Suburbanization and Energy

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1. Suburban Sprawl
2. Transportation in Suburbia
3. Structures in Suburbia
4. Land Use, Transportation, and Energy Consumption in Other Countries
5. Transportation Alternatives for U.S. Suburbs

Glossary

devolved land As defined by the U.S. Department of Agriculture, developed land is any land no longer a part of the rural land base of the United States. This includes large tracts of urban and built-up land, tracts of built-up land of less than 10 acres, and land outside of built-up areas that is part of a transportation system (i.e., roads, rail, and associated rights-of-way).

metropolitan statistical areas As defined by the U.S. Office of Management and Budget and used by the U.S. Census, this is the delineation of urban areas that includes the central city and any surrounding counties that are socially and economically connected to an urban center.

smart growth Alternative forms of development that use land efficiently, mix land uses (such as housing, business, and shopping), and encourage walking and public transit in addition to driving while protecting surrounding open space.

sprawl Low-density, automobile-dependent development with a strict separation of land uses.

vehicle miles traveled Surface transportation miles traveled annually by passenger and freight vehicles in the United States.

Shifting from the 19th to the 20th century, new forms of transportation reshaped U.S. urban areas. Streetcars and subway lines transformed cities such as Boston, New York, and Chicago, allowing for dense concentrations of businesses and hotels. These areas were surrounded by neighborhoods often bound by ethnicity and class.

Idealists planned expansions of the city as a whole through movements such as the City Beautiful movement and the Garden Cities movement as well as through model new suburbs such as Radburn, New Jersey, Mariemont, Ohio, and Greenbelt, Maryland. These designs were precursors for those built throughout the country to fulfill the American Dream of owning a single-family detached home and an automobile. The dream became reality for millions of Americans in the years after World War II, and construction accelerated due to incentives such as the home mortgage deduction and infrastructure investments.

Most notable in terms of its impacts on our energy consumption have been investments in highways needed to serve the form of transportation that would eclipse transit—the automobile. Additionally, the large structures connected by ribbons of asphalt in suburbia have consumed increasingly more energy. This article discusses suburbia’s ascendance in the United States, the transportation and construction impacts of this trend, as well as some alternatives to sprawl being debated including “smart growth.” Smart growth entails new policies and incentives to create a greater variety in the supply of modes of transportation coupled with more and better travel demand management to conserve energy and improve environmental quality.

1. SUBURBAN SPRAWL

Much of current land development takes a form called suburban sprawl. Sprawl can be roughly defined as low-density development with a strict separation of land uses connected mostly (or only) by roads and highways. Although some sprawl occurred in the form of streetcar suburbs in the first couple of decades of the 20th century, sprawl accelerated after World War II as returning G.I.s, their families, and
other citizens left cities for the suburbs in increasing numbers. This led to declines in the populations of central cities during the latter half of the 20th century (Table I).

A study by Janet Rothenberg Pack for the Brookings Institution examined population trends in 277 metropolitan statistical areas and found that flight from existing urban areas occurred throughout the United States from 1960 to 1990. The findings are summarized in Table II. In addition to the city-to-suburb migration evidenced by Table II, it is also clear that there have been interregional population distribution changes. Southern and western regions experienced the most population growth during these three decades. The population of suburban areas of these regions more than doubled from 1960 to 1990 (Table II).

Evidence shows that these population trends are continuing and that land development is occurring at twice the rate of population growth. Some of the best U.S. land-use data collection is done by the U.S. Department of Agriculture under the auspices of the Natural Resources Inventory (NRI). The NRI defines developed land as land that is no longer a part of the rural land base of the United States. This includes large tracts of urban and built-up land, tracts of built-up land of less than 10 acres, and land outside of built-up areas that is part of a transportation system (i.e., roads, rail, and associated rights-of-way). This land specifically consists of cropland, pasture land, range land, forest land, land enrolled in the federal Conservation Reserve Program, and other

### Table I


<table>
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<td>Washington, DC</td>
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<td>Pittsburgh</td>
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<td>604,332</td>
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<td>520,117</td>
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Data from Teaford (1993).

### Table II

Population Data (in Thousands) for U.S. Metropolitan Statistical Areas (MSAs), Cities and Suburbs, Divided by Region, 1960–1990

<table>
<thead>
<tr>
<th>Region</th>
<th>Total population</th>
<th>% change, 1960–1990</th>
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<tbody>
<tr>
<td>All MSAs</td>
<td>127,575</td>
<td>149,125</td>
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<tr>
<td>Cities</td>
<td>56,529</td>
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<td>Suburbs</td>
<td>71,046</td>
<td>88,557</td>
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<td>Northeast</td>
<td>39,173</td>
<td>43,229</td>
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<td>Cities</td>
<td>16,142</td>
<td>15,705</td>
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<tr>
<td>Suburbs</td>
<td>23,031</td>
<td>27,524</td>
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<td>Midwest</td>
<td>36,264</td>
<td>41,004</td>
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<tr>
<td>Cities</td>
<td>17,227</td>
<td>17,516</td>
</tr>
<tr>
<td>Suburbs</td>
<td>19,036</td>
<td>23,489</td>
</tr>
<tr>
<td>South</td>
<td>30,625</td>
<td>37,278</td>
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<tr>
<td>Cities</td>
<td>14,207</td>
<td>16,695</td>
</tr>
<tr>
<td>Suburbs</td>
<td>16,418</td>
<td>20,583</td>
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<tr>
<td>West</td>
<td>21,513</td>
<td>27,613</td>
</tr>
<tr>
<td>Cities</td>
<td>8,952</td>
<td>10,653</td>
</tr>
<tr>
<td>Suburbs</td>
<td>12,561</td>
<td>16,961</td>
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</table>

There are important regional differences in the relationship between these two factors in the sprawl equation. In the past couple of decades, the west has been growing but not sprawling as much as it has in the past (due in part to limits of developable land, whether due to topography or federal ownership), the northeast and the midwest have been sprawling but not growing much, and the south continues to grow and sprawl rapidly (Fig. 1).

2. TRANSPORTATION IN SUBURBIA

According to the U.S. Department of Transportation (DOT), as of 1995, every U.S. driver spent an average of 443 h every year behind the steering wheel, or 43 h more than in 1990. Although commuting to and from work only accounts for one-fifth of the miles that Americans drive daily, it is also notable that peak commuting hours have been increasing. In 1982, the average daily congested period was 2 or 3 h, but by 1999 this had doubled to 5 or 6 h.

There are economic impacts as well. Americans now spend more on transportation than food, clothing, or health care. As of 1998, according to the U.S. Department of Labor, 17.9¢ from every household dollar is spent on transportation, 98% of which is spent on buying, operating, and maintaining cars. This household expenditure is second only to housing (19¢). Transportation is also sapping the strength of the American economy. The Texas Transportation Institute found that congestion cost 75 metropolitan areas $67.5 billion due to lost income and increased truck operating costs as well as excess fuel consumption (5.7 billion gallons) in 2000.

During the latter half of the 20th century, U.S. planners, engineers, and decision makers relied mostly on the expansion of road system capacity to alleviate traffic congestion. As quoted in “Divided Highways,” a history of the U.S. interstate highway system, in June 1969 Transportation Secretary John Volpe commented on this problematic modus operandi:

The federal government spends as much money on highway construction in 6 weeks as it has put into urban transit in the last 6 years. … Unless we intend to pave the entire surface of the country—and no one wants that—we have to stop this trend. We already have 1 mile of highway for every square mile of land area in the USA.

According to the DOT, 30 years later the United States had 2 miles of highway for every square mile of territory. This country has made massive investments in building a 4-million-mile highway and road network since World War II. According to a 1997 National Research Council report, U.S. highways, streets, and associated rights-of-way totaled approximately 20 million acres, or 1% of U.S. land area. Based on this figure, the Harvard School of Design estimated roads impact one-fifth of the U.S. land base in the forms of fringe noise, air, and water pollution effects from vehicle traffic.

The environmental impacts of our growing road system are significant. Habitat loss and fragmentation reduce wildlife population diversity and abundance, contributing to species imperilment. In fact, the National Wildlife Federation reported that sprawl is the main cause of species imperilment in California. Wetlands loss can also be traced to our expanding transportation system: in the Environmental Protection Agency’s (EPA) “National Water Quality Inventory: 1996 Report to Congress,” 6 states reported significant wetlands loss due to highway construction and 10 reported significant loss due to residential development. This report also found that 38% of assessed U.S. estuary miles are impaired and that 46% of this impairment is due to polluted urban runoff. This is not surprising. Runoff from impervious surfaces such as roads is considerable: Runoff from a 1-acre parking lot is 16 times that of an undeveloped meadow.

Americans have made good use of increases in pavement. U.S. vehicle miles traveled (VMT) increased steadily throughout the second half of the 20th century. According to the DOT, from 1970 to 1990 VMT doubled from 1 to 2 trillion per year, and as of 1998 Americans traveled 2.6 trillion miles annually.
Driving increasingly more miles has meant turning away from other modes of transportation, such as mass transit. Using data originally from the DOT and the American Public Transportation Association and subsequently provided by the Surface Transportation Policy Project, Fig. 2 highlights this relationship for most of the 20th century. Transit boardings hit their peak in 1946 at approximately 23.5 million, whereas annual VMT decreased during World War II (1943–1945) and then continued its climb. This brief reversal of centurywide trends can be attributed to wartime policies such as the rationing of gasoline. In the 1920s, the larger trend lines had already taken shape. At century’s end, however, VMT was barely growing, whereas transit stabilized and grew steadily from 1996 to 2001. The latest data available from 2002 show a decline in transit use of 1.3% and an increase in VMT of 1.7%. One overall trend is clear: Americans are driving increasingly more every year (Fig. 2).

2.1 Transportation Impacts on Energy and Air Quality

All of this driving has a major impact on U.S. petroleum consumption. According to the DOT, the transportation sector consumes more than 65% of the petroleum used in the United States and highway vehicles account for approximately 84% of this consumption. Basically, Americans are consuming increasingly more oil just to get around, despite improvements in efficiency. Stagnating fuel economy of the U.S vehicle fleet due to the popularity of sport utility vehicles and light trucks doubtless contributes to this trend. According to the EPA, U.S. fuel economy peaked in 1987–1988 and is currently 6% lower than in 1988. Using U.S. Department of Energy (DOE) data, Fig. 3 shows that oil consumption by the U.S. transportation sector closely follows VMT growth—steadily upward toward the 9 million barrels per day mark.

Unfortunately, combustion of all this oil also pumps many unhealthy pollutants into the air. In addition to carbon monoxide (CO), cars and trucks are also the source of volatile organic compounds (VOCs) and oxides of nitrogen (NO\textsubscript{x}). When VOCs and NO\textsubscript{x} mix while exposed to the hot sun, a chemical reaction takes place producing ozone. In recent years, ground-level ozone has been particularly problematic for large, sprawling U.S. cities such as Atlanta and Houston. Ozone is an irritant to the lungs and eyes, causing coughing and chest pains. It aggravates asthma and can have especially harmful effects on children, who breathe more air per pound of body weight than adults.

Transportation is responsible for many of these emissions, as Benfield et al. found in their 1999 book, “Once There Were Greenfields”:

In particular, cars and other highway vehicles continue to emit some 60 million tons of carbon monoxide per year, about 62% of our national inventory of that pollutant; cars and other highway vehicles continue to emit some 7 million tons per year, almost 26%, of our volatile organic compounds … and they emit around 8 million tons per year, about 32%, of our nitrogen oxides.
The transportation sector is also a growing part of the total anthropogenic greenhouse gas emissions, especially carbon dioxide. According to the EPA, transportation sources accounted for approximately 31% of U.S. carbon emissions (460.4 million metric tons of carbon) in 1997. This sector is growing rapidly: Total emissions increased 10% between 1990 and 1997. According to the DOE, more than half of this increase can be traced to cars and trucks: As of 1999, 60% of transportation-related emissions were due to the combustion of gasoline.

3. STRUCTURES IN SUBURBIA

Although the impact of a transportation sector that underwent near-complete transformation in the 20th century has been examined most closely by experts and scholars, the low-density patterns of development have also meant an increase in the average size of houses, schools, and commercial buildings. This too has energy impacts.

3.1 Residential Buildings

According to the DOE, housing is the second largest source of carbon emissions in the United States. In 1999, residential buildings accounted for 19% of total U.S. CO₂ emissions at 290.3 million tons of carbon equivalent. According to the DOE, electricity accounted for most (63%) household carbon emissions as of 1997. Not surprisingly, the large-lot, detached-housing-only residential units that make up an increasing part of the U.S. landscape consume a great deal of electricity (as well as other types of energy) compared to more modestly sized housing types. In fact, according to the DOE, as of 1997 single-family detached housing made up by far the largest percentage of residential sector energy consumption at 73.4%.

Table III summarizes consumption levels for different U.S. housing types in 1997.

A good measurement for the increase in housing size in the United States is the number of rooms in a unit. The DOE’s 1997 Residential Energy Consumption Survey showed that the size of units has grown steadily larger, resulting in greater energy use due to increased requirements for heating, air-conditioning, as well as lighting. Figure 4 shows this trend from 1978 to 1997.

Another yardstick for comparing the environmental impacts of different housing types is the ecological footprint of a given residence. Ecological footprint analysis is a tool designed by William Rees of the University of British Columbia and Mathis Wackernagel of the nonprofit Redefining Progress in the 1990s. This framework basically measures the depletion of “natural capital” by calculating how much world-average bioproductive land is needed to sustain a given population. The tool is versatile and has been used by households, schools, cities, and even nations.

This method of analyzing the impact of human activity sometimes uses the loss of “sinks” (soil,
vegetation, and water resources that absorb CO₂, removing it from the atmosphere) to account for fossil fuel consumption. It also includes the bioproductive-land-equivalent impacts of food, the built environment, and forest. Overall, it is a useful sketch tool for comparing impacts, and an analysis of housing footprints yields interesting results. Specifically, Table IV provides the results of a 1995 study of different Canadian housing types using this tool.

Suburban sprawl includes a large number of single-family detached houses. For every detached house built instead of a townhouse, ecological footprint per capita increases 17%. Also, for every detached house built instead of an apartment, a person’s ecological footprint increases 40%.

As the awareness of the significant impacts of residential development on the environment has grown, a cottage “green building” industry has also grown. Several U.S. jurisdictions and groups have codes, departments, or certification programs for green building. Austin (Texas), Boulder (Colorado), San Francisco, Seattle, Dade County (Florida), Oregon, Pennsylvania, New Jersey, New York, Minnesota, Maryland, Colorado, and Texas all feature green building efforts of some kind. Among private sector groups, the National Association of Homebuilders, the American Institute of Architects, the American Lung Association, and the Energy Efficient Building Association have programs. The U.S. Green Building Council is also working with nongovernmental organizations such as the Natural Resources Defense Council (NRDC) to develop standards for residential development as part of its Leadership in Energy and Environmental Design (LEED) certification process.

This increased interest in green building is driven in part by increasing demand. For example, 89% of U.S. consumers surveyed in a 2000 Professional Builder magazine poll said they “were willing to pay more for green building features if they improved quality, durability, and the health of the home.” More than half would pay an additional $2500–5000 and 9.5% would pay an additional $10,000 for a green home.

Considerable energy savings are possible through efficient design. In a 1998 study of the savings possible via cost-effective energy efficiency investments (in lighting, appliances, etc.) in Illinois, the American Council for an Energy Efficient Economy (ACEEE) found that 32 and 27.5% savings in electricity were achievable for existing and new single-family units, respectively. A similar 1997 ACEEE study found 37.5% (existing) and 26.5% (new) in possible savings in Pennsylvania and New York and a 51.5% (existing) and 30.0% (new) possible savings in New Jersey, all for single-family units. Therefore, possible electricity savings through energy efficiency improvements for the type of housing typically found in sprawling developments in these four states ranges from 26.5 to 51.5%.

However, few green building programs integrate criteria about neighborhood density and location efficiency, which are key components of smart growth. Changes are afoot, though. For example, Austin, Texas, has a Smart Growth Initiative complete with a matrix for calculating just how “smart” particular development proposals are, and LEED is developing new design standards that integrate “smart growth” criteria. Given the popularity of the approximately 100 New Urbanist developments built thus far, the addition of location efficiency as a criterion for determining how “green” a building is should ensure that such buildings continue to fetch a premium in the marketplace.

### 3.2 Educational Buildings

Buildings in the U.S. educational system comprise approximately 13% of total commercial building floorspace. According to the DOE, they are the largest at 25,100 square feet on average per building, compared to the average for all commercial buildings.

#### Table IV

Footprints of Various Household Types in Acres

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<th>Category</th>
<th>Standard lot detached house</th>
<th>Small lot detached house</th>
<th>Townhouse</th>
<th>Walk-up apartment</th>
<th>High-rise apartment</th>
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<td>Housing</td>
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<td>1.95</td>
<td>1.61</td>
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</table>

of 12,800 square feet. Newer schools use more energy per square foot than older schools, according to the Energy Information Administration. The National Trust for Historic Preservation finds that newer schools are larger and more apt to be located in sprawl locations than older ones. In 2000, the Department of Education studied the functional age of schools, or the number of years since a building had been constructed or renovated, and found that newer schools were larger:

On average, small schools had older functional ages than medium or large schools. Additionally, large schools were more likely than small schools to have a functional age of less than 5 years, and the small schools were more likely than large schools to have a functional age between 15 and 34 years.

This is not surprising given requirements imposed on school construction by states and localities. For example, many states adhere to the guidelines created by the Council of Educational Facility Planners International (CEFPI) when planning new school construction:

- At least 10 acres of land plus 1 acre for every 1000 students for elementary schools
- At least 20 acres of land plus 1 acre for every 100 students for middle schools
- At least 30 acres of land plus 1 acre for every 100 students for high schools

Not surprisingly, buildings on this land are also larger than they have been in the past. In 1995, CEFPI released what it terms the “starting point” for planning new school construction:

3.3 Commercial Buildings

According to the DOE, in 1999 commercial buildings consumed 16% of U.S. primary energy, and 75% of this consumption was in the form of electricity. As of 1995, the greatest energy consumers were buildings that provided or hosted food sales or services, health care-related services, lodging, public assembly, public order and safety services (i.e., police stations), and office spaces. According to the Alliance to Save Energy, carbon dioxide emissions from the commercial buildings sector have increased 30% since 1980, faster than any other sector.

The DOE sums up the scale of our stock of commercial buildings as follows:

In 1995, there were 4.6 (with a ±0.4 margin of error) million commercial buildings in the United States comprising 58.8 (±3.9) billion square feet of floorspace. That amount of commercial floorspace exceeds the total area of the state of Delaware and amounts to more than 200 square feet for every resident in the United States.

In spite of the tremendous amount of land development in recent decades, this stock is surprisingly comprised mostly of older buildings. The median building age is 30.5 years, and more than half of the buildings were built before 1970. According to the DOE, site energy intensity has not decreased significantly since the beginning of the 20th century. A lack of progress in the 1990s is confirmed by a November 2000 assessment of energy consumption by the EPA, which states, “Total energy consumption in commercial buildings remained roughly constant from 1989 to 1995, as did energy use per square foot.”

Highlighting the potential to conserve energy, the EPA cites studies showing that “by investing in simple profitable building upgrades, many U.S. homes and businesses could reduce their annual energy use by nearly 30%.” Through both private and public sector programs, such savings have been achieved in some cases. The EPA’s Energy Star program, for example, claims to have partnered with 15% of the “commercial, public, and industrial building market” and rewarded 90 energy-saving buildings with the Energy Star label. These buildings prevent 45 million metric tons of carbon equivalent worth of emissions. Also, the Rocky Mountain Institute has performed many studies that show potential energy savings for commercial buildings: In one analysis, they found potential savings of 75% for a vacant 13-story, 200,200-square foot office building outside Chicago.

4. LAND USE, TRANSPORTATION, AND ENERGY CONSUMPTION IN OTHER COUNTRIES

Urban settlement patterns in other countries have remained fairly compact. Combined with adequate transportation infrastructure, this leads to lower dependence on the automobile in countries such as those in Europe. In fact, European land-use and
transportation policies and practices are often evoked when trying to define policy alternatives for achieving more effective growth management in the United States.

For example, Pietro Nivola of the Brookings Institution finds that U.S. cities interested in improving their condition could adopt some policies used frequently in Europe, such as reducing public funding for highway construction, reducing urban crime, and providing fiscal relief for city businesses and residents through revenue-sharing arrangements such as those used by Germany and Canada. Timothy Beatley of the University of Virginia has researched best practices in European countries, including Copenhagen’s 1947 land-use “finger plan” that concentrates development into a hand shape, with the city center as the palm and transit-line-centered digits extending outward with protected green spaces between the lines. Due in part to the choices offered by these innovative land-use and transportation policies, 31% of Copenhagen commuters ride transit to work and 34% bike to work. This compares poorly to U.S. cities, where transit and bike home-to-work trips make up merely 5% and 2% of the total, respectively.

European cities are faring better in terms of fuel use. In 1999, Europe was second only to the United States (at 25%), with 15% of total global carbon emissions from fossil fuels. However, according to the DOE, European emissions per capita were less than half those of the United States (2.4 vs 5.6 tons).

A study of 48 global cities by Peter Newman and Jeffrey Kenworthy shows just how energy-intensive U.S. transportation patterns have become. The averages for gasoline used for private transportation are summarized in Fig. 5.

They found generally that gasoline-oriented cities are “heavy energy users while those with any significant level of electricity use [to run a rail system] in their transportation system are low energy users overall.” Even after correcting for economic factors, such as U.S. income, gasoline prices, and fuel efficiencies, they found that gasoline use was still significantly higher (47–63%) in the United States than in other world cities, on average. In fact, the authors noted that “a purely economic approach to transportation matters will be inadequate, and that matters of infrastructure and urban form have direct influence on transportation patterns.” One advantage to investing in more transportation options in order to reduce trips and trip lengths is a phenomenon termed transit leverage. Newman and Kenworthy cite Neff, who found that transit does not simply replace car travel on a one-to-one ratio. In fact, Neff found that 8.6–12.0 km (5.3–7.4 miles) of car travel is replaced by 1 km (0.62 miles) of transit according to data from the United States.

Interestingly, Newman and Kenworthy also found that there is little connection between transportation and economic growth. Whereas in U.S. cities gross regional products per capita were only 0.85 those of Europe, car use was 2.41 times higher in the United States.

Nonetheless, the suburban sprawl model is being adopted by Second and Third World countries as a means to prosper. Private car use in Europe and China is increasing. As Molly O’Meara Sheehan of the Worldwatch Institute wrote,

In the Czech Republic, car use surged and public transit use fell as the number of suburban hypermarkets ballooned from 1 to 53 between 1997 and 2000. Today, the proliferation of such developments around Prague has boosted the number of hypermarkets in the Czech Republic above that in The Netherlands.

5. TRANSPORTATION ALTERNATIVES FOR U.S. SUBURBS

As discussed previously, since the mid-20th century popularization of the automobile, the usual response to demand for faster commutes and trips has been to provide a more ample supply of new highway and road capacity. However, in recent years various studies have described a phenomenon that puts in doubt the effectiveness of this tactic for reducing congestion. The phenomenon is not surprising: Greater availability of pavement spurs more and longer trips by road users. What is sobering is the extent of the phenomenon.

![Figure 5](image-url)
The influence of new road and lane construction on travel behavior is referred to as induced travel, which has been studied in all 50 states and 70 regions. The idea is simple: New road capacity acts as a magnet for drivers, inducing them to take more and longer trips than they would have otherwise. According to the growing academic literature as summarized in 2000 in a presentation by Lewison Lee Lem of the EPA, the impact can be substantial: An average increase of 10–30% of total VMT can be traced to induced travel. Short-term induced increases range from 2 to 5% for every 10% increase in road capacity. Long-term increases may result in increasing travel 5–10% for every 10% increase in capacity.

Some of this additional traffic is also a product of new land development and new users who occupy new subdivisions and shop in new malls. Transportation investments often have an impact on land development. A study performed for the Brookings Institution by Marlon Boarnett confirmed the relationship between transportation policy and land use, concluding that highways can induce changes in regional development patterns. In fact, this study found that highway investments shift economic development away from existing communities to newly built areas. Just as empty roads and traffic lanes act as magnets for new driving, highway interchanges draw new development.

Smart-growth policies and practices offer one possible way to deal with out-of-control VMT and pavement growth. These policies are being embraced by localities and states throughout the country. It is time for such a shift. Many surveys in the past few years have shown that Americans are tired of suburban sprawl and its symptoms—loss of open space, traffic congestion, and blight in older communities. For example, in a 1999 poll by the Pew Center for Civic Journalism, sprawl and its effects tied with crime as the issue of most importance at the community level.

What is smart growth? Roughly, smart growth is development that involves a mix of land uses (e.g., commercial and residential), which occurs in or adjacent to existing communities and which provides a variety of transportation choices for residents and workers. Orienting and designing new development to make it convenient for residents and workers to take transit is especially important, and there is even a name for this kind of development—transit-oriented development.

Many advocates propose taking advantage of significant infill development and redevelopment opportunities created by population declines in central cities and older suburbs and postwar leapfrog development patterns. Retrofitting U.S. suburbs so that we take advantage of vacant and abandoned lots means more compactness and convenient access to shops and potential workplaces. After decades of sprawl, there are plenty of opportunities for such retrofits. One example that is receiving much attention is “greyfields.” These are the older regional malls that litter many older suburbs. Unfortunately, “litter” is an all-too-apt term since many of them are vacant, having been left behind by companies seeking to build ever-larger stores and malls. According to a study by PricewaterhouseCoopers and the Congress for New Urbanism, 140 of approximately 2000 regional malls are greyfields, and 200–250 are on their way to that status. These sites are perfect for redevelopment given their large size—35 acres on average—plus the fact that their location in older suburbs often means proximity to transit.

Redevelopment activities such as this will mean more jobs and more residents per acre, which many studies have found correlate well with decreases in VMT. A 1992 study by Cambridge Systematics found 20–25% fewer car trips per household in more compact, transit-oriented suburbs than in sprawling, auto-dependent suburbs. In a 1994 NRDC-sponsored study of several San Francisco communities, John Holtzclaw found that a doubling of residential density is accompanied by a 20–40% reduction in VMT. Also, Reid Ewing concluded in a 1997 study that when controlling for effects of variables such as income, a doubling of urban densities results in a 25–30% reduction in VMT.

It is important to clarify that when researchers say “doubling,” they are usually talking about modest regional or neighborhood averages for density or compactness. Some Americans might think that the only alternative to sprawl is New York City-level density. However, this is not the case. There are a number of alternatives to suburban sprawl, including some models within suburbia. For example, Ed Risse of Synergy Planning estimated in 2001 that if the Washington, DC region were to adopt the suburb of Reston’s density of 9 or 10 people per acre, the region would be able to accommodate 25 years of demand for urban development on vacant and underutilized land within a 20-mile radius of Washington’s center. Reston is only compact relative to other segments of suburbia: It remains a quiet, leafy community due in part to the 1300 acres of green spaces it has permanently set aside.

Some studies of the impacts of changes in the built environment on travel demand have yielded various results. In a 2001 synthesis of the literature, Reid Ewing and Robert Cervero concluded that travel
demand is pretty inelastic in the face of individual changes in the built environment, but that there are large cumulative effects, a combination of smart-growth characteristics, such as increases in density, mixing land uses, design changes, and wider regional accessibility of different land uses.

New, sophisticated modeling techniques have demonstrated the effectiveness of such strategies. Several EPA studies utilize four-step travel demand models to show that major reductions in VMT are achievable. These models use information about travel patterns to calculate how many trips will be generated, where trips will be distributed, and how the trips will be split between different transportation modes (i.e., walking, biking, train, and bus) and also to assign the traffic among different routes and times of day. In two studies, the EPA worked with local jurisdictions to choose likely sites for infill/redevelopment and greenfield development and used transportation models to forecast differences in miles traveled. Table V summarizes the findings.

Exchanging development patterns in the San Francisco, Los Angeles, and Chicago areas, NRDC researchers found strong correlations between density and urban form and VMT. In areas with smart-growth characteristics, such as small lot sizes, transit services, and walkable neighborhoods, residents find it less necessary to drive. This powerful relationship is expressed in Fig. 6.

Also, in EPA-commissioned studies of travel behavior in the Sacramento and Nashville regions, NRDC and Criterion Consultants found that VMT per capita in neighborhoods was lower in urban and older suburban neighborhoods. In Nashville, VMT per capita was 30% lower among suburbanites in an older, more compact suburb as opposed to a newer, more sprawling suburb. In Sacramento, the rate of fuel consumption was as much as 50% lower in an urban community compared to two suburban neighborhoods.

It should be noted that there is great potential for synergy among several nascent market transformations, including smart growth. The combination of green building techniques, cleaner vehicle technologies such as hybrid engines and fuel cells, and changes in development of new suburbs and retrofits of existing communities should yield significant benefits in terms of energy conservation, climate change, and environmental quality.

5.1 The Return of Rail?

When we selected cars and trucks as our vehicles of choice, we shunned another kind of infrastructure—rail, especially intracity rail. Urban streets and even highways took the place of trolley systems that spread like webs through our cities. We had built approximately 45,000 miles of trolley lines by 1915. According to the American Public Transportation Association, we currently have a paltry 3100 miles of light and heavy rail serving our cities. As discussed previously, ridership on public transportation peaked at 23.4 billion trips in 1946 and declined steadily throughout the decades, bottoming out in 1972 at 6.5 billion.

However, there have been considerable increases in recent years and for 5 years in a row in the late 1990s the rate of transit boarding growth actually exceeded the growth rate of driving. The trend during the past 10 years is shown in Fig. 7.

In response to increasing demand, new rail starts have increased in recent years, including some starts in unexpected southern and western cities. As columnist Neal Peirce noted, applications for federal funding for new bus and rail projects leaped from 20 in 1997 to 191 in 1998. The federal program for new transit starts remains popular and hence oversubscribed. Also, the American Public Transportation Association reported that as of 2000, there

<table>
<thead>
<tr>
<th>Location</th>
<th>Daily VMT (%)</th>
<th>CO₂ reduction (%)</th>
</tr>
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<tbody>
<tr>
<td>San Diego, CA</td>
<td>48 (per capita)</td>
<td>45</td>
</tr>
<tr>
<td>Montgomery County, MD</td>
<td>58 (per capita)</td>
<td>46</td>
</tr>
<tr>
<td>West Palm Beach, FL</td>
<td>61 (per capita)</td>
<td>50</td>
</tr>
<tr>
<td>Atlanta, GA</td>
<td>14.5–52</td>
<td>Not calculated</td>
</tr>
</tbody>
</table>
were approximately 1500 miles of new light rail and heavy rail lines in the proposal, planning, design, or construction phase.

This boom in new rail construction is a nationwide phenomenon. The following are examples from Railway Age’s 2001 “Passenger Rail Planner’s Guide”:

- Charlotte, North Carolina, has completed a major investment study for an 11.5-mile light rail line that will share 2 miles of track with the town’s trolley.
- Atlanta’s Metropolitan Area Rapid Transit Authority (MARTA) is planning to extend its rail system with a 4.2-mile line, and work has begun on a 47-acre transit-oriented development on MARTA-owned land that will include BellSouth as a tenant.
- The Southwest Ohio Regional Transit Authority and the Transit Authority of Northern Kentucky are studying an 18-mile light rail segment that would connect Covington, Kentucky, and central Cincinnati.
- A 17.4-mile light rail extension in St. Louis was slated to open this year, and an additional 8.8-mile segment is planned.
- The Dallas Area Rapid Transit Authority is constructing two new lines for its successful system, which will more than double the system’s current 20 miles.
- The Denver Regional Transportation District recently opened an 8.7-mile extension to its system and is planning another 19-mile line.
- Salt Lake City recently built a 15-mile light rail line that is wildly popular; several extensions are planned or under way.

Many jurisdictions devoting resources to building new transit are outside of America’s Rust Belt and in the Sun Belt—the American south and west. Increasing rail investments can help to catalyze transit-oriented smart growth since concentrating development around rail nodes helps ensure their fiscal viability. In fact, the Federal Transit Administration includes land-use criteria when awarding Full Funding Grant Agreements for new transit service. New transit investments throughout the country provide evidence that smart-growth strategies are widely applicable—both for revitalizing northeastern and midwestern cities and older suburbs that have felt sprawl’s impacts most keenly and for the rapidly growing southern and western United States.

In summary, the possible comeback of rail transportation in the United States is good news indeed for those concerned about 20th-century changes in development patterns that have transformed suburbanization, transportation, and energy consumption in the United States.

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