redevelopment a classic smart growth infill project, favored by everyone from the city’s mayor to the vice president of the United States (at the time, Al Gore).

The dilemma was that the redevelopment project required a bridge over Interstate 75/85 to connect to a rapid transit station and a neighborhood to the east, plus ramps for access to the interstate highways. At the time, the Atlanta region was out of compliance with federal transportation conformity requirements and, as a result, could not tap into federal funds to add to its highway system. It could not even construct certain highway improvements using nonfederal funds. The proposed bridge and ramps were included in this prohibition.

Under a program called Project XL (excellence and leadership), the EPA has the power to waive environmental regulations when a superior environmental outcome may be achieved by some otherwise prohibited action. Based on an analysis showing that redevelopment of the Atlantic Steel site would produce less VMT and vehicle emissions than development of likely alternative sites in outlying areas, the EPA ultimately waived the conformity requirement for this project.

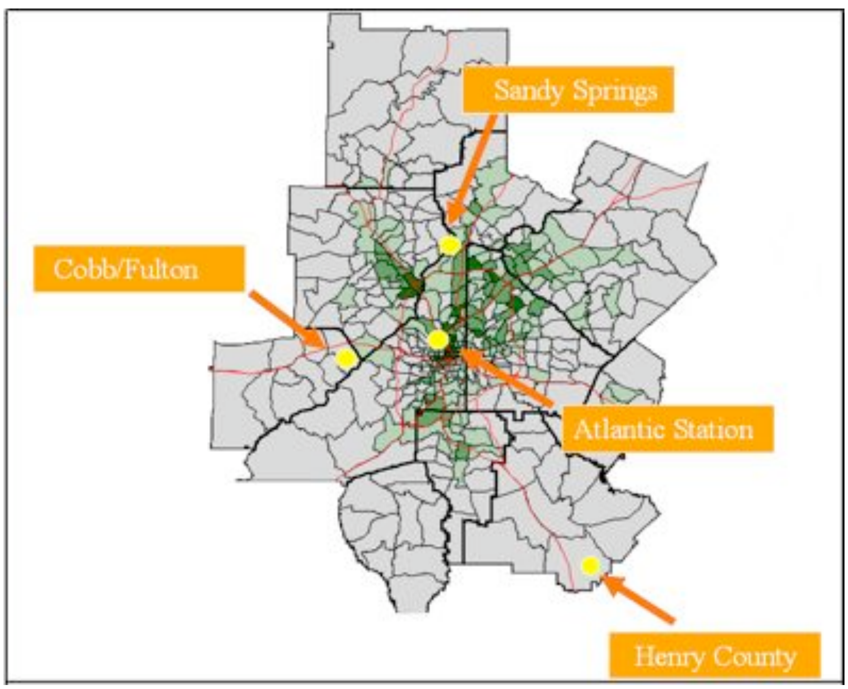
For this analysis, a team of consultants evaluated the Atlantic Steel project from two standpoints:

- *Regional location.* The Midtown site was compared to three greenfield sites large enough to accommodate the proposed development. The sites were at increasing distances from the urban core: a perimeter beltway location, a suburban location, and an exurban location, each with a development density and site plan typical of its location. The map below shows the location of the Atlantic Steel site and the three greenfield sites relative to the urban core.

- *Site plan.* Three alternative plans for the Atlantic Steel site—incorporating different intrasite densities, land use mixes, street networks, and streetscape design elements—were compared. They were the Jacoby Development Corporation's original site plan, an "improved new urbanism case" developed through a charrette process by Duany Plater-Zyberk & Company (DPZ), and a final compromise plan incorporating key DPZ concepts.

The original Jacoby design mixed land uses primarily on the site's east side, nearest the MARTA rapid transit station. On the west side, the developer proposed a single-use office park with buildings set back from the street and separated by stretches of undeveloped green area and parking. Residences were located between the office park and the retail/hotel district. The street network was an adaptation of the site's existing grid system, with some connections to neighborhood streets to the south.

Alternative regional locations evaluated.
Based on EPA (1999)



With everything riding on EPA approval, the agency had the leverage to push for a more integrated site plan. The DPZ plan, generated at a design charrette, mixed land uses within the site to a great degree, while holding the amount of office, retail, and residential development constant. Only the far west side retained the single-use character of the original site plan, in an office district. The redesign featured shorter blocks, narrower streets, improved streetscapes, and clear pedestrian paths. Auto speeds were controlled to provide a better pedestrian environment. Densities were increased near transit stops. The street grid of the surrounding neighborhood was extended into the site, and land uses were moved to permit shared parking.

Jacoby's final site plan is a compromise between the two earlier plans. The land use mix is more fine-grained than the original plan's but not as fine-grained as the DPZ redesign. The street network is more fine-meshed than the original plan's but less so than the redesign. Other concepts from the DPZ charrette, and from the literature on the built environment and travel, have been retained.

Alternative site plans evaluated
Based on EPA (1999)

Figure 2 Atlantic Steel site, Jacoby original

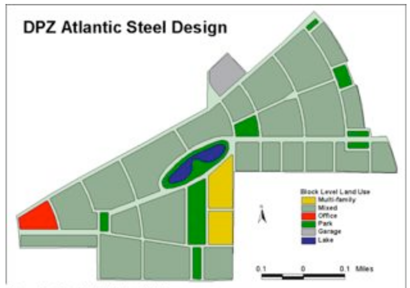


Figure 3 Atlantic Steel site, DPZ

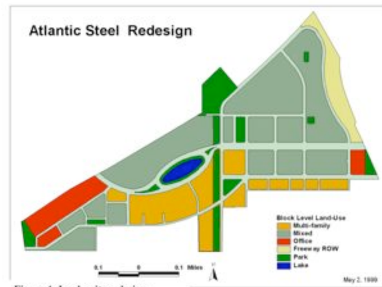
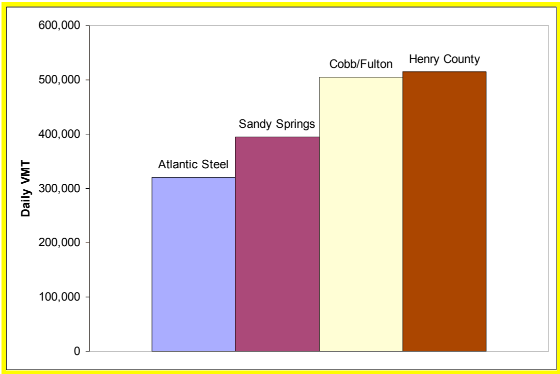


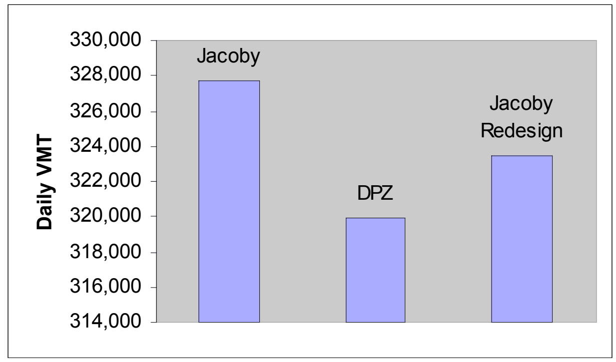
Figure 4 Jacoby site redesign

First, the EPA consultant team performed an in-depth evaluation of travel forecasting methods used in the Atlanta region. The evaluation resulted in various refinements to the Atlanta Regional Commission's conventional travel forecasting model to better account for regional location and destination accessibility, and in postprocessing of model outputs to better account for the first three Ds—density, diversity (mix), and design (Walters, Ewing, and Allen 2000). Postprocessing employed an early version of the Smart Growth Index model with elasticities derived from a review of recent research on the built environment and household travel (as described in section 3.2).

Model results demonstrated that VMT and emissions would be about 30 percent lower at the Atlantic Steel infill site than at the remote greenfield locations, and an additional 5 percent lower with the revised site plan (see Figure 3-28). As a result, for the first time, the EPA designated a land development proposal as a regional transportation control measure, allowing for approval of the project and funding of transportation Aimprovements. Atlantic Station has become a highly successful, largely built and occupied, infill community (see photographs below).

Figure 3-28 VMT Generated by Regional Location and Site Plan Alternatives
Source: EPA 1999.





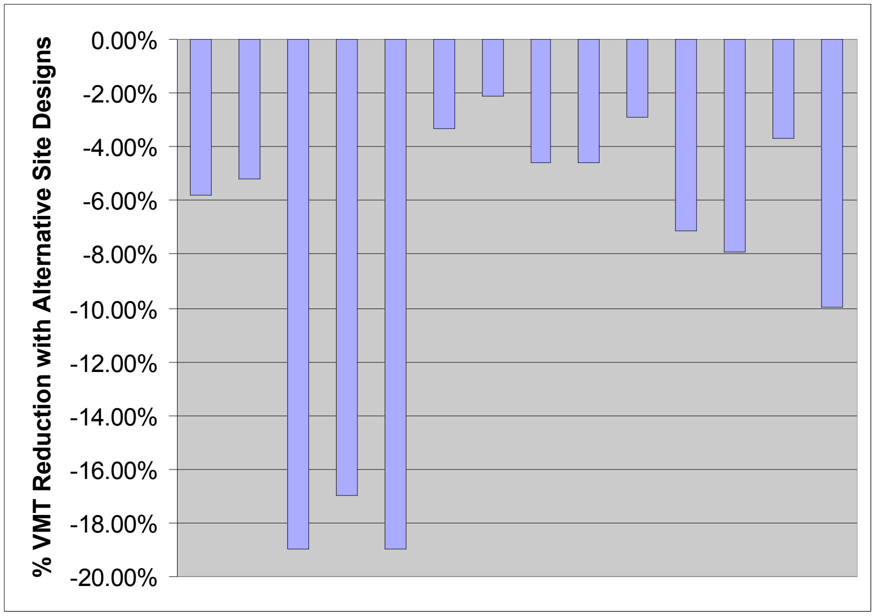
Atlantic Station today.

Source: Jacoby Development Company

3.4.2 Site Plan Influences on VMT

The Atlantic Steel study—and similar studies in San Diego, Wilmington, Portland, Oak Ridge, San Antonio, and Toronto—have forecasted the impacts of site design on vehicle trips, VMT, and/or CO_2 emissions (Hagler Bailly 1998; EPA 1999, 2001a, 2001b; IBI Group 2000). Figure 3-29 presents the findings of these studies. In each case, alternative development plans for the same site are compared to a baseline or trend plan.

Figure 3-29 Effect of Site Design Alone on VMT

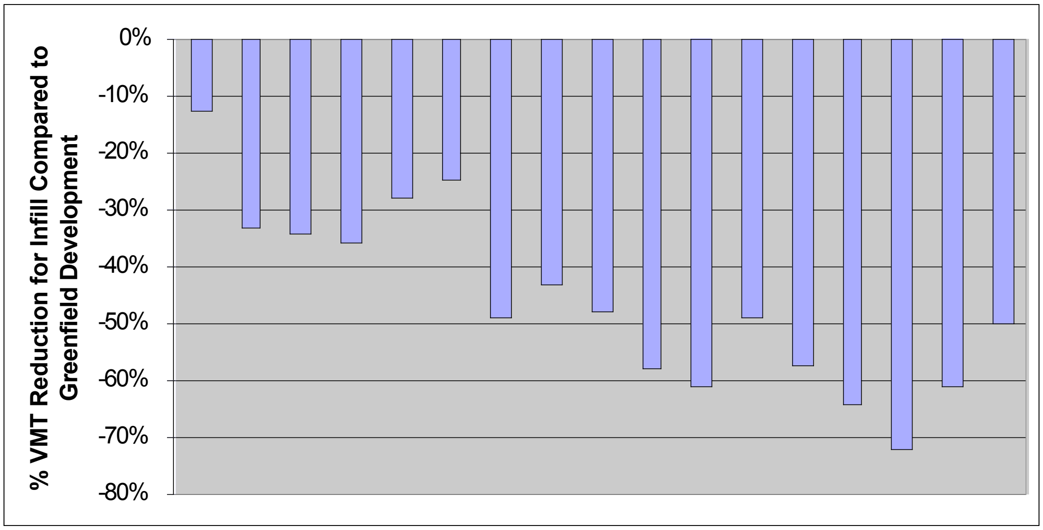


Results suggest that VMT and CO_2 per capita decline as site density increases and the mix of jobs, housing, and retail uses becomes more balanced. However, the limited number of studies, differences in assumptions and methodologies from study to study, and the variability of results make it difficult to generalize.

3.4.3 Regional Location Influences on VMT

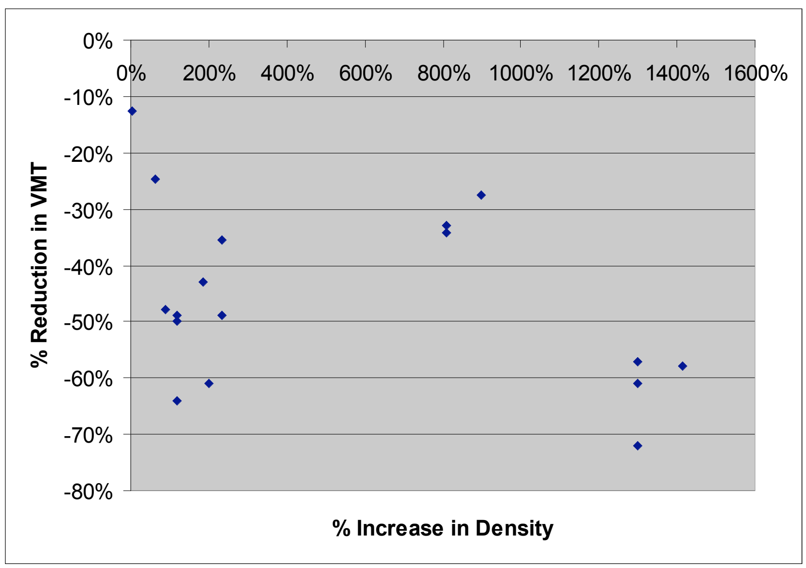
Approximately ten studies have considered the effects of regional location on travel and emissions generated by individual developments (EPA 1999, 2001a, 2001b, 2006; Hagler Bailly 1998; Hagler Bailly and Criterion Planners/Engineers 1999; IBI Group 2000; Allen and Benfield 2003; U.S. Conference of Mayors 2001). The studies differ in methodology and context, and in some cases include changes in site design. But they tend to yield the same conclusion: infill locations generate substantially lower VMT per capita than do greenfield locations, from 13 to 72 percent lower (see Figure 3-30).

Figure 3-30 Effect of Regional Location and Site Design on VMT



In Figure 3-31, the distribution of data points indicates that, while higher density is associated with reduced VMT, other factors also are at work. We suspect that regional location explains most of the scatter, and that the relationship between density and VMT is due in part to regional location as well. The highest densities are programmed for the most central locations.

Figure 3-31 Relationship between Density Increase and VMT Reduction

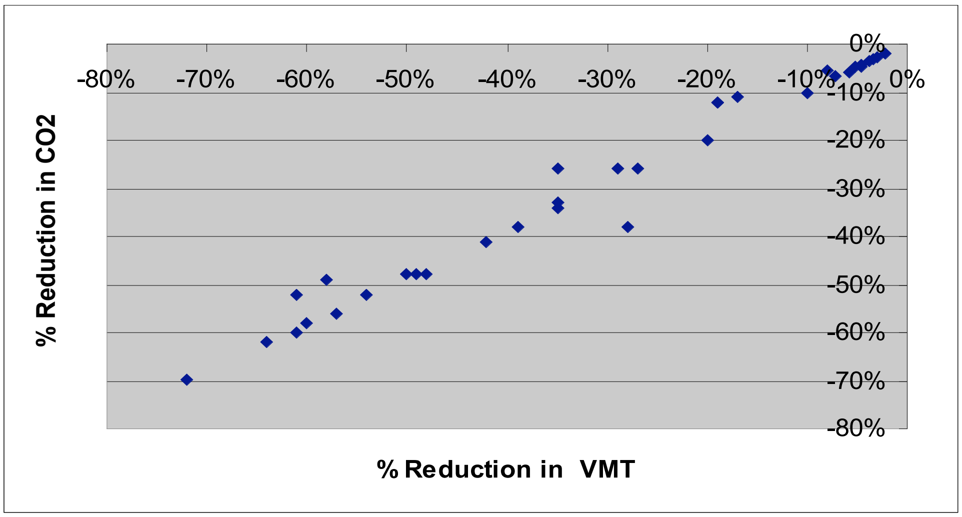


The data from project-level simulations are too limited to conduct a true meta-analysis of the variance in VMT per capita. However, the data clearly suggest that development that combines an infill location with higher density and good urban design can produce dramatic VMT reductions compared to typical greenfield development. VMT reductions cluster between about 30 and 60 percent. When compared with the results of the site design studies, which show VMT reductions of 2 to 19 percent, the effect of regional location appears much stronger than that of project density and site design alone.

3.4.4 The Relationship between VMT Reduction and CO_2 Reduction

These project-level simulations indicate that dense infill developments also are associated with reduced CO_2 emissions (see Figure 3-32). On a percentage basis, CO_2 reductions are not quite as large as VMT reductions. The regression line suggests an elasticity of CO_2 emissions with respect to VMT of 0.96. This is likely due to emission penalties associated with reduced vehicle operating speeds at infill locations.

Figure 3-32 Reduction in CO_2 Emissions versus Reduction in VMT



4. Environmental Determinism versus Self Selection

There is a long-running debate in urban planning about the degree to which the physical environment determines human behavior. The theory of environmental or architectural determinism ascribes great importance to the physical environment as a shaper of behavior. The counter view is that social and economic factors are the main or even exclusive determinants of behavior.

To outsiders, this debate may seem simplistic. Any extreme view would be. Yet, we all bring paradigms to the study of travel behavior, paradigms that affect our interpretation of the facts. Depending on one's point of view, the documented relationship between the built environment and travel might just as well be due to 1) individuals who want to walk or use transit selecting pedestrian- or transit-friendly environments (self selection) as it is to 2) pedestrian- and transit-friendly environments causing individuals to use these modes of travel more than they would otherwise (environmental determinism).

For many of the studies reviewed in Chapter 3, we can discount self selection because the unit of geographic analysis is the region or county. Travel preferences likely fall far down the list of factors—after job access, climate, cost-of-living, and family ties—that people consider when choosing a region or county in which to live. For those moving from one neighborhood to another, however, a desire to walk or use transit could be a factor in their decision, a possibility to which we now turn our attention.

4.1 The Empirical Literature on Self Selection

Does residential choice come first, and travel choice or some other outcome follow (environmental determinism)? Or do people's propensities for travel and physical activity determine their choice of residential environment (self selection)? Between environment and attitude, which drives behavior?

More than anything else recently, the possibility of self-selection bias has engendered doubt about the travel benefits of compact urban development patterns. According to a Transportation Research Board/Institute of Medicine report (2005), "If researchers do not properly account for the choice of neighborhood, their empirical results will be biased in the sense that features of the built environment may appear to influence activity more than they in fact do. (Indeed, this single potential source of statistical bias casts doubt on the majority of studies on the topic to date.)"

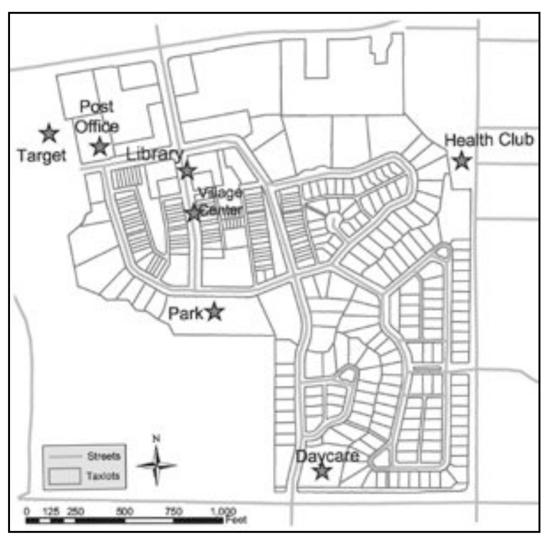
Self selection occurs if the choice of residence depends in a significant way on attitudes about, or preferences for, one mode of transportation over another. In the language of research, such attitudes will confound the relationship between residential environment and travel choices. Most of the "evidence" for or against self selection is circumstantial.

Many studies have cited associations between attitudes and travel choices as evidence of self selection. Favorable attitudes about walking correlate with walking; favorable attitudes about the environment correlate with transit use. It would be surprising, indeed, if travelers who are favorably disposed toward a given mode did not use that mode more frequently than others, regardless of where they live. But this does not mean that attitudes account for the observed relationship between the built environment and travel. For self selection to occur, attitudes must also influence residential choices.

Planning researchers frequently ask new residents whether transit accessibility, walkability, or access to specific destinations were factors in their location decisions. Access considerations usually fall well down the list of location factors, after housing price and quality, neighborhood amenities, and school quality.

Typical of such surveys is one by Dill (2004). Fairview Village is a mixed-use, new urbanist neighborhood in suburban Portland, Oregon, with interconnected streets and attractive streetscapes (see the photograph and site plan below). Residents were asked to rate the importance of location factors in choosing their new home. The highest-rated factors were neighborhood safety, neighborhood style, and house price. Among access variables, "quick access to the freeway" was ranked highest at number eight. Pedestrian access ranked lower. "Having stores within walking distance" was 12th in importance, and "having a library within walking distance" was 14th. Still, pedestrian access was rated as more important in Fairview Village than in two nearby subdivisions matched for income, home value, home size, and year built. Apparently, self selection is present but weak. Whatever the underlying cause, attitude, or environment, walk trips are much more frequent in Fairview Village, and VMT per adult is 20 percent lower than in otherwise comparable suburban subdivisions (see Figure 4-1).

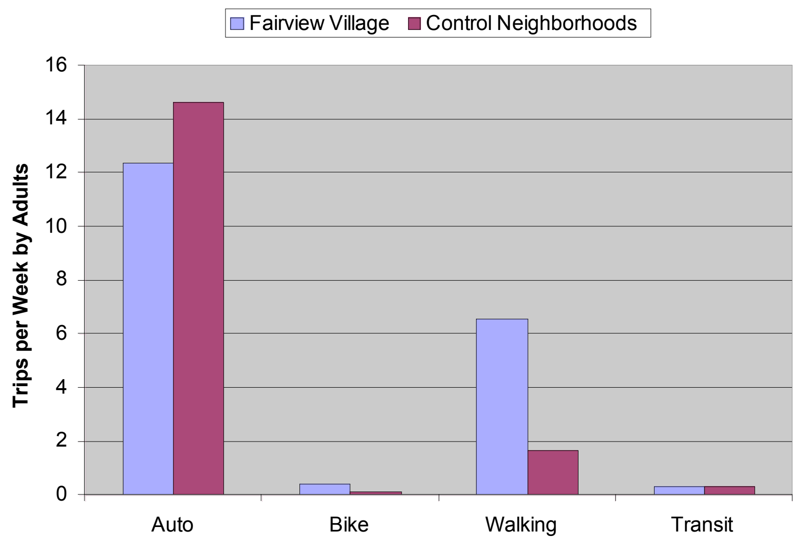
Fairview Village City Hall and nearby housing.



Fairview Village site plan.
Source: Rose 2004

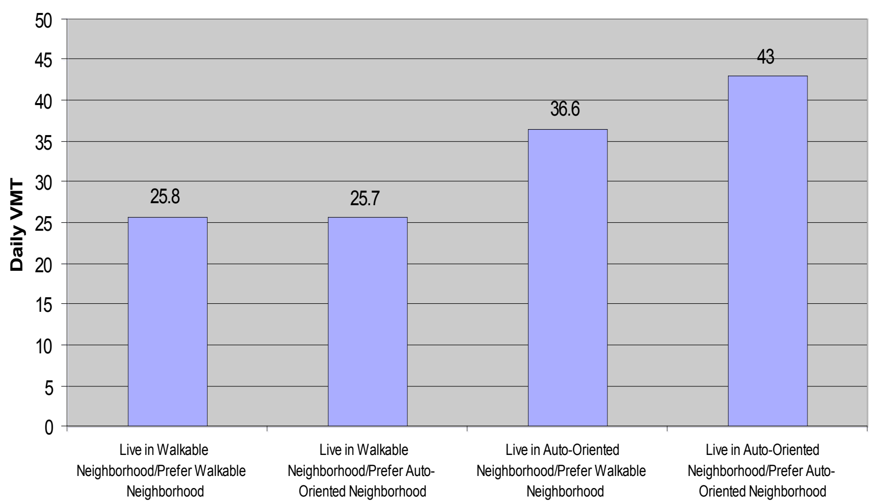
Figure 4-1 Number of Trips by Mode and by Neighborhood*
Source: Based on data in Dill 2004.

*By adults, per week.



The strongest survey-based evidence of self selection is Lund's (2006) study of people who had recently moved to transit-oriented developments (TODs) on rail lines in California. For TOD residents, transit access ranked third among location factors in San Francisco and fifth in Los Angeles and San Diego (where, amazingly, it ranked lower than highway access). One-third of all respondents mentioned transit access as one of the top three reasons for locating in a TOD. These residents were much more likely to use transit than those not citing transit access as a location factor. Yet, because the survey did not collect comparable data on prior travel mode, we cannot draw any inference regarding the strength of attitudes versus environment or on the effect of transit-oriented development on net regional transit use.

Figure 4-2 Average VMT by Neighborhood Type and Residential Preference
Source: Frank et al. forthcoming.



The strongest survey-based evidence of environmental determinism is Frank et al.'s (forthcoming) in-depth study of 8,000 households in Atlanta, which indicates that the built environment and availability of alternatives can lead anyone, regardless of preference, to drive less. Just comparing those who stated a preference for walkable environments, VMT was 40 percent lower among those who actually lived in a walkable neighborhood than among those who lived in an auto-oriented neighborhood (see Figure 4-2). Roughly one in three current residents of automobile-oriented neighborhoods would prefer to live in a walkable environment but were unable to find one, given current development patterns. This alone indicates a ready-made market for compact development.

At least 28 studies using different research designs have attempted to test and control for residential self selection (Mokhtarian and Cao forthcoming; Cao, Mokhtarian, and Handy 2006). Nearly all of them found "resounding" evidence of statistically significant associations between the built environment and travel behavior, independent of self-selection influences: "Virtually every quantitative study reviewed for this work, after controlling for self-selection through one of the various ways discussed above, found a statistically significant influence of one or more built environment measures on the travel behavior variable of interest (Cao, Mokhtarian, and Handy 2006).

Mokhtarian and colleagues find research designs used in studies to date all wanting in some respect. Still to be determined through future research are the absolute and relative magnitudes of this influence. What all of this tells us is that the built environment and self selection *both* influence travel choices; we just do not yet know enough to calculate their relative impacts.

4.2 The Built Environment May Matter in any Case

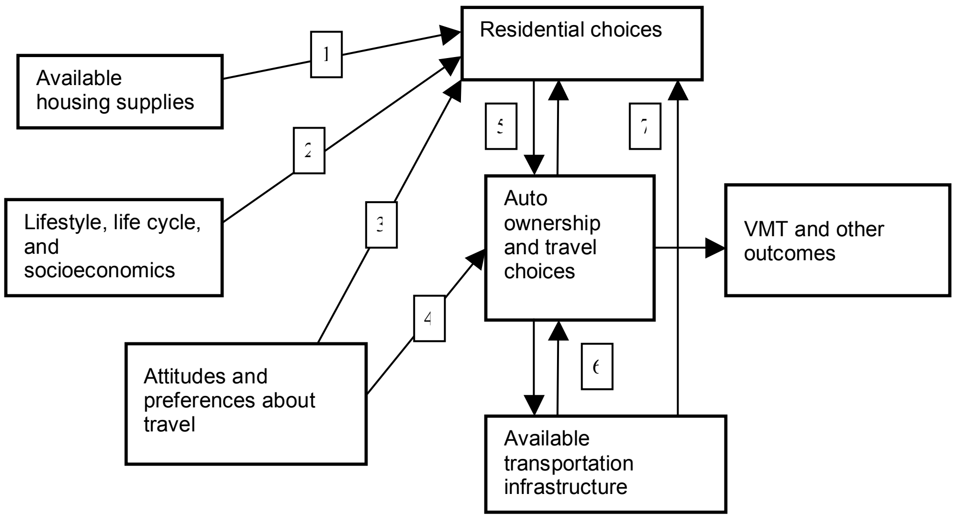
The fact that people to some extent "self select" into neighborhoods matching their attitudes is itself a demonstration of the importance of the built environment in travel behavior. If there were no such influence, people who prefer to travel by transit or nonmotorized modes might as well settle in sprawling areas, where they have no alternative to the automobile.

Whether the association between the built environment and travel is due to environmental determinism or self selection may have little practical import. Where people live ultimately depends on housing supply and demand. As Lund, Willson, and Cervero (forthcoming) note, ". . . if people are simply moving from one transit-accessible location to another (and they use transit regularly at both locations), then there is theoretically no overall increase in ridership levels. If, however, the resident was unable to take advantage of transit service at their prior residence, then moves to a TOD (transit-oriented development) and begins to use the transit service, the TOD is fulfilling a latent demand for transit accessibility and the net effect on ridership is positive)."

The conceptual model in Figure 4-3 indicates why self selection may be less important than the recent focus in the literature suggests. Attitudes about travel have direct effects on travel choices (link 4). Attitudes also may have indirect effects through the mediator, residential choice (link 3). This is the theory of self selection. If link 3 is strong relative to link 4, self selection may be the main mechanism through which the built environment affects travel and health outcomes. If link 3 is weak, residential choices may still affect travel directly through link 4. This is the theory of environmental determinism.

Note that strong self selection may actually enhance the effect of the built environment on travel, not render it insignificant, as some of the literature implies. Whether it does or not depends on housing supply (link 1) relative to demand (links 2 and 3). Housing supply may affect travel regionally if certain types of residential environments are undersupplied. We will refer to this as the theory of latent demand. As shown in Figure 4-4, the ability to self select (link 3) is moderated by housing supplies.

Figure 4-3 Mechanisms by which Attitudes and Preferences Might Affect Travel Choices and VMT



Think of travel outcomes in two dimensions (as in Figure 4-4). One dimension relates to the relative strength of self selection versus environmental determinism. The other depends on the supply of walkable or transit-served places relative to demand across a region. Of course, these dichotomies are false. Both dimensions are continuous, and reality almost certainly lies somewhere along a continuum.

But for three of the four extreme scenarios, the development of new walkable, transit-oriented places should lead to net increases in walking and transit use across the region. Even if self selection is the dominant mechanism through which the built environment influences travel, developers meeting latent demand for walkable, transit-oriented environments will be contributing to reduced VMT. Indeed, the only way that these developers will not have a positive impact is if such places already are adequately supplied.

This does not appear to be the case. There is ample evidence that the demand for walkable, transit-oriented environments far exceeds the current supply. In a study of residential preferences in Boston and Atlanta, Levine, Inam, and Tong (2005) find a huge unmet demand for pedestrian- and transit-friendly environments, particularly among Atlanta residents (see Figure 4-5). It causes these researchers to conclude:

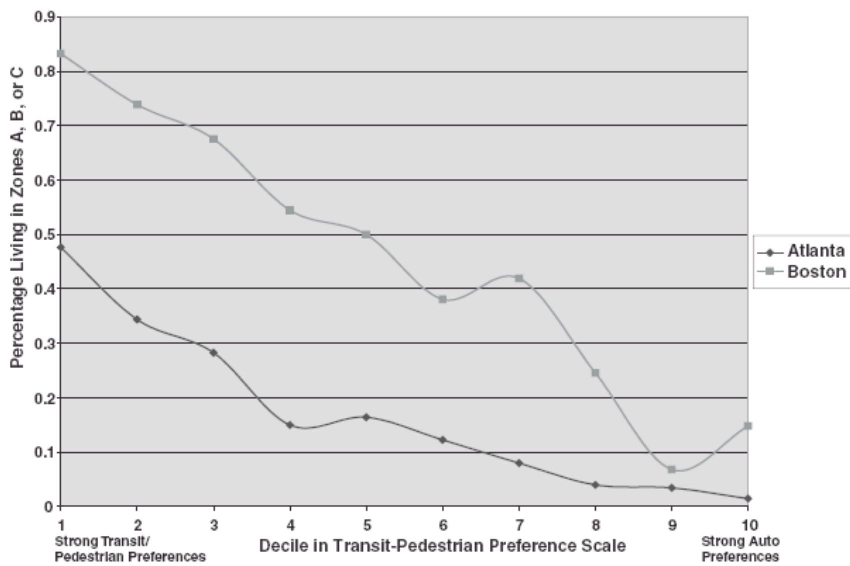
> . . . given the gap depicted in Figure [4.5], it seems unlikely that new transit-oriented housing in Atlanta would fill up with average Atlantans; rather, it would tend to be occupied by people with distinct preferences for such housing who previously lacked the ability to satisfy those preferences in the Atlanta environment. Self-selection in this case would be a real effect, but it would hardly negate the impact of urban form on travel behavior. This is because in the absence of such development, those households would be unlikely to reside in a pedestrian neighborhood and would have little choice but to adopt auto-oriented travel patterns.

For more data on the growing and unmet demand for compact development, see Belden Russonello & Stewart (2003), Myers and Gearin (2001), Center for Transit-Oriented Development (2004), Levine and Frank (2007), Logan (2007), and Nelson (2006).

Figure 4-4 Effect of New Walkable, Transit-Oriented Developments on Regional VMT

	Self Selection Dominates	Environmental Determinism Dominates
Walkable, transit-oriented places undersupplied at present	VMT decreases	VMT decreases
Walkable, transit-oriented place adequately supplied at present	VMT stays the same	VMT decreases

Figure 4-5 Relationship of Transit-Pedestrian Preference to Residence in Transit- and Pedestrian-Friendly Zones
Source: Levine, Inam, and Tong 2005



Thus, it is clear that both self selection and environmental determinism may account for VMT reductions with compact development. A recent study in the San Francisco Bay Area suggests that more than 40 percent of the ridership bonus associated with TOD is a product of residential self selection (Cervero and Duncan 2003). Whatever the source, regional transit ridership is higher than it would be otherwise, and regional VMT is lower.

5. Induced Traffic and Induced Development

Figure 4.3 illustrates two additional links with potential impacts on regional VMT. Link 6 represents a phenomenon called induced traffic, link 7 a related phenomenon called induced development.

Tony Downs of the Brookings Institution first explained the phenomenon of induced traffic in his 1962 "Law of Peak-Hour Traffic Congestion." As he explained more recently,

> … traffic flows in any region's overall transportation networks form almost automatically self-adjusting relationships among different routes, times, and modes. For example, a major commuting expressway might be so heavily congested each morning that traffic crawls for at least thirty minutes. If that expressway's capacity were doubled overnight, the next day's traffic would flow rapidly because the same number of drivers would have twice as much road space. But soon word would spread that this particular highway was no longer congested. Drivers who had once used that road before and after the peak hour to avoid congestion would shift back into the peak period. Other drivers who had been using alternative routes would shift onto this more convenient expressway. Even some commuters who had been using the subway or trains would start driving on this road during peak periods. Within a short time, this triple convergence onto the expanded road during peak hours would make the road as congested as it was before its expansion (Downs 2004).

Controversy exists over whether and to what extent the addition of highway capacity induces new traffic and promotes urban development in proximity to the added highway capacity. The notion of induced traffic challenges the view that the expansion of existing roads or the building of new roads will necessarily relieve highway congestion.

The concept of induced development challenges the view that highway investments are a response to growth and development, as opposed to a cause of them. In the highway "wars" that ensue between environmental and development interests, opposing sides have very different positions on the nature and magnitude of induced traffic and induced development. In this brief review, we will attempt to sort out facts from debating points.

5.1 Case Study: Widening Interstate 270

Interstate 270, which angles to the northwest from the Washington, D.C., beltway in Montgomery County, Maryland, was widened in the late 1980s and early 1990s. In 1999, the *Washington Post* ran a story comparing actual traffic volumes on I-270 to pre-construction projections (*Washington Post* 1999). The article declared the widening a failure based on the amount of induced traffic, which effectively used up the added capacity. By the year 2000, traffic volume for certain sections of I-270 already exceeded forecasts for 2010.

This was a time of growing interest in the phenomena of induced traffic and induced development. The Maryland-National Capital Park and Planning Commission and the Metropolitan Washington Council of Governments responded with a study that suggested that highway-induced development was mainly responsible for the high and premature levels of congestion on I-270 (NCRTPB/MWCOG 2001). Also blamed was the failure to build all transportation facilities in the adopted regional transportation plan. Some projects had been delayed and others dropped.

On the subject of induced development, the study concluded that "higher observed traffic volumes relative to the 1984 forecast appear to be due in large part to shifts in population, employment, and travel to the I-270 corridor from other areas in the region, rather than to entirely new travel." For the region as a whole, population growth was 5 percent lower than had been forecasted in 1984, while employment growth was 9 percent higher. The two together suggested small (if any) net impacts of I-270 on regional growth.

However, population and employment had clearly shifted to the I-270 corridor, at the expense of other areas. Specifically, population and employment in the I-270 corridor were, respectively, 23 and 45 percent higher than forecasted in 1984. For all of Montgomery County, they were 7 and 21 percent higher than forecasted. Meanwhile, population and employment were 9 and 23 percent lower than forecasted in Prince George's County, and 29 and 3 percent lower than forecasted in the District of Columbia. These shifts in development are illustrated in Figures 5-1 and 5-2.

Figure 5-1 Difference between Actual and Forecasted Households by Subarea (2000)
Source: NCRTPB/MWCOG 2001.

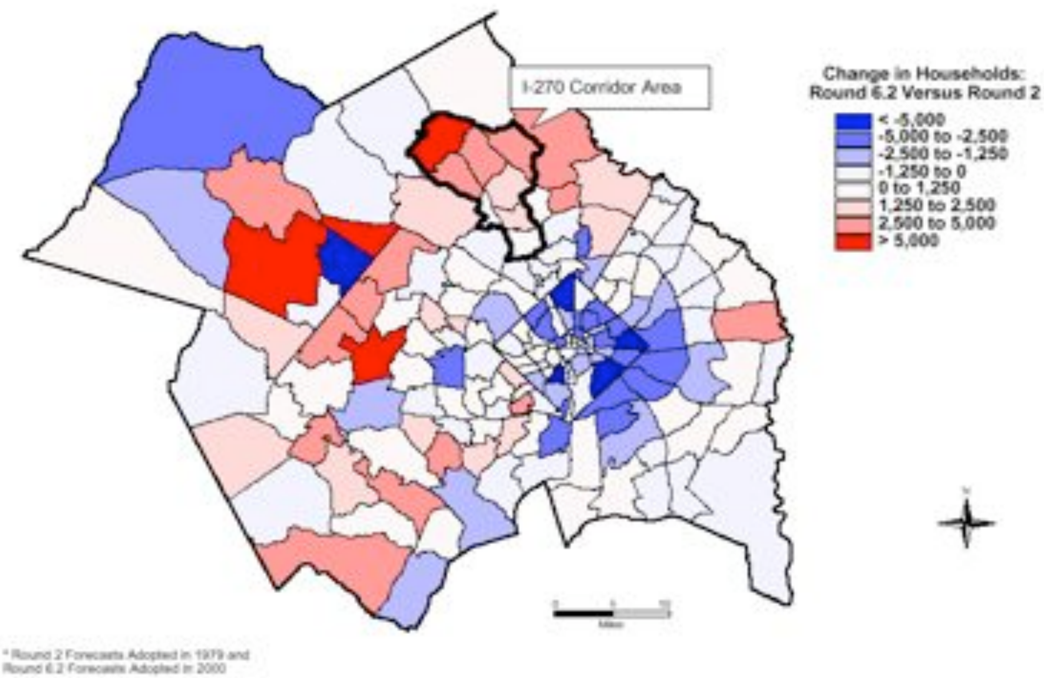
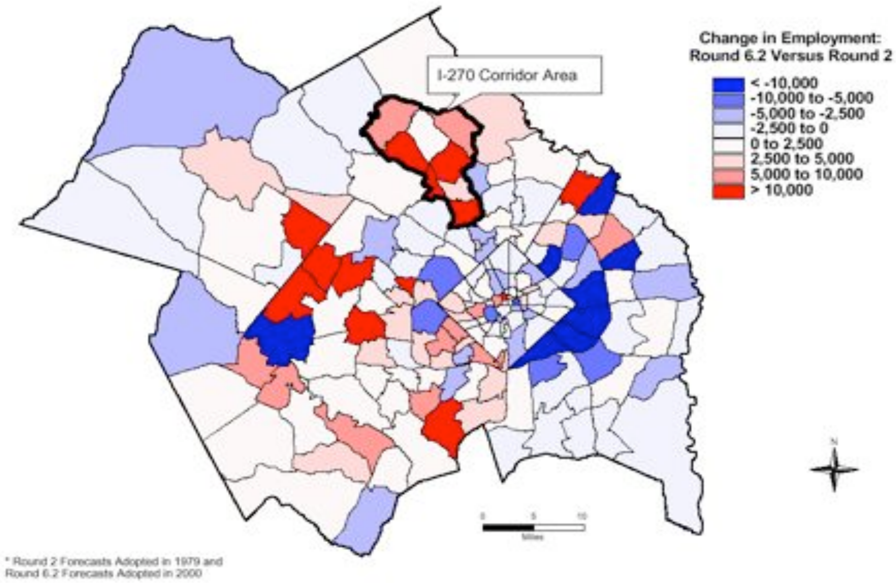


Figure 5-2 Difference between Actual and Forecasted Employment by Subarea (2000)
Source: NCRTPB/MWCOG 2001.



The experience with the I-270 widening mirrors the literature on highway-induced traffic and highway-induced development.

5.2 The Magnitude of Induced Traffic

Cervero (2002) compares elasticity values across studies in a meta-analysis. Again, an elasticity is the percentage change in one variable that accompanies a 1 percent change in another variable. An elasticity of VMT with respect to lane miles of 0.5 implies that every 1 percent increase in lane miles is accompanied by a 0.5 percent increase in VMT. At the facility level, a 100 percent increase in lane miles is what we would get if a facility were widened from two to four lanes.

In his meta-analysis, Cervero (2002) extracts the average elasticities shown in Figure 5-3.

Figure 5-3 Elasticities of VMT with Respect to Capacity
Source: Cervero 2002.

	Facility-Specific Studies	Areawide Studies
Short-term	0	0.4
Medium-term	0.265	NA
Long-term	0.63	0.73

Based on the meta-analysis, Cervero (2002) concludes that ". . . the preponderance of research suggests that induced-demand effects are significant, with an appreciable share of added capacity being absorbed by increases in traffic, with a few notable exceptions." The average long-term elasticity of 0.73 suggests that for every 1 percent increase in areawide highway capacity, VMT increases by 0.73. The actual increase in a given corridor or metropolitan area depends on the level of congestion. Adding capacity in an area with no congestion has no effect; adding capacity in an area with severe congestion has huge effects. This is apparent from Figure 5-4, which shows the VMT increase per lane-mile of capacity added in California metropolitan areas. The induced traffic effect is greatest in the congested San Francisco, Los Angeles, and San Diego metro areas (see Figure 5-4).

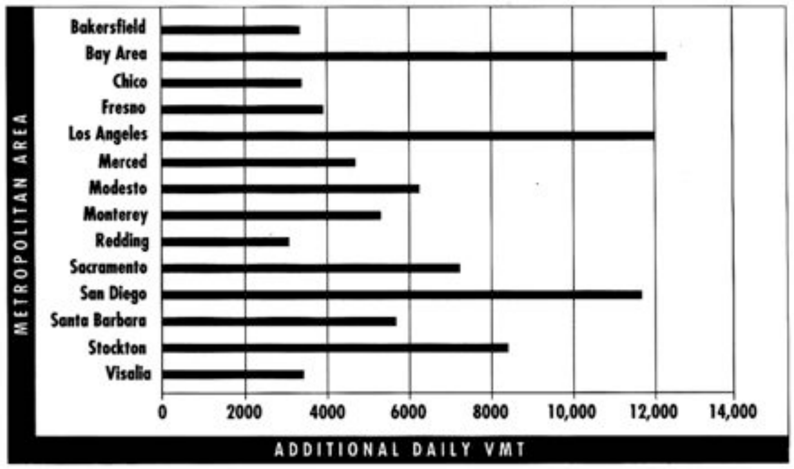


Figure 5-4 Estimated Additional VMT from an Additional Lane-Mile, California *Metropolitan Areas Source: Hansen and Huang 1997.*

5.3 The Role of Induced Development

Induced traffic and induced development are related. One can think of induced development as a cause of induced traffic, not immediately but over the longer term. To better understand induced traffic and its connection to induced development, it is necessary to explore the behavioral consequences of additions to roadway infrastructure capacity.

In the short term, a variety of behavioral changes can contribute to increased traffic without any induced development. These include route switches, mode switches, and changes in destination. In addition, new trips may be taken that would not have occurred without the addition in infrastructure capacity.

In the longer run, increases in highway capacity may lower travel times so that residents and businesses are drawn to locate in the area surrounding the expanded highway capacity. The question is always whether the new development that occurs in proximity to the highway was induced to locate there as a consequence of the expansion or whether it would have occurred anyway, regardless of the highway. Indeed, the highway investment may be a response to new or anticipated development, rather than vice versa. If the development itself would not have occurred otherwise, the development and the traffic it generates can be considered induced.

Definitionally, a gray area exists if the development that occurs near a highway would have occurred somewhere else in the region in the absence of the investment. Some would call this induced development, others redistributed development. We use the term induced development liberally, to mean any development that would not have occurred at a given location without a highway investment.

5.4 Historical Changes in Induced Development

Clearly, the impacts of highway investments are less today than they once were. Construction of the Interstate Highway System, in particular, has tied virtually every place in the country to everywhere else. Most studies finding sizable highway impacts (for example, Mohring 1961 and Czamanski 1966) date back to the first round of interstate highway construction, which created huge positive externalities for areas gaining access to the network. By the early 1970s, the Interstate Highway System was largely complete. Incremental additions or improvements to the network have since produced comparatively small improvements in interregional accessibility.

How great are highway impacts on economic and land development in the post-interstate era? This is a subject of great debate. In a well-known point-counterpoint, Giuliano (1995) minimized the importance of highway investments for three reasons: "The transportation system in most U.S. metropolitan areas is highly developed, and therefore the relative impact of even major investments will be minor. The built environment has a very long life. . . . Even in rapidly growing metropolitan areas, the vast proportion of buildings that will exist 10 to 20 years from now are already built. . . . Transport costs make up a relatively small proportion of household expenditures."

Cervero and Landis (1995) countered that "although new transportation investments no longer shape urban form by themselves, they still play an important role in channeling growth and determining the spatial extent of metropolitan regions by acting in combination with policies such as supportive zoning and government-assisted land assembly." They then challenged Giuliano's empirical evidence, and presented evidence of their own.

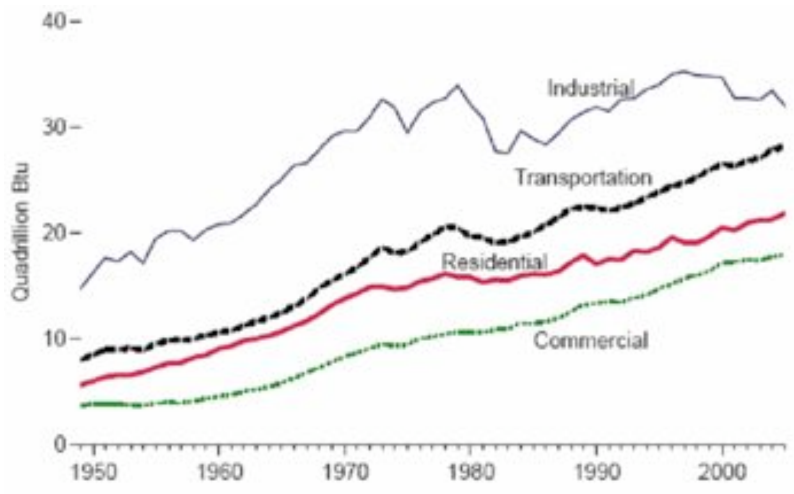
5.5 What Is Known about Induced Development

Who is right? Giuliano probably is right about aggregate impacts, while Cervero and Landis probably are right about localized impacts. The induced development literature has been reviewed by Huang (1994), Boarnet (1997), Boarnet and Haughwout (2000), Ryan (1999), and Bhatta and Drennan (2003). A recent review by Ewing (2007) concludes:

- Major highway investments have small net effects on economic growth and development within metropolitan areas. Instead, they mostly move development around the region to take advantage of improved accessibility. Induced development is very close to a zero-sum game.
- Highway investment patterns tend to favor suburbs over central cities, and thereby contribute to decentralization and low-density development.
- Major highway investments may actually hurt regional productivity, if they induce inefficient (read "low-density") development patterns.
- Corridors receiving major highway investments experience land appreciation, and therefore are likely to be developed at higher densities than developable lands outside the corridors.
- Highways may be necessary to induce development, but they are not sufficient to do so. To the extent that current planning and zoning caps hold, impacts within a corridor will be moderated.
- Counties receiving major highway investments attract population and employment growth to a greater degree than they would otherwise.
- Nearby counties may experience more or less growth than they would otherwise, depending on the strength of spillover effects.
- Nonresidential development is more strongly attracted to major highways than is residential development, particularly in the immediate vicinity of facilities.
- The induced development impacts of interstate-quality highways are wider and deeper than those of lesser highways and streets.
- It takes many years after construction for development to adjust to a new land use/transportation equilibrium.
- The induced development impacts of major highways extend out at least one mile, and probably farther.
- The relationship between highway capacity and growth is a two-way relationship, in that growth induces highway expansion as well as the reverse.

6. The Residential Sector

Figure 6-1 Total U.S. Energy Use by End-Use Sector, 1949 to 2005



With regard to development impacts on energy use and emissions, the transportation sector has gotten most of the attention (Ewing 1994; Kessler and Schroeer 1995; Burchell et al. 1998; Bento et al. 2003; EPA 2003; Frank and Engelke 2005; Frank et al. 2006). This is understandable. The transportation sector is the second-biggest energy user in the United States, and is catching up with the industrial sector (see Figure 6-1). It is the sector that is most reliant on oil as an energy source. However, as a long-term threat to the planet, energy use by the residential sector also is significant. In 2004, the U.S. residential sector produced more than one- fifth of total energy-related CO_2 emissions (EIA 2004).

As with the transportation sector, the United States has relied almost exclusively on technological advances to address the problem of limited energy supplies and constantly increasing energy demands of the residential sector (Siderius 2004). Evidence exists that per capita energy use and associated emissions will continue to rise, and that advances in technology alone will be insufficient to achieve sustainable growth in energy use (Kunkle et al. 2004; Lebot et al. 2004; Siderius 2004). Therefore, demand-side measures will be required to keep supply and demand in reasonable balance.

Also like the transportation sector, residential energy use and related emissions have a relationship to urban development patterns. Impacts are felt through changes in housing stock, urban heat islands (UHIs), and transmission and distribution losses (see Figure 6-2). The first two effects have been quantified (see Rong and Ewing 2007). After controlling for household characteristics, residential energy use varies with house type and size, which in turn vary with the degree of urban sprawl. These relationships, taken together, allow us to estimate the effects of urban sprawl on residential energy use, indirectly, through the mediators of house type and size. The average household living in a compact county, one standard deviation above the mean sprawl index, would be expected to consume 17,900 fewer BTUs of primary energy annually[27] than the same household living in a sprawling county, one standard deviation below the mean index.

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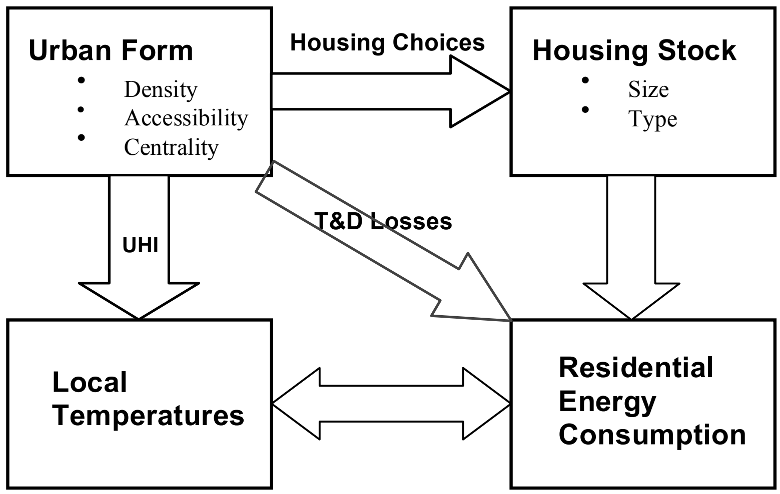
[27] Primary energy is energy contained in raw fuels, which is transformed in energy conversion processes to more convenient forms of energy, such as electrical energy and cleaner fuels. In energy statistics, these more convenient forms are called secondary energy.

Figure 6-2 Causal Paths between Urban Development Patterns and Residential Energy Consumption
Source: Rong and Ewing 2007.



UHI effects are strongest in compact areas, leading to an increase in cooling degree-days and a reduction in heating degree-days. Degree-days, in turn, directly affect space heating and cooling energy use. These relationships, taken together, allow us to estimate the effects of urban sprawl on residential energy use indirectly, through the mediating effect of UHIs. Nationwide, as a result of UHIs, an average household in a compact county, one standard deviation above the mean sprawl index, would be expected to consume 1,400 fewer BTUs of primary energy annually than an average household in a sprawling county, one standard deviation below the mean index.

Throughout most of the nation, the two effects, housing and UHI, are in the same direction, though.the housing effect is much stronger than the UHI effect. The total average savings of 19,300 BTUs amounts to 20 percent of the average primary energy use per household in the United States

[NOTE: THE FOLLOWING CHAPTER IS STILL IN PRELIMINARY FORM AND IS SUBJECT TO CHANGE]

7. Policy and Program Recommendations

Climate stabilization will require the U.S. to reduce GHG emissions by 60 to 80 percent below 1990 levels by 2050. To stay on that path, our GHG emissions will need to be well below 1990 levels by 2030, and leading analysts believe we have less than 10 and possibly less than 5 years to get on track.[28] In the transportation sector, progress will be required on all three legs of the stool: vehicle efficiency, fuel content, and vehicle miles traveled (VMT).[29] The national policy discussion on vehicles and fuels is mature and active, and a variety of proposals would have the automobile and oil industries take responsibility for their contributions to GHG. But no one has been put in charge of reducing the GHG impacts of VMT growth.

In this chapter, we aim to identify the roles and responsibilities for various levels of government to meet our climate challenge. Civic leaders, consumers, businesses, and other stakeholders can also make substantial contributions.

The key to substantial GHG reductions is to get all policies, funding, incentives, practices, rules, codes, and regulations pointing in the same direction to create the right conditions for smart growth. Innovative policies are often in direct conflict with the conventional paradigm that produces sprawl and automobile-dependence. One example is the link between federal transportation funding and VMT levels, thereby rewarding states for VMT growth.[30] Another example is the low-density zoning that keeps localities car-dependent, undermining local expenditures on transit, walking, and cycling.

Fortunately, many communities and states have demonstrated that comprehensive reforms can both reduce the need for driving, and improve overall quality-of-life. They have responded to public demands and market forces pushing for compact development, and CO_2 emissions reductions have been a bonus.

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[28] Rosina Bierbaum, Dean of the School of Natural Resources at U. of Michigan, presentation to Presidential Climate Action Program analyzing trends in IPCC analyses, June 2006 at Wingspread Conference Center, Racine, WI

[29] Vehicle-hours of travel (VHT) is another useful indicator.

[30] Specifically, the formulas by which the total payout of dollars from the Federal Highway Trust Fund is sub-allocated or "apportioned" to each State rewards such factors as VMT fuel use and lane-miles of travel. An overview of the apportionment process is provided by the GAO 2006 report available at http://www.gao.gov/new.items/d06572t.pdf

7.1. Federal Policy Recommendations

Although land use planning and growth management are primarily local and state responsibilities, the federal government plays a powerful role in shaping growth patterns and travel choices through regulations, funding, tax credits, performance measures, technical assistance, and other policies. To accomplish the emissions reductions we have discussed in this book, we recommend the implementation of the following major federal policies. We have chosen these options because they are likely to deliver better performance results (e.g., greater return on investment for every public dollar invested) than the *status quo* while also fostering development with a smaller carbon footprint.

7.1.1. Require Transportation Conformity for Greenhouse Gases

Federal climate change legislation should require regional transportation plans to pass a conformity[31] test for carbon dioxide emissions, similar to other criteria pollutants. The Supreme Court ruling in *Massachusetts v. EPA* established the formal authority to consider greenhouse gases under the Clean Air Act, and a transportation planning conformity requirement would be an obvious way for EPA to exercise this authority to produce tangible results.

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[31] Transportation conformity for conventional air pollutants (requiring regular assessments and course corrections to prevent transportation programs from undermining timely achievement of clean air standards) was created by the 1977 Clean Air Act Amendments and strengthened when that Act was amended in 1990. In 1991's Intermodal Surface Transportation Efficiency Act (ISTEA), Congress further codified conformity and created the Congestion Mitigation and Air Quality Improvement Program (CMAQ) as a complementary program to help regions achieve conformity (a "carrot" to conformity's "stick").

What is Conformity?[1]

Under Section 110 of the Clean Air Act, [1] states develop and implement air pollution control plans called State Implementation Plans (SIPs) to demonstrate attainment with National Ambient Air Quality Standards (NAAQS) set by EPA at levels deemed necessary to protect public health and welfare. The 1990 Clean Act Amendments, along with subsequent transportation legislation, required air quality and transportation officials to work together through a process known as conformity. A metropolitan region that has exceeded the emission standards for one or more of the pollutants must show that the region's transportation plan will conform to applicable SIPs and contribute to timely attainment of the NAAQS. According to the regulations, a proposed project or program must not produce new air quality violations, worsen existing violations, or delay timely attainment of the NAAQS.[1] The metropolitan planning organizations (MPOs) must demonstrate this conformity through their long range transportation plans and transportation improvement programs (TIPs) – which identify major highway and transit projects the area will undertake over a 20-25 year period. Projects that do not conform cannot be approved, funded or advanced through the planning process, nor can they be implemented unless the emissions budget in the SIP is revised.

If a region's TIP has expired without adopting a new TIP projected to stay within the motor vehicle emissions budget in the SIP, the area faces what is known as a conformity lapse. During this period, the MPO cannot approve funding for new transportation projects or new phases of previously funded transportation projects except for those projects that are adopted as Transportation Control Measures in the SIP or are otherwise exempt from conformity as air quality neutral activities. If an area fails to submit a required SIP by a deadline, it may face a "conformity freeze", in which it cannot approve any new projects until this deficiency is remedied, and if this failure is prolonged, can face the ultimate sanction of losing federal transportation funding. For some metropolitan areas, this potential loss of transportation funds can be more than $100 million per year.[1] While there have been 63 areas in the US that have suffered a conformity lapse, no state or region has ever lost federal transportation funds as a result of a conformity lapse, freeze, or sanctions.

State and local governments would be required to adopt mobile source CO_2 emission reduction budgets (like the emissions budgets for other pollutants) that demonstrate reasonable progress in limiting emissions.[32] Currently, regions that fail to develop transportation plans consistent with "Reasonable Further Progress" goals risk curbs on federal transportation funds. This could be reinforced by incentives that reward places that effectively reduce per capita VMT. Conversely, a portion of transportation funds could be withheld from places that fail to make progress toward reducing VMT *per capita* (see discussion below in State Policy section).

[32] The California Energy Commission offered a similar proposal to require regional transportation planning and air quality agencies to adopt regional growth plans that reduce GHG emissions to state-determined climate change targets. California Energy Commission, "The Role of Land Use in Meeting California's Energy and Climate Change Goals." http://www.energy.ca.gov/2007_energypolicy/documents/

Though we acknowledge that to date, land use and transportation demand management (TDM) policies have generally not played a large role in meeting regional conformity requirements,[33] we believe that comprehensive strategies would be more successful. Responsibility should be "nested" so that the federal government is responsible for the GHG impacts of federal transportation spending (see Green-TEA discussion below) and state and local governments bear responsibility for the GHG impacts of their transportation spending.

7.1.2 Use Cap-and-Trade (or Carbon Tax) Revenues to Promote Infill Development

Many climate proposals[34] focus on the creation of a market-based cap-and-trade system similar to policies adopted in Europe[35] and ones that are likely to be formed in California[36] and other states. By placing a price on greenhouse gas emissions, a cap-and-trade system can send the right signal for reducing the emissions associated with vehicle travel.[37] Moreover, regulated parties (such as oil companies) will have incentives to support policies that slow VMT growth, because actions that increase VMT will make carbon emission allowances more costly. Therefore, federal policies that subsidize growth patterns that increase *per capita* VMT would generate higher overall compliance costs.

A related issue that is being discussed within the federal cap-and-trade debate is how to best use the revenues generated by such a system. If cap-and-trade is adopted, the value of carbon allowances will be worth an estimated $50 to $300 billion per year by 2020 based on recent Congressional proposals. A portion of these revenues could be used to fund infrastructure for infill development, technical assistance to help communities seeking to rewrite codes and regulations that inhibit infill development, and transportation choices that support compact infill development.

In order to ensure adequate emission reductions, to accelerate the introduction of new technology into the marketplace and to moderate the price of allowances, some are proposing policies which complement a cap-and-trade system. Specifically, two of three legs of the transportation sector stool would be covered by new product performance standards. In the case of the auto industry, the longstanding tool is the Corporate Average Fuel Economy (CAFE) program. California is developing a low-carbon fuel standard (LCFS) that leads the nation. With the successful launch of the new Leadership in Energy and Environmental Design—Neighborhood Development

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[33] For example, in its 2002 SIP, the State of Maryland included smart growth policies that it expects to yield modest air quality benefits. Sacramento anticipates significant emissions savings from land use measures in its Blueprint transportation plan. In Atlanta, a modeling exercise on the emissions benefits of infill development rescued the region from its conformity lapse and associated restrictions on funding new transportation projects (1998-2000), but the region lacked the political support or transit funding to implement the modeled smart growth scenario. See CCAP (2004), "Two for the Price of One: Clean Air and Smart Growth (Workshop Primer)." http://www.ccap.org/transportation/smart_two.htm and "Atlanta's Experience with Smart Growth and Air Quality." http://www.ccap.org/transportation/smart_two.htm

[34] For example, see, Pew (2007), "Senate Greenhouse Gas Cap-And-Trade Proposals," http://www.pewclimate.org/docUploads/Economy-wide%20bills%20110th%20Senate%20-%20August%202.pdf

[35] See European Union Greenhouse Gas Emission Trading Scheme, http://ec.europa.eu/environment/climat/emission.htm

[36] For example, see California Market Advisory Committee, http://www.climatechange.ca.gov/policies/market_advisory.html

[37] For example, see Winkelman et. al (2000), "Transportation and Domestic Greenhouse Gas Emissions Trading," http://www.ccap.org/pdf/TGHG.pdf

(LEED-ND) certification standards from the U.S. Green Building Council, now may be the time to consider something analogous for new development products. This is especially so if public funding—allowance revenue, gas tax revenue—is to be made available to support such "cooler growth." Public support should be coupled with some sort of guarantee of performance, whether in the form of standards or similar policy for new development.

Other options, such as a carbon tax, are also being debated and could also provide reinforcing price signals for VMT reduction and revenue for compact development and more transportation choices.

7.1.3 Enact "Green-TEA" Transportation Legislation that Reduces GHGs

The Intermodal Surface Transportation Efficiency Act of 1991 (known as ISTEA), represented a revolutionary break from past highway bills with its greater emphasis on alternatives to the automobile, community involvement, environmental goals, and coordinated planning. The next surface transportation bill could bring yet another paradigm shift—it could further address environmental performance, climate protection and green development. We refer to this opportunity as "Green-TEA."[38]

Transportation policy is climate policy. With another $300 billion to be reauthorized by Congress in 2009, it represents the largest category of federal infrastructure funding. As discussed in this book, how this money gets spent has a major impact on the nation's VMT and greenhouse gas emissions.

Accountability for GHG Impacts of Transportation Spending. Congress should require the U.S. Department of Transportation (US DOT) to assess the GHG impact of proposed reauthorization bills to determine conformity with national climate goals (i.e., a target percentage below 1990 levels by 2030, consistent with reaching 60-80 percent below 1990 GHG levels by 2050). This analysis would be based in large part on newly required regional scenario analyses conducted by Metropolitan Planning Organizations (MPO). If the transportation bill is expected to generate emissions that are inconsistent with national climate goals, then US DOT should develop a national climate plan that conforms to a mobile source GHG emissions budget and work with MPOs to modify their plans accordingly.

More Funding for Transportation Choices. A half-century ago, the U. S. adopted the Federal-Aid Highway Act of 1956, launching an unprecedented engineering project that quickly changed everything about the way Americans travel and build communities. Today, the Interstates are complete, and we need to invest in an equally ambitious effort to complete the rest of the nation's transportation system. While we work to maintain our world-class highway network, we must build other world-class systems, including public transportation and bicycling and pedestrian networks. These should be complemented by policies that encourage compact, mixed-use development, telecommuting, and pricing of auto use to better manage congestion and raise revenue for alternatives, such as New York City's proposed congestion pricing system.[39]

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[38] As proposed by the Center for Clean Air Policy, see http://www.ccap.org/transportation/smart.htm.
[39] http://www.nyc.gov/html/planyc2030/downloads/pdf/full_report.pdf.

Such investment is badly needed. Demand for New Starts funding is so great that most cities offer far more than the required local match to secure federal funds. Roughly 300 transit projects are authorized in the current federal transportation bill, yet funding is far below demand, producing only about a dozen projects every six years. The process to secure federal funding is also notoriously burdensome and time-consuming. Bicycle and pedestrian travel has also increased in the last decade, and is anticipated to rise. Currently, dedicated federal funding for these "non-motorized" choices stands at about 1.4 percent, even though bike and walking trips account for between 8 and 9 percent of all trips taken.

More Funding for Repair and Reconstruction. Making repair and reconstruction of existing infrastructure the top priority is consistent with climate change goals. Less money should be allocated to new or expanded highways, until deficiencies in critical facilities (e.g., those that threaten public health and safety) are eliminated and even then, only if highway projects can be shown to reduce greenhouse gas emissions and VMT.

"Fix-it-first" policies would establish powerful incentives for reinvestment in existing neighborhoods.[40] New infrastructure investment would stimulate infill development and opportunities for more transportation choices, shorter trips, and reduced GHG emissions. Investment in repairs will help ensure that our bridges, tunnels, and other facilities are safe to use. Such investments can be justified on cost-effectiveness grounds. For example, a recent report from the Sacramento Area Council of Governments found that providing infrastructure for sprawl developments costs an average of $20,000 more per unit than for smart growth developments. With regard to repair, deferred maintenance may reduce expenditures in the short term, but years of neglect create poorly performing infrastructure with much larger long-term repair and reconstruction costs. Deteriorating infrastructure in a community can also discourage private investment.

Increased investment would make up for the federal government's flagging contribution to infrastructure maintenance over the past several decades. The graphs below show that although both capital and operations & maintenance (O & M) spending have grown dramatically since 1980, the federal share of O & M has not risen at the same rate. This has increased pressure on state and local governments to make up the gap in funding needed to maintain aging infrastructure. The problem is particularly evident in older suburban neighborhoods where developers are seeking to build compact mixed-use projects but are facing resistance from residents concerned about their capacity to accommodate growth.

A fix-it-first policy can be implemented through several mechanisms. One option is to apply strict performance-based criteria to core funding programs (National Highway System, Interstate Maintenance, Surface Transportation Program, and Bridge Program) so that no funds can be spent on new roadway capacity until all critical facilities are brought up to minimum safety standards. Another alternative is to create minimum set-aside requirements for repair and reconstruction. For existing programs, like the Bridge and Interstate Maintenance programs, funding could be also increased to ensure that such set-aside requirements are practical.

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[40] The declaration of findings in the 1991 ISTEA legislation includes an emphasis on maintaining and enhancing system components before investing in new ones; similar State legislation enacted in New Jersey could provide a model to follow in other States.

To ensure that locales follow through with plans for redevelopment, a share of federal funds could be held back and rewarded only after infill-enabling policies are implemented successfully. Such a strategy has been used for infrastructure investment under Massachusetts' smart growth program.

The private sector can also be enlisted in the effort. Specifically, tax credits and low-interest revolving fund loans should be offered to privately financed projects that revitalize and retrofit public infrastructure. Such investments would not only benefit those projects, but would also catalyze investment in adjacent areas.

7.1.4 Replace Funding Formulas with Funding Based on Progress Toward National Goals

We recommend that transportation agencies develop a system of performance measures to meet specific national, state, and local goals pertaining to climate stabilization, energy security, accessibility for low-income and disabled persons, and safety. We believe that a mode-neutral plan to achieve such goals will result in several-fold increases in funding for public transportation, bicycling and pedestrian facilities, and reinforcing land-use changes. The kinds of programs that might see major increases include federal New Starts and Small Starts, federal Safe Routes to School, Transportation Enhancements, the Non-Motorized Pilot Program (which should be converted from a pilot to a regular program), and the Jobs Access and Reverse Commute Program.

Applying performance criteria to roadway infrastructure will likely result in a decrease of unnecessary and traffic inducing highway projects, because most projects have never been scored against any rigorous performance criteria. Many are among the 6,371 new earmarks from the 2005 SAFETEA-LU Act or are otherwise justified based on criteria that are much looser than those faced by transit proposals. Also, they are less likely to be able to compete as well with regard to the urgent national priorities of energy security and climate change discussed in this book.

To achieve a performance-oriented approach, our nation will have to fundamentally transform its transportation policies. Current funding formulas are based on VMT, fuel use and lane miles – thus rewarding increased GHG emissions. Moreover, gasoline tax revenues are dependent on the steady or increasing VMT levels and more funding is allocated to areas with more VMT. As long as our transportation industry is dependent on VMT levels being high, the task of reducing VMT will be extremely difficult. The current crisis in the federal transportation trust fund is actually an excellent opportunity to rethink how revenues are raised in light of national priorities for energy and climate.

States could require metropolitan transportation improvement programs (TIPs) to demonstrate their compliance with statewide measures, creating pots of money to use as rewards for meeting desired targets, and tracking the effectiveness of various VMT-reduction strategies. Potential measures to be achieved by 2030 might include:

- Reduce per capita VMT in a metropolitan region by 25 percent;
- Reduce statewide per capita VMT by 20 percent;
- Reach a state of good repair for roads and bridges to address safety and maintenance issues; and
- Double access to transportation alternatives and increased mode shares for transit, bicycling, walking, carpooling, or telecommuting to expand the transportation choices available to all Americans.

The original ISTEA legislation, as passed by the Senate in 1991 (and way ahead of its time), provides a model of how federal funding could be transformed to a performance-based system. This legislation would have created an Energy Conservation, Congestion Mitigation, and Clean Air Act Bonus program. The original language was as follows:

> This paragraph shall apply beginning in fiscal year 1993 and shall apply only to those States with one or more metropolitan statistical areas with a population of two hundred fifty thousand or more. The amount of each such State's Surface Transportation Program funds determined pursuant to section 133(b)(1)(A)(i) shall be reduced by multiplying such amount by a factor of 0.9 if the State's vehicle miles of travel per capita is more than 110 per centum of its vehicle miles of travel in the base year. Reductions in apportionments made pursuant to the preceding sentence shall be placed in a Surface Transportation Bonus Fund and shall be used, to the extent such funds are available, to increase the amount of Surface Transportation Program funds determined pursuant to section 133(b)(1)(A)(i) by a factor of 1.1 for each State affected by this paragraph, if such State's vehicle miles of travel per capita is less than 90 per centum of its vehicle miles of travel per capita in the base year. Funds remaining thereafter in the Surface Transportation Bonus Fund, if any, shall be apportioned to the States affected by this paragraph in proportion to each State's share of Surface Transportation Program funds determined pursuant to section 133(b)(1)(A)(i) among all such States prior to any adjustments made pursuant to this paragraph. Funds so apportioned shall be treated as funds pursuant to section 133(b)(1)(A)(i) area treated. For the purposes of this paragraph, the term "base year" shall mean the year 1990 for fiscal years 1993, 1994, and 1995, and shall mean the year 1995 for fiscal years 1996 and all subsequent fiscal years."

Such a bonus program could be administered either through state allocations and metropolitan suballocations, or better still, through direct allocations to MPOs (as described in the next section).

7.1.5 Provide Funding Directly to Metropolitan Planning Organizations

When MPOs were first established and formally recognized, a number of federal programs requiring regional planning came within their purview (Lewis and Sprague 1997). With the "new federalism" of the Reagan administration, MPOs lost most of the programs they briefly controlled (McDowell 1984). The one program remaining was transportation planning, but new regulations gave states full sway in determining the functions for MPOs. This meant that many MPOs were in the role of merely "rubber-stamping" decisions already made by state highway departments (Solof 1997).

The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 reversed this trend, somewhat. ISTEA gave MPOs new authority and responsibilities. MPOs were to craft 20-year long-range transportation plans that were fiscally constrained to meet realistic revenue projections. They also had to adopt short-range transportation improvement programs to formally allocate federal transportation dollars to specific projects. They also now had some additional money to allocate. Before ISTEA, federal law mandated that states siphon off a tiny percentage (less than 1%) of their allocation of federal transportation dollars for MPOs. This money did not fund projects; it was to be used for MPO basic operations (staff, facilities, etc.). The funds for projects had to come through the state DOT, and hence was subject to the state's discretion and priorities.

ISTEA changed this by providing a minimum suballocation to MPOs (with 200,000+ population): in addition to providing some operating funds, states had to guarantee a minimal amount of project funding to their MPOs. Under the current transportation law, SAFETEA-LU, that amount is 5% of a state's federal highway allocation (Wolf, Puentes, Sanchez and Bryan 2007).

As important as these changes were, they have hardly made a dent in what is an increasingly inequitable distribution of transportation dollars. Metropolitan areas contain more than 80% of the nation's population and 85% of our economic output (Puentes and Bailey 2005). Investment by state DOTs in metropolitan areas lags far behind these percentages (Hill, Geyer, Puentes, et al 2005).

The issue is not just the *amount* of funding; it is also the authority to decide *how* the money is spent. More than one-third of the states that receive Congestion Management Air Quality funds—funds that by definition are to be used in MPO areas—do not suballocate those funds to their respective MPOs. Only 12 states suballocate federal Transportation Enhancement program dollars to MPOs. The state decides how these funds are to be spent. Even with the 5% of funds that are required to be suballocated to MPOs, many MPO staff report that the state DOT still wields substantial influence (Puentes and Bailey 2005).

What is necessary to remedy the long history of structural and institutional causes behind these inequities is a new system of allocating federal transportation funds directly to metropolitan areas. Instead of sending federal allocations to the states and expecting the states to "do the right thing" for metropolitan areas, future federal legislation should provide for the direct allocation funds to MPOs, without filtering funds through state DOTs.

Moreover, the amount of allocation should be closer to the proportion of an MPO's population and economic activity compared to other MPOs and non-MPO areas in the same state. A starting basis for making these calculations is the point-of-sale gas tax collection. Because different states have different relative demands for rural and interstate facilities, this formula could be adjusted on a state-by-state basis to reflect those variations.

7.1.6 Develop a National Blueprint Planning Process that Encourages Transportation Choices and Better System Management

Good planning is critical to the viability of alternative transportation modes and land use reforms at a regional scale. The State and Metropolitan Planning sections of the transportation reauthorization bill (Green-TEA) could require Land Use and Transportation Scenario Analyses for all regional transportation plans. Near-term Transportation Improvement Programs and Long Range Transportation Plans currently require alternatives analyses for specific large projects, but not for the full program or land use plans. It is difficult to discern the benefits from coordinated transportation land use policies on a project-by-project basis. Therefore, under the current system, innovative land use-based policies are more difficult to justify.

The next federal transportation bill should fix this problem by examining both the project scale and cumulative benefits of projects. It should also increase funding for coordinating regional transportation and land use planning to facilitate maximizing opportunities for transit-oriented development, intermodal transportation centers, and more compact, walkable neighborhoods. Scenario and visioning initiatives should also include robust public participation components. Efforts such as the California Blueprint Planning Grants and Blueprint Learning Network provide useful models for other states and regions.[41] Regions whose plans help attain performance goals should be able to access additional funding for implementation and other uses. A "Green-TEA" could establish a National Blueprint Learning Network and National Blueprint Planning Grants.

7.1.7 Place More Housing Within Reach

Many homebuyers "drive til they qualify," that is, they purchase a less expensive home further away from where they would ideally like to live.[42] With rising gasoline costs, the financial trade-off between a longer commute and cheaper housing is changing.[43] The potential savings from living in a convenient location with transportation choices is becoming a more important aspect of affordability.[44]

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[41] California Department of Transportation (2007), "Blueprint Learning Network." http://www.dot.ca.gov/hq/tpp/offices/orip/BLN.htm. Also see California Department of Transportation (2007), "California Regional Blueprint Planning Program." http://calblueprint.dot.ca.gov/

[42] Carrie Makarewicz, Tom Sanchez et. al. , Housing and Transportation Financial Tradeoffs and Burdens for Working Households in 28 Metropolitan Regions, Center for Neighborhood Technology and Virginia Tech, 2006, at H-T-Tradeoffs-for-Working-Families-n-28-Metros-FULL.pdf.

[43] Barbara Lipman (ed), A Heavy Load: The Combined Housing and Transportation Burdens of Working Families, Center for Housing Policy, National Housing Conference 2006 at www.nhc.org.

[44] Scott Bernstein, Carrie Makarewicz, Kevin McCarty; ***Driven to Spend***, Center for Neighborhood Technology and Surface Transportation Policy Partnership, 2005, at www.transact.org. Center for Neighborhood Technology and Center for Transit Oriented Development, The Affordability Index: A New Tool for Measuring the True

The Congressionally chartered Millennial Housing Commission has called for a dramatic increase in investment for housing that is affordable to a wide range of individuals and working families of modest means, including teachers, firefighters, nurses, and older Americans. Contrary to widespread beliefs, transit oriented development serves an extremely diverse population and will continue to do so.[45] Greatly expanding the supply of housing in walkable neighborhoods with high-quality transit is a way to satisfy this unmet demand and offer living arrangements that more people can afford. Recent studies for the Federal Transit Administration, the Dept. of Housing and Urban Development, and the Ford Foundation show that much of the need for housing over the next 30 years can be met within walking distance of the nation's 4,000 existing and development transit stations, with significant reduction of VMT.[46] Transportation investments, land development practices, and coordinated planning can also help achieve affordability and access goals while also reducing greenhouse gas emissions. Tax credits can provide a powerful incentive for investment in projects with coordinated land use and affordable housing.

Smart Location Tax Credit. The federal government and some state governments currently provide tax credits for hybrid vehicles, solar technology installation, and other technologies that reduce energy use. The same can be done for smart locations that inherently save energy from vehicle trips. The federal government should direct states to identify smart locations based on the "4D" performance criteria discussed in this book: density, diversity, design, and destination accessibility. Developers of new for-sale or rental units within the most efficient location tiers could qualify for a federal Smart Location Tax Credit. A portion of the incentive can be used to finance affordable units. The transportation choices available in these locations would reduce household transportation costs, an important cost saving to the people living in these homes.

Housing Rehabilitation Tax Credit: For existing housing, federal tax credits for rehabilitation should be provided to revitalize all existing housing units in neighborhoods that generate lower VMT per household than the regional average. As discussed above, federal guidelines would require each state to identify smart location zones that would benefit from the rehabilitation tax credit.

These tax credits serve multiple and critical national needs, from affordable housing to neighborhood reinvestment. They could be funded by reducing subsidies that are incompatible with a national focus on climate change, such as capping the tax-free parking benefit at its current level ($215 per month) or a reduced level (that is, capping it at $200 per month). Also, they could complement existing federal tax incentives that support affordable housing, reinvestment, and historic preservation. The value of tax credits could be increased when the Low Income Housing Tax Credit is also used to benefit smartly located and/or rehabilitation projects, which would help create housing choices for households of different income levels.

Affordability of a Housing Choice, Brookings Institution, 2006 at www.brookings.edu/metro/umi/pubs/20060127_aff**index**.htm.

[45] Preserving and Promoting Diverse Transit-Oriented Neighhborhoods, Center for Neighborhood Technology and Center for Transit Oriented Development, 2006 at http://www.cnt.org/repository/diverseTOD_FullReport.pdf.

[46] Hidden in Plain Sight: Meeting the Coming Demand for Housing Near Transit, Center for Transit Oriented Development 2005 at www.reconnectingamerica.org.

The federal Historic Preservation Tax Credit has been one of the most effective tools for revitalizing neighborhoods and repopulating older cities, suburbs, and towns. It should be strengthened and expanded to benefit a wider range of historic properties and to be combinable with other tax credits to facilitate more revitalization and affordable housing production.[47]

7.1.8 Create a New Program to Provide Funding to "Rewrite the Rules"

Builders, developers, and industry analysts have conducted market research studies that show a strong and growing demand for walkable, mixed-use neighborhoods with good transit access (see Chapter 1). However, outdated local development regulations (such as subdivision regulations, zoning, parking standards) often make this type of development the hardest thing for a developer to build. Ironically, creating neighborhoods that resemble some of our nation's most appealing places, such as the Georgetown neighborhood in Washington, D.C., or Charleston, South Carolina, is technically illegal in many places because such construction would violate current codes.

The problem is not lack of desire from cities, counties, or towns. In fact, many localities want to modernize their obsolete codes. However, limited planning funds make it hard to both run the development process and redesign it. The federal government provides vast technical assistance resources for everything from agricultural practices to homeland security. Congress should establish a new program to help communities update development rules to support more walkable, town-style, environmentally friendly development.

At the very least, such changes should allow smart growth and compact development a chance to compete by facing the same development process that conventional development must follow. Leveling the playing field would benefit consumers as they shop around for housing and development choices. Most communities already have a surplus of large-lot, single-family homes, and those that wish to change increasingly want to rewrite the rules to encourage compact development, much in the same way that conventional suburban development was subsidized and facilitated through federally discounted mortgages, infrastructure, planning and zoning rules, and other incentives. Changing the rules in just the 50 largest American metropolitan areas would quickly bring more housing, neighborhood, and transportation choices to about 168 million people, or more than half of all Americans.

7.2. State Policy Recommendations

In the absence of major federal action, many states are already moving ahead with plans to reduce CO_2 emissions. Some states have banded together in compacts like the Regional Greenhouse Gas Initiative and the Western Regional Climate Change Initiative to create cap-and-trade programs. In addition, twenty-nine individual states have created climate action plans; California and New York have some of the best defined plans.

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[47] Working with the Internal Revenue Service and State Historic Preservation Offices, the National Park Service in 2006 approved 1,253 rehabilitation projects that attracted a record-breaking $4.08 billion in private investment, which is equivalent to a more than 5 to 1 return on federal tax credits invested.

State climate plans in New York, Connecticut and Massachusetts include comprehensive VMT-reduction recommendations, though implementation has been mixed.[48] New York state requires its Metropolitan Planning Organizations to report GHG impacts of Transportation Improvement Programs and Long Range Transportation Plans (both are required to receive federal transportation funds).[49] Connecticut created an Office of Responsible Growth to promote transit-oriented development, provide transit alternatives, encourage walkable communities and target state funding to support development in designated Responsible Growth areas.[50] The California Energy Commission runs a working group tasked with developing recommendations on achieving GHG reductions from smart growth policies. In August 2007, the Commission released a set of policy recommendations on land use and climate change based on a comprehensive review of state and local efforts.[51]

Our recommendations for state policies incorporate development and land use as VMT and CO_2 reduction strategies and will work with or without the federal policies described above. They include:

1) Set state targets for VMT as part of a CO_2 reduction plan;
2) Adopt state transportation and land use policies that supports climate goals;
3) Improve transportation planning models to reflect the latest research on how the built environment affects travel behavior (regional travel forecasting, trip generation, etc.);
4) Align state spending with climate and smart growth goals;
5) Eliminate perverse local growth incentives; and
6) Create economic development incentives.

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48 CCAP (2003) on Collaboration with the New York Greenhouse Gas Task Force, "Recommendations to Governor Pataki for Reducing New York State Greenhouse Gas Emissions." http://www.ccap.org/pdf/04-2003_NYGHG_Recommendations.pdf. See also CCAP(2004), "Connecticut Climate Change Stakeholder Dialogue: Recommendations to the Governor's Steering Committee." http://www.ccap.org/Connecticut.htm.

49 ICF Consulting (2005), "Estimating Transportation-Related Greenhouse Gas Emissions and Energy Use in New York State." http://climate.dot.gov/docs/nys.pdf.

50 Rell (2006), Executive Order 15. http://www.ct.gov/governorrell/cwp/view.asp?A=1719&Q=320908.

51 California Energy Commission, "The Role of Land Use in Meeting California's Energy and Climate Change Goals," August 2007.
http://www.energy.ca.gov/2007publications/CEC-600-2007-008/CEC-600-2007-008-SF.PDF.

7.2.1. Set State Targets for Vehicle-Miles of Travel

Establish a GHG Reduction Plan That Includes a Target for VMT Reductions

If the federal government does not act to reduce GHG emissions and VMT, states can take the lead and establish their own goals. Whether federally or state driven, the state target should be allocated among local governments within the state, or, where localities are highly fragmented, to regional governments.

To achieve the targets, local and regional governments would submit plans to the state using the strategies that best fit their communities. States would then rate those plans and provide greater financial support and regulatory relief to those places with better implementation plans. Meeting VMT targets provides the opportunity to achieve significant co-benefits (e.g. greater housing and transportation choice, fiscal savings, providing services in underserved neighborhoods), so the state may also rate local plans according to their achievement of these benefits. To help communities meet these targets, the state can provide grants and technical assistance to help localities develop realistic plans that score better and become eligible for greater state aid. New federal transportation policy (Green-TEA) could help by providing supportive policies and incentives.

As explained in Section 7.1.1., this system is similar to the one currently employed to meet air quality standards under the Clean Air Act (CAA). Under the CAA, metropolitan regions must inventory their emissions sources and develop plans to bring those emissions in line with clean air standards. For example, most metro regions already inventory their VMT and associated emissions. They also project future VMT and develop strategies to reduce emissions from both current and future auto trips.

Washington State's Commute Trip Reduction program employs a similar strategy and is focused explicitly on reducing single-occupant vehicle commutes and greenhouse gases.[52] To achieve these goals, the state has set targets for reductions in single occupant vehicle commutes and VMT per commuter. Local jurisdictions must then set goals that are at least equal to the state goals and create plans for achieving the target measures. This program is described on the web site as follows:

> 1) **Program goals.** This section establishes the goals and targets for the CTR program that every city and county shall seek to achieve at a minimum for the affected urban growth area within the boundaries of its official jurisdiction. Every two years, the state shall measure the progress of each jurisdiction and region toward their established targets for reducing drive-alone commute trips and commute trip vehicle miles traveled per CTR commuter. Local and regional goals and measurement methodologies shall be consistent with the measurement guidelines established by WSDOT and posted on the agency's web site.

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[52] See the Washington Department of Transportation Web site at http://apps.leg.wa.gov/WAC/default.aspx?cite=468-63-030

2) **Statewide minimum program goals and targets.** The goals and targets of local jurisdictions for their urban growth areas shall meet or exceed the minimum targets established in this section.

a) The first state goal is to reduce drive-alone travel by CTR commuters in each affected urban growth area. This will help urban areas to add employment and population without adding drive-alone commute traffic. The first state target based on this goal is a ten percent reduction from the jurisdiction's base year measurement in the proportion of single-occupant vehicle commute trips (also known as drive-alone commute trips) by CTR commuters by 2011.

b) The second state goal is to reduce emissions of greenhouse gases and other air pollutants by CTR commuters. The second state target based on this goal is a thirteen percent reduction from the jurisdiction's base year measurement in commute trip vehicle miles traveled (VMT) per CTR commuter by 2011.

3) **Local program goals and targets.** Local jurisdictions shall establish goals and targets that meet or exceed the minimum program targets established by the state. The goals and targets shall be set for the affected urban growth area in the city or county's official jurisdiction, and shall be targets for the year 2011 based on the base year measurement for the urban growth area.

a) Each local jurisdiction shall implement a plan designed to meet the urban growth area targets. Progress will be determined every two years based on the jurisdiction's performance in meeting its established drive-alone commute trips and VMT targets. Local jurisdictions shall establish base year values and targets for each major employer worksite in the jurisdiction. However, the targets may vary from major employer worksite to major employer worksite, based on the goals and measurement system implemented by the jurisdiction. Variability may be based on the following considerations:

7.2.2. Adopt State Transportation and Land Use Policies That Supports Climate Goals

Guide Transportation Investments to Projects That Support the Creation of Walkable Communities, More Transportation Choices, and the Achievement of Climate Goals

The prevailing method of transportation planning—trying to keep up with demand by simply "projecting and providing"—has proved to be both more expensive and less successful than many would wish. In spite of large transportation investments, congestion nationally continues to worsen year after year. Further, future projected needs far outstrip any reasonable estimates of available funds. Finally, beyond fiscal constraints, climate change, an aging population, changing market demand, and other macro-trends suggest that a continuation of strategies that rely nearly exclusively on automobile transportation is untenable.

Instead, states can work with localities and the public to identify future land use and transportation scenarios that provide a wide and suitable array of transportation choices, manage the growth of VMT and emissions, reduce household and government transportation expenses, and support greater access and mobility for all citizens. The California Department of Transportation is currently supporting this approach through its BluePrint project where localities proactively examine future growth scenarios and make investments to achieve the desired scenario. Similar processes have worked in Utah (Envision Utah) and Oregon (The LUTRAQ project). In these latter cases, the preferred future growth scenarios reduced vehicle miles of travel, created better traffic outcomes and saved infrastructure costs. Both studies are included in the literature reviewed above.

Once a future land use/transportation scenario is identified, states can then direct every new investment toward building that scenario. This is substantially different from the current process, because rather than simply responding to land use changes transportation investments now help to shape those changes in a way that leads to better outcomes. Investing in a specific vision for a region's or community's future will ensure that the future is more than just the sum of individual projects, and that development decisions and policies help meet economic, environmental, community, and fiscal goals. State policy changes that implement this approach include:

- A shared state and local vision of the future transportation system;
- Evaluating the full range of options and outcomes in a mode-neutral way, including system and demand management, land use, and alternative modes;
- A State transit village program to coordinate state policy for growing transit locations and identify future transit-oriented development (TOD) opportunities (e.g., New Jersey);
- State standards to allow roads to adapt to the surrounding land use and the adoption of context-sensitive design more broadly (many states, including Montana, Ohio, Massachusetts, Texas, and Washington);
- State access management policies that are consistent with the future transportation system (e.g., managing highway access for new developments to better manage traffic loads; leading examples include policies in Colorado, Maryland, Florida, Oregon, and Delaware);
- State connectivity policies that rely more on a larger number of smaller, interconnected road facilities, with accompanying state funding for smaller-scale roads;
- A Fix-it-First infrastructure policy (e.g., New Jersey's Fix-it-First program for transportation);
- Adoption of a "complete streets" policy and an emphasis on providing a variety of attractive transportation options to the maximum number of people (e.g., St. Louis and San Diego);
- Elimination of state restrictions that prohibit gasoline tax revenues from being spent on public transportation and other modes (most states do not have such prohibitions); and
- Requirements for developers to assess and mitigate climate impacts of large projects (e.g., Massachusetts[53]; King County, Washington[54]).

[53] Massachusetts Executive Office of Energy and Environmental Affairs (2007), "MEPA Greenhouse Gas Emissions Policy and Protocol." http://www.mass.gov/envir/mepa/pdffiles/misc/ghgemissionspolicy.pdf.
[54] King County (2007), "Executive Order on the Evaluation of Climate Change Impacts through the State Environmental Policy Act." http://www.metrokc.gov/exec/news/2007/pdf/climateimpacts.pdf.

Also, with successful trials around the globe, roadway pricing strategies will likely become a key tool in managing traffic congestion and raising revenue in the U.S. States will play a key role in approving metropolitan pricing schemes, as will the federal and local governments. Such efforts can have a major impact on VMT reduction and funding alternatives, such as infill development, cycling and walking infrastructure, transit operations and capital, and other priorities.

7.2.3. Align State Spending With Climate and Smart Growth Goals

Set Performance Standards for Discretionary and Formula-Allocated Spending, and Target Spending to Areas that Rank Better for Smart Growth

States should ensure that funding programs support climate and VMT reduction goals and should adopt policies to reward local governments that help to meet such goals. States should begin by inventorying all available discretionary funds in such areas as housing, economic development, infrastructure, water and sewer, schools, transportation, state facilities, and recreation. These funds can then be allocated to localities according to their performance in meeting state goals. This inventory should include not only state funds, but also federal funds passed through the state over which the state has discretionary control. These discretionary funds, if thoroughly identified and pooled, can amount to a significant incentive for counties and municipalities. When Massachusetts employed this approach, discretionary funds totaled roughly $500 million within an annual state budget of $27 billion.

After completing its inventory of discretionary funds, the state should develop a coordinated investment approach that would tie funding to local performance on the state's priorities for transportation, housing, tax reduction, and climate. One mechanism for judging performance is a scorecard modeled on the Commonwealth Capital Fund in Massachusetts. This scorecard system awards points when local governments change their development rules and funding to promote more compact, mixed-use, walkable neighborhoods. Communities that score well receive access to some funding when the rule changes are made, and receive access to the larger, remaining portion of funding when new development projects are permitted—tightly linking spending with results.[55] These incentives have lead directly to hundreds of changes to local zoning in Massachusetts cities and towns. These changes contributed to increased production of multi-family housing units from 3,800 to more than 7,000 units annually.

Another state scorecard system is used by the California Infrastructure and Economic Development Bank's Infrastructure State Revolving Fund Program. It rates applications on a 200-point scale that gives substantial preference to projects that:

1) are located in or adjacent to already developed areas and in a jurisdiction with an approved General Plan Housing Element;
2) are located in or adjacent to and directly benefit areas with high unemployment rates, low median family income, declining or slow growth in labor force employment, and/or high poverty rates; and
3) improve the quality of life by contributing to public safety, health care, education, day care, greater use of public transit, or downtown revitalization.

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[55] For more information on Massachusetts' Commonwealth Capital Fund and its scorecard, please see: www.mass.gov/?pageID=gov3topic&L=2&L0=Home&L1=Smart+Growth&sid=Agov3.

Unlike a state's discretionary funds, "formula funds" are distributed to localities on the basis of a formula that is applied annually to a given funding stream (e.g., gas tax revenues, housing funds). Thus, each locality is guaranteed a share of this money. Without changing the geographic allocation of these funds, states can ensure that these dollars are invested in projects that contribute to meeting state goals. The top priorities should be to minimize long-term costs of maintenance and maximize the safety and security of existing roads, bridges, transit, water systems, and other critical community infrastructure. In doing so, the state gets the additional and climate-friendly outcome of making infill and redevelopment more attractive. Therefore, states can designate that a certain percentage of "formula-funded" transportation, school, housing, or other funds to go to the operation and maintenance of existing transportation, water, and wastewater infrastructure.

The remaining funds can be made available to projects that perform best with respect to meeting state goals. Projects within a locality should compete for these funds based on performance, without a predetermined water treatment technology or transportation mode. With this "means neutrality" built in, more innovative projects will be able to successfully compete and become established in the market.

7.2.4. Create Economic Development Incentives

Modernize Incentives to Support Growth and Climate Goals

The average state enables and oversees more than 30 different kinds of company-specific economic development incentives. Most are effectively as-of-right (rather than competitive or discretionary), and many are granted by local or regional bodies. While a few (e.g., brownfield remediation credits) are *de facto* limited primarily to developed areas, they are not officially linked to state land use policy or to transportation planning through enabling legislation. Very few state incentives are harnessed to facilitate shorter commutes, transit-oriented development, or other efficient practices.

Maryland's Smart Growth Areas Act explicitly seeks to better coordinate economic development with planning. Enacted in 1997, the law designates Priority Funding Areas (PFAs), defined as those areas that are already served by water and sewer infrastructure or are planned to receive infrastructure (both urban and rural). The state will spend infrastructure and economic development money only within these PFAs. Areas outside the PFAs are ineligible for state assistance in the form of infrastructure spending or economic development incentives; if development happens there, it will happen without help from the state. The law is one of several Maryland initiatives to preserve rural lands and revitalize cities and towns.

Illinois' Business Location Efficiency Incentive Act, enacted in 2005, gives a small additional corporate income tax credit under one common state incentive (Economic Development in a Growing Economy) if the job site is accessible by public transportation and/or proximate to affordable workforce housing.[56] Companies seeking the additional credit at sites that do not initially qualify can later qualify with a site remediation plan that includes measures such as an employer-assisted housing plan, shuttle services, pre-tax transit cards, or carpooling assistance.

By virtue of their statutory control over both state tax credits and the most common kinds of local incentives, such as property tax abatements, tax increment financing districts, and enterprise zones, states have an enormous amount of unrealized power to recast economic development as a tool for efficient growth and reduced VMT.

7.2.5. Eliminate Perverse Local Growth Incentives

Reduce Competition Between Local Governments and Eliminate the "Fiscalization of Land Use" That Distorts Local Priorities

Local governments rely upon a variety of state-regulated revenue streams to fund local public services. But state policies sometimes depress one stream (e.g., property taxes) while enabling another (e.g., local sales tax increments), giving local governments a fiscal incentive to avoid, for example, residential land use and instead subsidize big-box retail projects. The result of these decisions can be the concentration of jobs far from workers, under-provision of affordable housing and housing for families, and attempts to export negative impacts of development to neighboring jurisdictions.

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[56] SB2855, at http://www.ilga.gov/legislation/BillStatus.asp?DocNum=2885&GAID=8&DocTypeID=SB&LegId=23994&SessionID=50, promoted by a coalition of public interest organizations including Good Jobs First, Center for Neighborhood Technology, Chicago Metropolis 2020 and other groups.

It is difficult for local governments to address these issues on their own. Those that are friendly to family housing or affordable housing can become overwhelmed if their neighbors seek to block these housing types. Localities that do not aggressively zone for commercial land use risk being out-competed by neighbors that do. While local governments in a few metro areas, such as Minneapolis/St. Paul and the City of Charlottesville and Albemarle County, Virginia, have developed pacts to deter intraregional competition, this is relatively rare.

States can eliminate the perverse incentives that local governments face in the development market. In Massachusetts, local governments were reluctant to permit housing for families, fearing that an influx of children would add to the cost of education. The state now provides towns with a hold-harmless guarantee: if education costs rise, the state makes up the difference. In Arizona, local government retail incentive packages became so large and so frequent that the state passed a law prohibiting them in the Phoenix metro area. For many New England states, property taxes are the dominant funding source, and property tax reform is seen as the potential solution. In parts of the West where property tax caps are more common, sales taxes can be a driver of land use decisions, and reform efforts must focus on this dynamic.

According to the National Association of Industrial and Office Properties' (NAIOP) web site, where localities have taken steps to reduce competition for tax base the following lessons can be drawn[57]:

- In the Twin Cities Region in Minnesota, this technique has notably reduced disparities among the localities included in the pool concerning their assessed non-residential property values per capita. When this arrangement was put into effect in 1975, the greatest disparity was 50 to 1; today it is 12 to 1. It is not clear whether this technique has greatly reduced competition among adjacent or nearby localities for added non-residential development projects.32
- In the Dayton, Ohio, region, this technique has made it possible for multiple municipalities to cooperate in promoting the economic development of the entire region, including the provision of affordable housing and cultural facilities serving the entire region.
- In the Hackensack Meadows District, in New Jersey, this technique has made it possible for a regional body to develop a land-use plan that is rational from the broader perspective of an entire region, even though that region encompasses parts of 14 municipalities and two counties, without causing fiscal disadvantages to any of the those 16 legal entities.
- In Rochester, New York, the city is able to collect more funds from the local option sales tax that flows through the county government than it could if it charged that tax only within its own boundaries.

[57] http://www.naiop.org/governmentaffairs/growth/rtbrs.cfm.

7.3. Regional and Local Policy Recommendations

Many local governments are committing to action to reduce greenhouse gas emissions; more than 650 mayors have signed on to the U.S. Conference of Mayors' Climate Protection Agreement,[58] and about 400 have signed on as "Cool Mayors" with ICLEI's Mayors for Climate Protection program.[59] The Sierra Club, in partnership with King County, Washington; Fairfax County, Virginia; and Nassau County, New York, recently launched the "Cool Counties" campaign. To achieve their greenhouse gas reduction goals, these localities will have to include policies that reduce VMT. The following policies can help local governments reach the CO_2 reductions they want, while also creating and supporting strong, healthy, diverse communities where people have more choices in where they live and how they get around:

1) Change the development rules to modernize zoning and allow mixed-use, compact development;
2) Favor location-efficient and compact projects in the approval process;
3) Prioritize and coordinate funding to support infill development;
4) Make transit, pedestrians, and bikes an integral part of community development; and
5) Invest in civic engagement and education.

7.3.1. Change the Development Rules

Examine the Rules and Regulations That Govern Development, and Determine if and how They Need to be Changed to Get Smart Growth That Reduces CO_2 Emissions

As discussed in the State Policy Recommendations section, many communities want to create mixed-use neighborhoods, integrate new development with transit stops, allow more density and more compact neighborhoods, offer more types of housing to allow people of different income levels to live in the same neighborhood, or require sidewalks, bike lanes, and other bicyclist and pedestrian amenities. But many find that their development rules do not allow them to get the type of development they want. Sometimes a community may even develop a vision of what its residents want from development, only to find that it simply is not possible to fulfill the vision under the existing regulations. Part of the strategy for reducing CO_2 emissions from vehicles is to make it easier to build more location efficient, compact developments that allow people to choose walking, bicycling, or public transit.

To achieve that goal, communities should examine their development rules and determine if and how they need to be changed to meet smart growth, CO_2 reduction, and other community goals. Several tools, such as scorecards and zoning code audits, are available to help communities figure out what they need to change to get the kind of development they want.[60] Some opportunities for reform include:

- zoning codes;
- subdivision regulations;

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[58] As of August 2007; see http://usmayors.org/climateprotection/listofcities.asp for the list of signatories.
[59] See http://www.coolmayors.com/common/directory/browse_mayors.cfm?clientID=11061 for the list of mayors.
[60] See, for example, the policy and code audit tools from the Smart Growth Leadership Institute at http://www.sgli.org/implementation.html and samples of scorecards from around the country at http://www.epa.gov/smartgrowth/scorecards/.

- street design standards;
- parking standards;
- annexation rules;
- design guidelines; and
- any other regulation that affects the location and design of development.

Rarely do these regulations require a complete overhaul to make smart growth projects permissible “by right”; many times, it can be done with tools like area plans or overlay zones.

For example, Nashville/Davidson County, Tennessee, had subdivision regulations that applied to rural, suburban, and urban areas equally. Therefore, building more dense and compact development in the central city was not possible. With assistance from the Smart Growth Leadership Institute, the county revised its subdivision regulations so that different standards could be applied to different areas.[61] Now the county can preserve the character of its rural areas while permitting the vibrant development it wants in more urban areas.

Such regulatory reform efforts are largely responding to market demand that is strong across the nation. A recent national survey of developers found that more than 60 percent agreed with the following statement about compact, walkable development: ‘‘In my region there is currently enough market interest to support significant expansion of these alternative developments,” with a high of 70 percent in the Midwest and a low of 40 percent in the South Central region.[62]

State and local governments should also find ways to expedite and reward exemplary projects that meet the U.S. Green Building Council’s LEED for Neighborhood Development (LEED ND) certification standards, and consider adopting those standards as their own. Illinois, for example, just passed “The Green Neighborhood Grant Act,” which is the first state legislation to tie LEED ND standards to financial incentives. The Illinois program authorizes the Department of Commerce and Economic Opportunity to issue Requests for Proposals (RFPs) from model development projects that have received LEED ND certification, and award up to three grants to reimburse up to 1.5 percent of the total development costs.

7.3.2. Favor Good Projects in the Approval Process

Make It Easier, Faster, and More Cost Effective for Good Development Projects to Get Approved, and Offer Incentives and Flexibility to Get Better Development

Once communities have reformed their regulations to allow good development, they should make it easier for that good development to be approved. Predictability in the development process is valuable to everyone concerned: developers, local government, and community members. Laying out the guidelines and rules for what the local government considers a “good” development project makes the process more predictable and fair, as does defining the benefits developers will get from meeting or exceeding the community’s standards. Two main ways to favor good projects are to offer them flexibility and to speed the approval process.

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[61] See http://www.nashville.gov/mpc/subdivregs/intro.htm and http://www.sgli.org/communities.htm#nashville

[62] Jonathan Levine and Aseem Inam, "The Market for Transportation-Land Use Integration: Do Developers Want Smarter Growth than Regulations Allow?" *Transportation*, Volume 31, Number 4, November 2004.

Flexibility in meeting requirements gives developers room for innovation and creativity, as well as cost savings. If a development project meets or exceeds the community's goals and vision, the developer should be rewarded with, for example, a density bonus that allows them to build more in exchange for providing an amenity the community wants, like affordable housing. Alternatively, local governments can calculate the traffic reduction benefits of a development and adjust accordingly how much parking, road improvements, or air-quality mitigation the developer needs to deliver.

Developers tend to favor an approval process in which projects that follow certain guidelines or are located in targeted areas get streamlined or fast-tracked approvals. Communities might guarantee review of the project within a certain amount of time, or they might coordinate the various departments that need to review development proposals so that review happens quickly and smoothly. Of course, the process must include several opportunities for meaningful public input and review and must ensure compliance with other environmental safeguards.

Some communities do this by setting out specific desirable criteria; any development that meets these criteria gets a fast track to approval. With the advent of the LEED-ND green development guidelines, communities have a good starting point for setting standards to define walkable, environmentally responsible neighborhoods.

In Austin, Texas, the city developed a matrix of smart growth criteria to help it analyze development proposals within areas where it wants to encourage development. The matrix measures how well the project meets the city's goals, including the location of the project, its mix of uses, its proximity to public transit, its pedestrian-friendly design, compliance with nearby neighborhoods' plans, and other policy priorities, including tax base increases. For projects that score above a certain level on the matrix, the city will waive some fees or invest public money in infrastructure for the development.[63]

In other places, an outside organization plays a similar role, setting up a list of criteria and offering public support for projects that meet those criteria. For example, the Greenbelt Alliance in the San Francisco Bay Area will endorse developments that are "pedestrian-oriented and transit accessible, use land efficiently, and provide affordable housing."[64] The Greenbelt Alliance will send a letter of support to the appropriate officials and actively support a project at public hearings if requested. Similar programs, with varying degrees of endorsement, are run through alliances in many other regions.[65] While this outside support doesn't guarantee a faster process, the stamp of approval from a neutral entity can help some projects get approved.

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[63] See http://www.ci.austin.tx.us/smartgrowth/default.htm.

[64] See http://www.greenbelt.org/whatwedo/prog_cdt_index.html.

[65] See, for instance, the Vermont Smart Growth Collaborative's Housing Endorsement Program (http://www.vtsprawl.org/Initiatives/sgcollaborative/VSGC_housingendorsement.htm) or the Urban Land Institute-supported Smart Growth Alliances Information Network. (http://www.uli.org/Content/NavigationMenu/MyCommunity/SmartGrowth/SmartGrowthAllianceInformationNetwork/Smart_Growth_Allianc.htm).

7.3.3. Prioritize and Coordinate Funding to Support Infill Development

Find Funding Sources to Support Infill Development, Coordinate Funding to Get the Most Impact, and Prioritize Infrastructure Projects to Determine Where the Investment will Do the Most Good

Just as at the federal and state levels, local governments should prioritize funding, including infrastructure spending, to support development that helps reduce CO_2 emissions and meets other community, economic, and environmental goals. By directing infrastructure funds to infill projects, whether to repair existing infrastructure or build new facilities, the community is investing in the type of development that can help reduce CO_2 emissions by creating more options for residents. Just as importantly, it is not subsidizing development in far-flung areas that will generate more vehicle trips. This money is a public investment, and it should be spent wisely and with the goal of doing the most good for the most people. As the Metropolitan Council of the Twin Cities region of Minnesota puts it:

> For the metropolitan transit and transportation system, putting growth where the infrastructure to support it already exists means roads that *don't have to be built*. Providing transportation options that include fast, convenient transit services means freeway lanes that *don't have to be added*. And, where new infrastructure is necessary, investments in more connected land-use patterns will be the most fiscally responsible use of limited public resources for transportation.[66] [emphasis theirs]

Scorecards are useful to set priorities for public spending. Similar to the scorecards mentioned previously in this chapter, communities can set up criteria based on location in an area designated for growth; proximity to transit, housing, workplaces, and other amenities; need for new infrastructure; and accommodation of automobiles, pedestrians, bicyclists, and transit. Infrastructure projects and other expenditures that score highly on the scorecard get priority, or get more public funding compared to projects that score poorly.

To get the most from their investments in infrastructure, transit, housing, and other expenditures, local governments should coordinate their land use policies with these investments. This means directing development to areas around transit stations, sharing parking among different uses, building new schools in places easily accessible to the neighborhoods they will be serving, and so forth.

7.3.4. Make Transit, Pedestrians, and Bikes an Integral Part of Community Development

Create a Comprehensive Vision and Plan for Creating Safe and Accessible Routes, Networks, Environments, and Linkages to Destinations. Rewrite Rules as Necessary, and Invest in Supportive Infrastructure.

If communities make it easier for people to walk, bike, or ride transit, they create new options for people besides driving. Making transit, bike, and pedestrian amenities part of planning guidelines creates predictability for developers and can help reduce traffic from new development, which is

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[66] *2030 Regional Development Framework*, Metropolitan Council, pp. 6-7, adopted January 14, 2004, amended December 14, 2006, http://www.metrocouncil.org/planning/framework/Framework.pdf.

a major concern of many of those who live in adjacent neighborhoods. Streets that are built with not only cars, but also bicycles, transit, and pedestrians in mind—often known as "complete streets"—are safer and make people feel more comfortable walking or biking. They are also often more attractive, with shade trees, benches, and other amenities. And they provide options for people who can't or choose not to drive, including children, older people, and people with disabilities.

Localities should adopt complete streets policies and design guidelines to create safe and welcoming environments for pedestrians, cyclists, and transit users. These policies require the accommodation of all users of the right of way, and set out new procedures for ensuring that construction, reconstruction, and maintenance projects balance the needs of all users. Accommodating new, walkable development on land that once held dead shopping centers or factories, or creating transit-oriented developments at rail stations, is likely to require investments in building or retrofitting a street network for pedestrians and cyclists.[67]

A great example of a place that has put all the elements together is Arlington County, Virginia, a suburb of Washington, D.C. Arlington County's master transportation plan includes elements for transit, bicycling, and walking.[68] The county has two subway lines, part of Washington's Metrorail system, and numerous bus routes. It has coordinated its land use with these transit investments, concentrating development along the subway lines and tailoring bus lines to key corridors. The county has emphasized safe and appealing walking and biking environments, putting in bike lanes, sidewalks, crosswalks (many with "countdown" pedestrian signals to let people know how much time they have left to cross the street), and bike and walking paths that connect to trails that go throughout the Washington metropolitan region. The county has also brought in car-sharing services to make it easier for residents to own one car instead of two, or to go without a car.

As a result of having all these transportation options, Arlington has some of the highest rates in the country of commuting by means other than personal automobile. Thirty-nine percent of Arlington residents commute by public transportation, twice the national average, and 6 percent walk to work, well above the national average of 1 percent.[69] The numbers are even higher in the subway corridors; in the Rosslyn-Ballston corridor, along Metrorail's Orange Line, 38 percent of residents who live within half a mile of a station take transit to work, and 73 percent of riders using these Metrorail stations walk to the stations. The foot traffic has fostered a lively commercial, retail, and residential corridor that comprises only 7.6 percent of the county's land area, yet produces about a third of its real estate tax revenue. Meanwhile, automobile traffic has been below projections as county population has grown, showing the benefits of these transportation options not only for the people who choose to bike, walk, or take transit, but also for those who drive.

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[67] See www.completestreets.org.
[68] See http://www.arlingtonva.us/Departments/EnvironmentalServices/dot/planning/mplan/MasterPlans.aspx for a copy of the master plan.
[69] Arlington Master Transportation Plan – Second Draft, Transportation Demand Management Element – November 2006, p. 9.

7.3.5. Invest in Civic Engagement and Education

Engage and Educate Citizens in Visioning Exercises, and Require Opportunities for Meaningful Citizen Participation in Development Decision-Making

For plans to be as successful as possible, the people who will be living and working in the community must be involved in creating them. This means that residents have to have opportunities to learn about the issues and give their input on decision-making. Education might mean public meetings, gathering and publishing data and maps in an easily understood format that's relevant to people's lives, or keeping a Web site up to date on local development issues. With a foundation of basic knowledge about these issues, people are better equipped to participate in development decisions and in guiding the future of their community. When residents are engaged in the decision-making process from the beginning and feel like their concerns and ideas are being heard and considered, they are less likely to fight new development. The extra money spent on these education and engagement efforts pays off in the long run in better development projects that move through the process more smoothly.

One popular form of engagement is a visioning exercise, usually held on a regional or local scale. Participants review various scenarios for the future of the region or community and choose the one that they prefer. Usually there is a "business as usual" scenario that shows how continuing along the current path will affect open space, traffic congestion, development, air and water quality, and other quality of life issues. Other scenarios illustrate what the future could look like with denser development, more transportation options, and development directed to certain areas to preserve open space.

Visioning exercises have been conducted all over the country. One of the best examples is the Sacramento Region's *Blueprint Transportation and Land Use Study*, which used an extensive public outreach process, cutting-edge Internet-accessible planning software, and a detailed business-as-usual baseline growth forecast to help participants to explore alternative growth scenarios through 2050. The adopted preferred scenario features sophisticated infill development and transportation investments that will produce 12.3 fewer daily vehicle-miles of travel per household by 2050, a 27 percent reduction below the baseline. Other well-known examples include Envision Utah, which began in 1997 and was the first large-scale scenario planning exercise in the nation, as well as Louisiana Speaks, which was launched to help coastal communities craft redevelopment plans after the devastation from Hurricanes Katrina and Rita and attracted over 27,000 participants.

Visioning exercises create general principles and strategies for development, but the public should also be engaged in making decisions on specific development projects. They need to be involved from the beginning for their input to be meaningful, and they need to know that their ideas and concerns are being listened to and taken seriously, even if they don't end up being incorporated into the project. Some of the tools communities use to get citizen input are design workshops, charrettes, public surveys, or public meetings.

In a planning ordinance approved in 2001, the town of Davidson, North Carolina, requires new development projects to hold a charrette to get public input. These workshops allow the developer and the town's residents to understand each other's concerns and goals and to work together to make sure the development meets the community's needs. The process gives citizens the chance to have their voices heard, and it lets developers deal with problems before they can hold up the project in the approval process. Gathering public support at this early stage makes the approval process smoother for developers. Davidson has found that holding these *charrettes* helps preserve its small-town character and makes it easier to achieve its goal of making bicycling and walking safer and more pleasant.

7.4. Developing a Comprehensive Policy Package

Such a comprehensive overhaul of America's development processes will be a mighty challenge. But it is on the same ambitious scale as other proposals that are being considered in the climate change debate, including efforts to switch to renewable fuels, dramatically increase vehicle efficiency, end oil imports from hostile nations, or renew investment in nuclear power.

The fact is, no gigaton of reduction will come very easily, and few methods are likely to take advantage of consumer demand as much as those discussed in this book. In fact, many of the reforms discussed here focus on making government rules and regulations more flexible to give people more of what they want. Also, most of the communities that have adopted these reforms have done so for a wide variety of self-interested reasons, like traffic management or financial rewards, and not because they wished to reduce greenhouse gas emissions. We are confident that these improvements to the built environment can offer tremendous win-win benefits, and hope that these types of policies do get implemented across the nation and the world. They should become a sensible complement to any other climate policies that focus on energy, vehicles, power plants, or other strategies.

8. Conclusion

With regard to urban development and travel demand management, this publication asks and answers three critical questions facing the urban planning profession, land development community, and federal, state, and local policy makers:

- What reduction in vehicle miles traveled (VMT) is possible in the United States with compact development rather than continuing urban sprawl?
- What reduction in CO_2 emissions will accompany such a reduction in VMT?
- What policy changes will be required to shift the dominant land development pattern from sprawl to compact development?

The answer to the first question is a 20 to 40 percent reduction in VMT for each increment of new development or redevelopment, depending on the degree to which best practices are adopted (see Chapter 3). The answer to the second question is a 7 to 10 percent reduction in total transportation CO_2 emissions by 2050 relative to continuing sprawl (see section 1.7). The answer to the third question is a set of dramatic policy changes at all three levels of government (see Chapter 7).

Unlike other vehicle emissions, CO_2 emissions have never been regulated. Given the difficulty of changing longstanding policies, development patterns and, ultimately, lifestyles, is the 7 to 10 percent reduction in CO_2 emissions worth the effort? The answer, we believe, is "yes," for three primary reasons:

- The U.S. transportation sector cannot reach a sustainable level of CO_2 emissions through vehicle and fuel technology improvements alone. It also needs to reduce VMT, as the third leg supporting the policy stool (see Chapter 2).
- The shift from sprawl to compact development will have many other economic, environmental, and quality-of-life benefits, so any "costs" of this CO_2 reduction strategy will be offset by additional quantifiable benefits (see sections 1.5 and 1.6).
- Reductions in VMT and CO_2 emissions with compact development are sizable and long lasting compared to reductions achievable with other available actions (see section 1.7 and Chapter 3).
- Compact development provides an insurance policy against the worst effects of climate change and oil price spikes. In the worst case, current or future residents of compact development will have a variety of viable transportation options, while the residents of sprawl will not.

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