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Edited by Gregory K. Ingram and Yu-Hung Hong

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The Decline in Transit-Sustaining Densities in U.S. Cities, 1910–2000

Shlomo Angel, Alejandro Blei, Jason Parent, and Daniel A. Civco

People who live at higher densities tend to use public transit more often than people who live at lower densities. Modern investigation into the transit-density relationship stretches back at least 30 years (Pushkarev and Zupan 1977), and the topic continues to attract academic interest. Research recognizes a positive relationship, but the notion of a density level that is conducive to transit service remains an elusive concept. We hypothesize that much of the uncertainty rests on the particular blend of local conditions, including but not limited to transit accessibility, transit type, network design, socioeconomic characteristics, and the pricing of fares, all of which influence the strength of the transit-density relationship.

Transit service is possible at any density level. A strong government commitment might subsidize near-empty vans and buses in low-density areas, and many places in the United States operate such services out of social equity and personal mobility concerns. We do not discount the important role transit may play for individuals in low-density areas, but there is also little public appetite for inefficient government spending. Transit's vibrancy depends on healthy ridership, and low-density areas provide neither the potential riders nor the operational preconditions for frequent and attractive bus service.

A century of density decline in U.S. metropolitan areas has posed structural challenges to the provision of transit service. Density decline cannot continue in perpetuity, however, and the *rate* of density decline clearly slowed down between 1980 and 2000. That said, population densities are now too low for transit to succeed as a metropolitan mobility strategy. While central business districts, suburban business districts, edge cities, and transit-oriented neighborhoods and corridors within metropolitan regions may have experienced densification—and can be further densified in the future—this change is generally too small, in the transportation sense, to contribute to meaningful vehicle miles of travel (VMT) or greenhouse gas reductions at the metropolitan level. Both the share of metropolitan populations and the share of metropolitan areas that can sustain transit have declined substantially over time and are now exceedingly low in most U.S. cities.

The renewed interest in the transit-density relationship is motivated by robust urban growth projections and by the accompanying challenges to urban mobility and the need for greenhouse gas reductions. Where and how the projected additional 100 million Americans will settle by 2050 (U.S. Census Bureau 2004), for example, will have important implications for the options available for moving people and goods. If limiting greenhouse gas emissions is to play an important role in the ways we approach planning and policy for the future city, transportation, which contributes to nearly 30 percent of the nation's emissions, and housing, which contributes 17 percent, must figure prominently among the remedial actions. Within the transportation sector, modal contributions to emissions are believed to be 62 percent for passenger cars, light trucks, and motorcycles and 1 percent for buses (EPA 2005).

The relationship of the urban environment to travel behavior has received considerable attention in the academic literature, perhaps owing to the emergence of sprawl as a major public policy concern. Studies have examined the travel outcomes associated with the diversity of land uses and the design of the built environment (Cervero and Kockelman 1997), road density and the jobs-housing balance (Bento et al. 2003), and accessibility to activity centers (Ewing, Deanne, and Li 1996; Rodriguez and Joo 2004). Despite a variety of studies, conclusions are mixed as to the significance and strength of specific variables (Boarnet and Crane 2001; Rodriguez, Targa, and Aytur 2006). While one study (Taylor et al. 2009) concluded that population density is an important determinant of transit use in U.S. urban areas, another study (Ewing and Cervero 2010) claimed that population and job densities are only weakly associated with transit use. (Their meta-analysis showed that proximity to transit and street network design were believed to be more important.) Clearly, the determinants of travel behavior are multiple and complex. Yet despite the contested role of density in understanding travel behavior—and specifically transit use—density emerges as a statistically significant factor in nearly all studies.

Few authors have sought to peg the viability of bus transit to threshold population densities, referred to as transit-sustaining densities. Admittedly, the notion of population density as a common denominator for transit use does not tell the whole story, but there are compelling theoretical reasons why it can be a meaningful proxy. Ewing and Cervero (2010) found that VMT is negatively related to the accessibility of destinations. In theory, higher densities could bring origins and destinations closer together, thereby reducing distances, improving accessibility, reducing VMT, and improving the prospects of transit. Whether higher densities would improve accessibility in practice is a matter of empirical debate and would depend on the transportation network and travel patterns within an urban area.

Higher densities require greater sharing of resources over road networks, and more efficient packaging of network users can increase overall network performance. Transit's viability would increase at higher densities because such densities would enable the delivery of mobility efficiencies via transit vehicles. In other words, the higher the density, the more important alternatives for moving people rapidly and efficiently become, and the more relevant transit becomes to the overall transportation picture.

What, then, is a desirable density for transit service? We concur with Newman and Kenworthy (1989) and Holtzclaw (1994) that a density of approximately 30 persons per hectare is a good rule of thumb for basic bus service. We further recognize that approximately 50 persons per hectare would allow for frequent and attractive bus service (Orosz 2009). The transit densities we describe here apply to urban bus service and are to be distinguished from densities for light-rail and heavy-rail transit.

In this chapter, we explore transit-sustaining density across time and space. First, we examine how cities' average densities, measured at the census tract level, have changed over a 90-year period ending in 2000; second, we assess the change in cities' transit-sustaining areas, measured as a share of cities' total urbanized areas, over the same period; and third, we determine how cities' transit-sustaining populations, measured as a share of total population, have changed over time.

Historical Urban Tract Data for 20 U.S. Cities, 1910–2000

Historical population density data at the census tract level for U.S. cities and metropolitan areas are now readily available in digital maps (shapefiles) that can be analyzed using ArcGIS software. We chose 20 U.S. cities for analysis for one principal reason: the availability of tract density maps and population data extending as far back as possible, for some almost a full century. For seven of these cities—Baltimore, Boston, Chicago, Cleveland, New York, Pittsburgh, and St. Louis—tract density maps are available from 1910 on. Because of data loss, only two of these cities—Chicago and Cleveland—have tract density maps for 1920. Tract data for Milwaukee also become available from 1920 on. For 10 cities—Buffalo, Cincinnati, Columbus, Detroit, Indianapolis, Los Angeles, Nashville, St. Paul, Syracuse, and Washington—tract density maps are available from 1930 on, and for two additional cities—Minneapolis and Philadelphia—tract density maps are available from 1940 on.[1]

1. Census tract shape files for 2000 were downloaded from the Environmental Systems Research Institute (Esri) Web site, http://arcdata.esri.com/data/tiger2000/tiger_download.cfm. Historical census tract shapefiles and historical population data for these census tracts

We chose to focus on this data set for three reasons. First, it was the only readily available ArcGIS-compatible data set that included information on historical urban densities at the tract level going back to 1910. That means we could study the change in average density over a long period. The decennial census of 1910 was the first to use the "census tract," a small geographical area that could be studied over time. Second, the availability of historical data on tract densities made it possible to study changes over time in several other density metrics and to determine the extent to which these changes paralleled the change in average tract density. The density metrics compared to average tract density were (1) the share of the urban area with densities high enough to sustain public transport; and (2) the share of the population inhabiting these areas. Third, the availability of density data for several decades made it possible to investigate both the average rate of density change over time and the second-order changes in the rate of change. That is, it made it possible to investigate whether the rate of density change—whether positive or negative—was accelerating or slowing down over time. This is important, because if we are interested in projecting urban densities into the future, we should not simply assume that densities will remain the same or that they will either decline or increase at a constant rate.

The outer boundaries of the urbanized areas in the 2000 census were taken to be the outer boundaries of the cities studied. The U.S. Census Bureau defines an urbanized area as a set of contiguous census block groups or census tracts with a minimum density of 1,000 persons per square mile that together encompass a population of at least 50,000 people. The urbanized areas in the 2000 census were used to delimit the 20 metropolitan areas used in this part of the study.

We defined the urban land area of the U.S. cities we studied as the collection of urban census tracts within the set of administrative districts circumscribing the metropolitan area. In general, we use the term *census tract* loosely to mean a small geographical district within the administrative area of the city for which population data are available. The U.S. Census Bureau defines a census tract as follows:

> Census tracts are small, relatively permanent statistical subdivisions of a county. . . . Census tracts generally have between 1,500 and 8,000 people, with an optimum size of 4,000 people. . . . The spatial size of census tracts varies widely depending on the density of settlement. Census tract boundaries are delineated with the intention of being maintained over many decades. . . . However, physical changes in street patterns caused by highway construction, new developments, and so forth, may require occasional boundary revisions. In addition, census tracts occasionally are split due to population growth or combined as a result of substantial population decline. (U.S. Census Bureau 2000)

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were downloaded from the National Historical Geographic Information System Web site, http://www.nhgis.org/.

We defined census tracts as "urban" when their densities exceeded a certain threshold. We used the U.S. Census Bureau's threshold of 1,000 persons per square mile (3.86 persons per hectare) to include or exclude a tract from the urban area. This area was used by El Nasser and Overberg (2001), for example, in their measurement of U.S. sprawl. We calculated average urban tract density as the ratio of the total population in the urban tracts in the metropolitan area divided by the tracts' total area.

Using the area of the census tract to calculate density presents certain methodological difficulties. This approach assumes that the population within a census tract is evenly distributed. Thus, if the population was clustered in one-quarter of the tract, calculating tract density by gross tract area could produce misleading results. A potential solution to this problem is to use advanced mapping techniques, such as remote sensing, to classify the "built-up" area within each census tract and then to calculate density as a function of that area. Due to the historical nature of our work, it was not possible to use this method, and we recognize the limitations of our approach. We further recognize that census tracts may have been subdivided or expanded over time because of population growth or annexation. The extent of the effect of such modifications and the rate of such modifications throughout history are unknown to the authors. Knowledge of this sort presumably requires a separate study. While we understand the theoretical implications of census tract modification on our density calculations, we believe that the effects of these changes would not be so great as to distort the observed trends at the metropolitan level.

The Three Density Metrics Used in This Study

In measuring density in the cities studied, we used three metrics: (1) the average urban tract density; (2) the transit-sustaining area; and (3) the transit-sustaining population.

The *average density* was defined as the ratio of the total population residing in urban tracts in the metropolitan area to the total area of these tracts.

The *transit-sustaining area* was defined as the share of the total urban area of the metropolis in census blocks that had a density greater than 30 persons per hectare.

The *transit-sustaining population* was defined as the share of the population in the urban area of the metropolis living in the transit-sustaining area.

These three metrics were found to be correlated. In general, the higher the average density of a city, the higher its transit-sustaining area and its transit-sustaining population. The correlation matrix is shown in table 8.1. The high correlations among the three density metrics suggest that when the average density

Table 8.1
Correlations Among the Three Density Metrics Used in the Study

Metric	Average Density	Transit-Sustaining Area	Transit-Sustaining Population
Average density	1.000		
Transit-sustaining area	0.903	1.000	
Transit-sustaining population	0.781	0.863	1.000

Note: The significance (two-sided) of all correlations was less than 0.001.

of a city declines, the transit-sustaining area and the transit-sustaining population are likely to decline as well. This is important because researchers may often have access to average density data, but not to the other two density metrics, and because average density data can be obtained for large administrative areas, while the other two metrics require finer-grain data.

The Decline in Average Density, 1910–2000

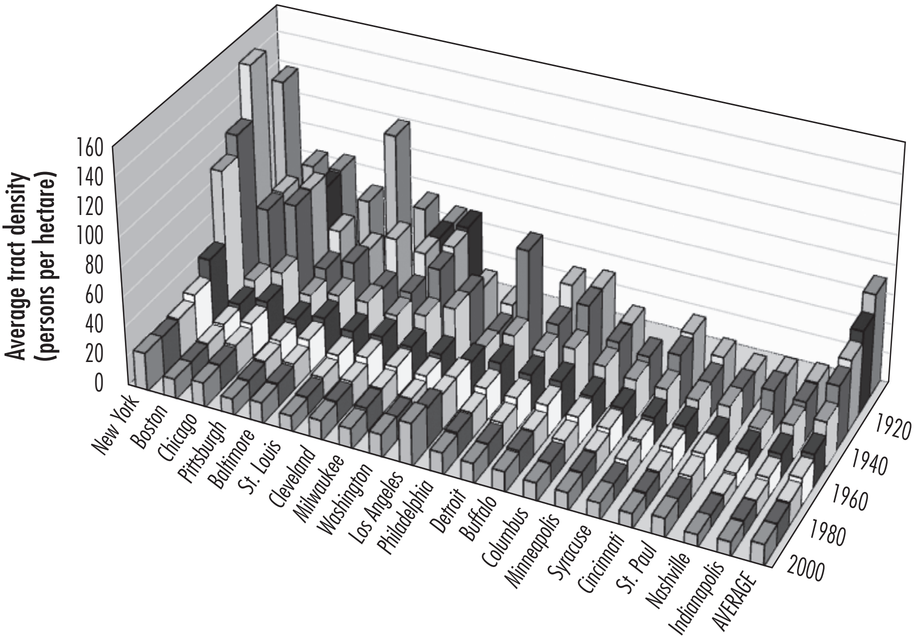
The decline in average density in the 20 U.S. cities studied is shown in figures 8.1–8.3.

Figure 8.1 shows the average tract density in each city in every decade. In 10 of the 20 cities studied, maximum average tract density was observed during the first year for which data are available. The year of observed maximum average tract density and the first year for which data are available (in parentheses) are as follows: 1910—Baltimore (1910); 1920—Milwaukee (1920); 1930—New York (1910), Boston (1910), Chicago (1910), Pittsburgh (1910), St. Louis (1910), Cleveland (1910), Detroit (1930), Buffalo (1930), Columbus (1930), Syracuse (1930), Cincinnati (1930), Indianapolis (1930); 1940—Philadelphia (1940), Minneapolis (1940), Nashville (1930); 1950—Washington (1930), St. Paul (1930); 2000—Los Angeles (1930).

Beginning sometime between 1930 and 1940, the decline in average tract density began in the older established cities of New York and Boston, as well as in the large cities of Chicago, St. Louis, and Detroit. We can only speculate as to the factors contributing to this decline. We suspect that cheaper transportation, including more affordable automobiles and the expansion of transit infrastructure, as well as demand for housing, played contributing roles.

With the exception of Los Angeles, 1950 marks a turning point; it is the year in which average tract density began declining for all cities. Average tract density decline began before 1950 for 17 of the 20 cities studied. In Los Angeles, density increased in every decade over the period 1940–2000. With an average tract density of 29.2 in the year 2000, Los Angeles was the most densely populated urban

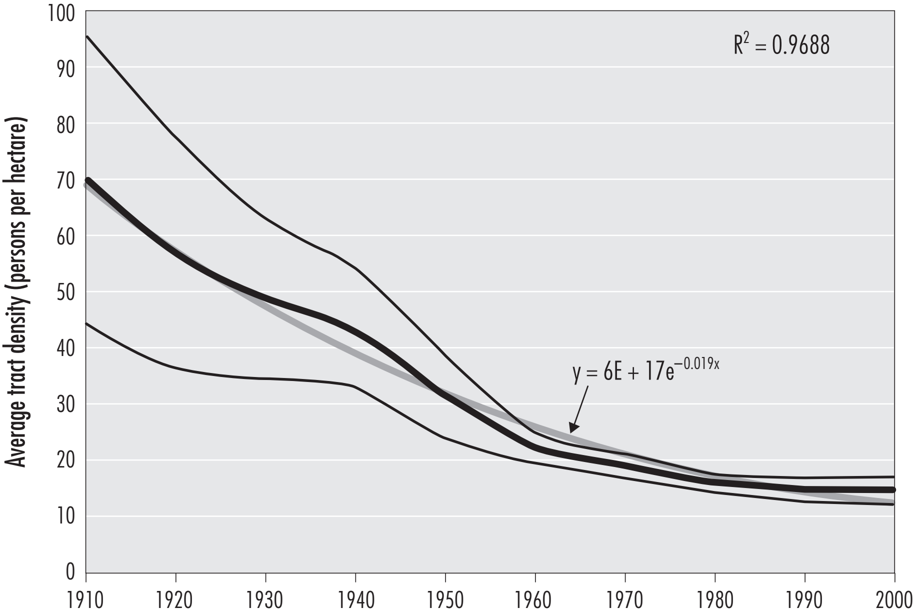
Figure 8.1
Decline in Average Tract Density in 20 U.S. Cities, 1910–2000



area in our sample at the most recent data point (minimally higher than New York), with an average tract density of 26.4. The anomalous observation for Los Angeles may be related to geographic barriers to expansion or to regulatory interventions that encouraged densification. It is notable that Los Angeles is the only western city in our sample. Further research is needed to determine whether other western cities experienced similar increases in average tract density.

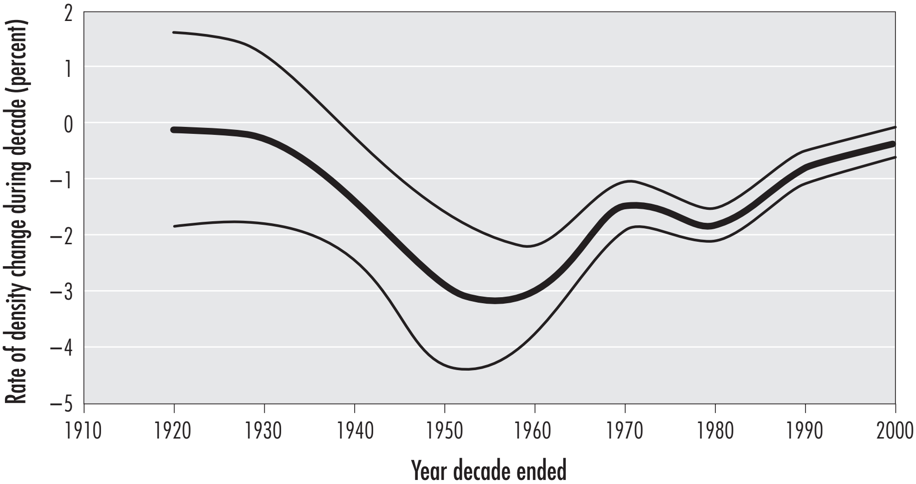
Figure 8.2 shows the average decline in the average tract density of the 20 cities studied. Average tract density declined every decade, from 70 persons per hectare in 1910 to 14.6 persons per hectare in 2000. As our sample did not include data for every city for every date, reported averages reflect the availability of data. A negative exponential curve fitted to the data shows a high degree of fit ($R^2 = 0.97$). It suggests that average tract density declined at the long-term rate of 1.9 percent per annum during the period studied. The convergence of the upper and lower error range at the 0.05 significance level mirrors the increase in the number of observations for later periods and indicates that the sample became more uniform over time. In other words, the cities' average tract densities were more similar in 2000 than they were in the past.

Figure 8.2
Average Decline in Average Tract Density in 20 U.S. Cities, 1910–2000



Note: Thin lines show upper and lower error range at 0.05 level of significance (two-tailed).

Figure 8.3
Annual Rate of Change in Average Density, 1910–2000



Note: Thin lines show upper and lower error range at 0.05 level of significance (two-tailed).

Figure 8.3 shows the annual rate of change in average density in every decade. Average density was stable between 1910 and 1930. It began to decline rapidly after 1930 at an accelerating rate, reaching 3 percent per annum in the 1940s and 1950s. Explanations for the increased rate of decline may include the mass construction of housing in suburban areas following World War II and a federal policy of road construction and expansion. The rate of decline then began to slow down, reaching less than 0.5 percent in the 1990s. The deceleration of density decline is harder to interpret. It is unlikely that disenchantment with suburbia is a likely cause. It also may be related to the idea that density decline cannot accelerate perpetually. In addition, economic forces may limit the extent of spatial expansion of an urban area. Figure 8.3 confirms that average population density in U.S. urban areas has reached a plateau at very low density levels and is unlikely to decline further in the years to come.

The Decline in Transit-Sustaining Area, 1910–2000

The decline in transit-sustaining area in the 20 U.S. cities studied is shown in figures 8.4–8.6. This metric relates the area of census tracts with population density over 30 persons per hectare as a share of total urban area.

Figure 8.4 shows the transit-sustaining area in each city in every decade. The maximum transit-sustaining area for each city (in parentheses) was observed in the following years: 1910—Baltimore (0.46); 1920—Milwaukee (0.51); 1930—New York (0.63), Chicago (0.54), Pittsburgh (0.34), St. Louis (0.41), Cleveland (0.39), Los Angeles (0.19), Detroit (0.43), Columbus (0.27), Syracuse (0.31), Cincinnati (0.13), Indianapolis (0.15); 1940—Boston (0.43), Washington (0.26), Philadelphia (0.51), Buffalo (0.54), Minneapolis (0.18), Nashville (0.04); 1950—St. Paul (0.10). With five exceptions (New York, Boston, Los Angeles, Minneapolis, and St. Paul), transit-sustaining area decreased every decade after reaching its maximum. New York, Boston, Minneapolis, and St. Paul experienced minor increases from 1990 to 2000. After reaching its peak in 1930, the transit-sustaining area of Los Angeles declined until 1960, but increased over the next 40 years. With a transit-sustaining area equal to 0.14 of its total area, Los Angeles had the highest observed transit-sustaining area in 2000. New York was second, with a transit-sustaining area equal to 0.10 of its total area. In 2000, the transit-sustaining area of individual cities ranges from 0.00 to 0.14 of total urban area.

Figure 8.5 shows the average decline in the transit-sustaining area of the 20 cities studied. The average share of U.S. urban areas that was dense enough to sustain public transport increased between 1910 and 1920 before it began its continuous decline. The authors recognize fault with the assumption that a transit-sustaining density of 30 persons per hectare can be accurately applied for a duration of 90 years. Changes to transit's cost structure, as well as the economic and technological realities commuters faced, are duly noted. Even if transit-sustaining density is different now than in the past, however, we find value in the ability to

Figure 8.4
Decline in Transit-Sustaining Area in 20 U.S. Cities, 1910–2000

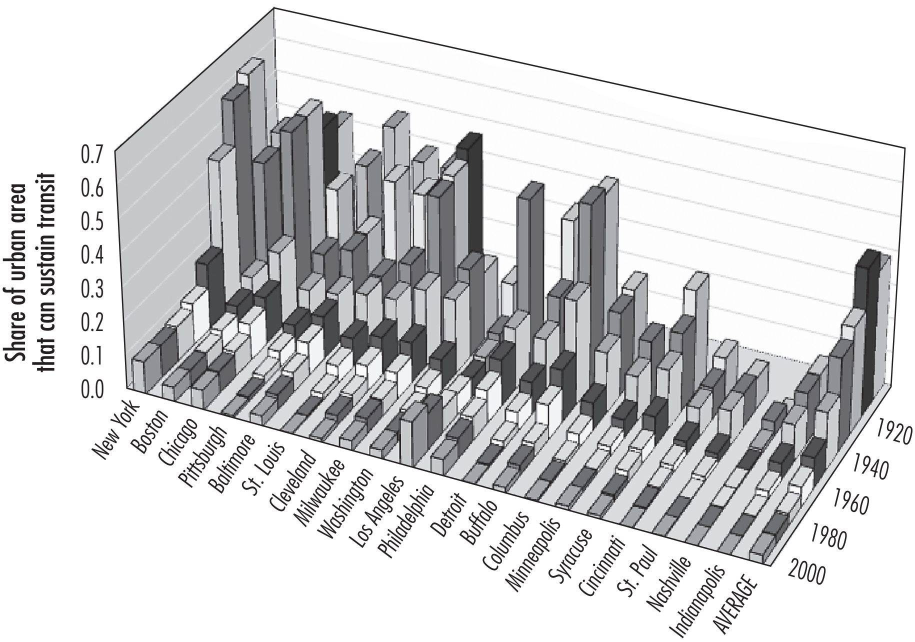
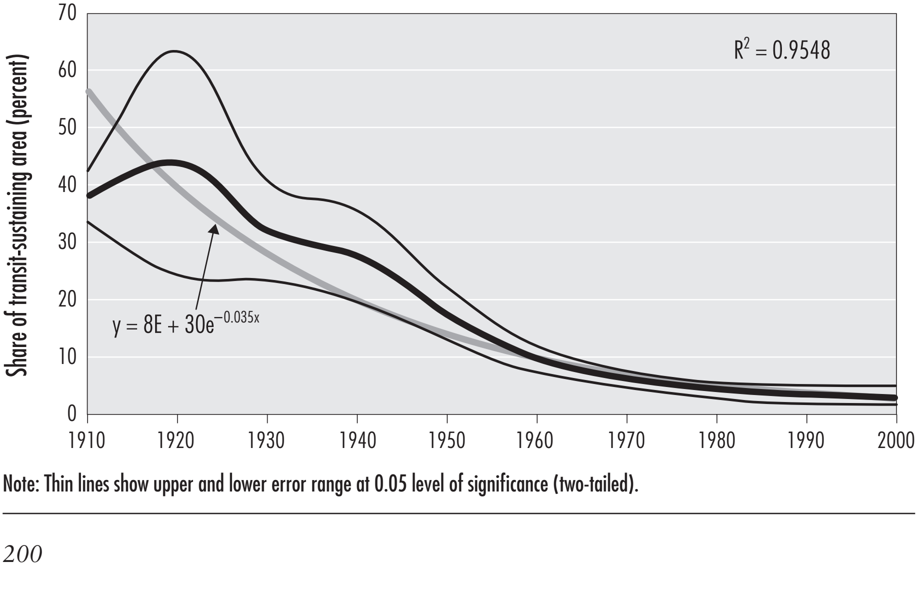
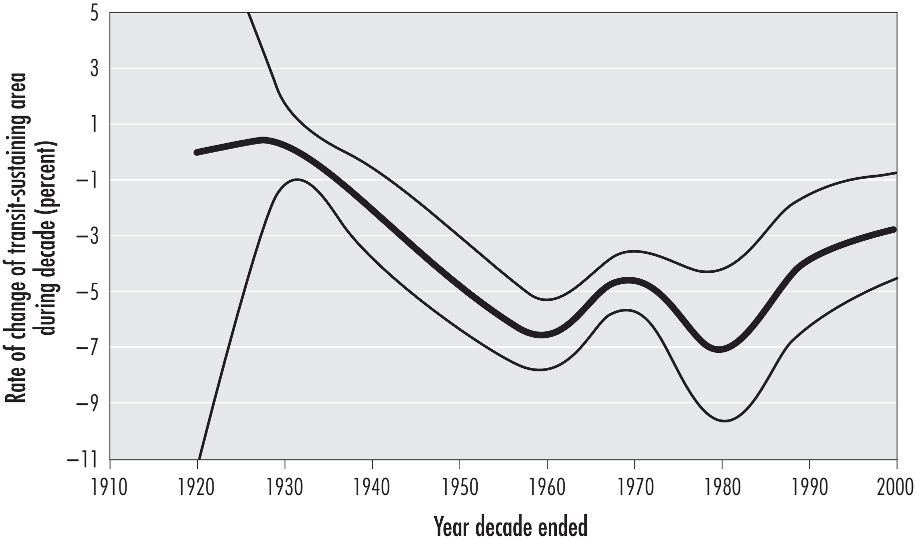


Figure 8.5
Average Decline in Transit-Sustaining Area in 20 U.S. Cities, 1910–2000



Note: Thin lines show upper and lower error range at 0.05 level of significance (two-tailed).

Figure 8.6
Annual Rate of Change in Transit-Sustaining Area, 1910–2000



Note: Thin lines show upper and lower error range at 0.05 level of significance (two-tailed).

compare what we know about the transit-density relationship today with density levels in the past.

A negative exponential curve fitted to the data shows a high degree of fit ($R^2 = 0.95$). It suggests that the average transit-sustaining area declined at the long-term rate of 3.5 percent per annum during the period studied, a more rapid decline than that of average density. This finding suggests that a doubling of population was associated with more than a doubling of urban land. The convergence of the upper and lower error range at the 0.05 significance level is due to the increased number of observations for later periods and indicates that the sample became more uniform over time in terms of the shares of transit-sustaining areas in cities. In other words, these shares were more similar in 2000 than they were in the past.

Figure 8.6 shows the annual rate of change in transit-sustaining area in every decade. The rate was stable at almost 0 percent between 1910 and 1930. It began to decline rapidly after 1930 at accelerating rates, reaching a rate of nearly 7 percent per annum in the 1960s and 1970s. It then began to slow down, reaching an annual rate of less than 3 percent in the 1990s. Transit-sustaining area in the United States was still declining in 2000, but less rapidly than before. This clearly poses a challenge: increasing transit use to levels that can begin to reduce greenhouse gas emissions requires, at the very least, halting this decline.

The Decline in the Transit-Sustaining Population, 1910–2000

The decline in the transit-sustaining population in the 20 U.S. cities studied is shown in figures 8.7–8.9.

Figure 8.7 shows the transit-sustaining population in each city in every decade. This metric relates the urban population living at transit-sustaining densities as a share of total urban population. The reader should note that this metric is quite different from the transit-sustaining area discussed in the previous section. In theory, as well as in practice, it is possible for the share of the transit-sustaining area to be quite small and for the share of the transit-sustaining population to be quite large. Indeed, it may be argued that the latter metric is more appropriate for discussing the effect of transit use on greenhouse gas emissions and energy savings.

The maximum transit-sustaining population for each city (in parentheses) was observed in the following years: 1910—Baltimore (0.94), Boston (0.91); 1920—Cleveland (0.87), Milwaukee (0.91); 1930—New York (0.97), Chicago (0.92), Pittsburgh (0.84), St. Louis (0.90), Los Angeles (0.69), Detroit (0.88), Columbus

Figure 8.7
Decline in Transit-Sustaining Population in 20 U.S. Cities, 1910–2000

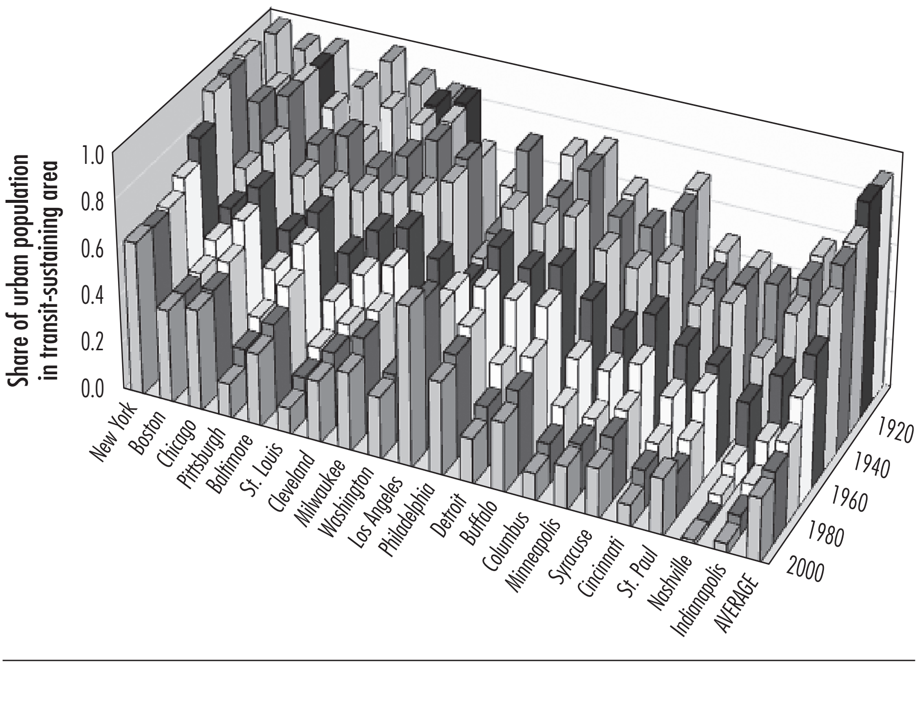
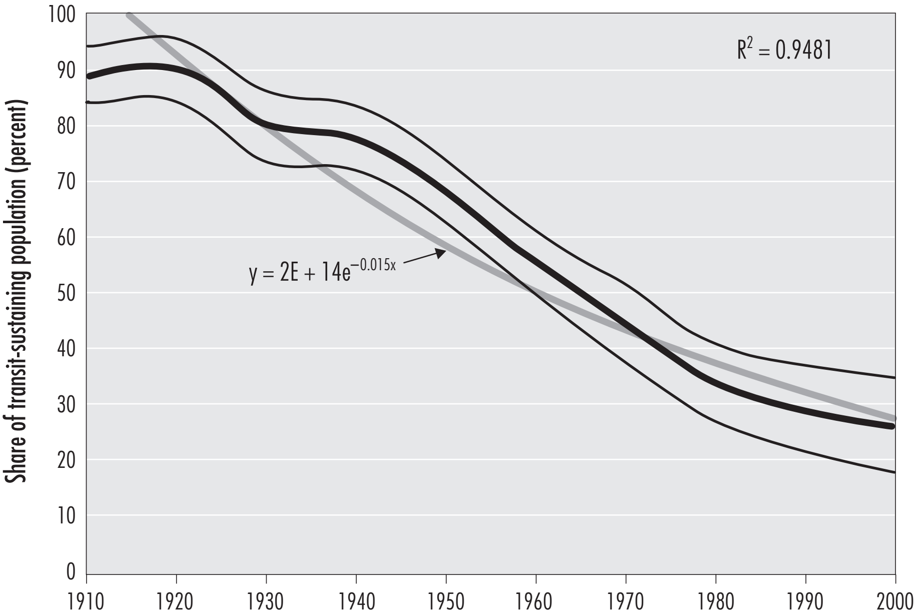


Figure 8.8
Average Decline in Transit-Sustaining Population in 20 U.S. Cities, 1910–2000



Note: Thin lines show upper and lower error range at 0.05 level of significance (two-tailed).

(0.78), Syracuse (0.86), Cincinnati (0.64), Indianapolis (0.71); 1940—Washington (0.84), Philadelphia (0.94), Buffalo (0.92), Minneapolis (0.74), St. Paul (0.60), Nashville (0.64). In 2000 Los Angeles had the highest transit-sustaining population as a share of total population (0.68), edging out the nation's most famous transit city, New York (0.65).

Figure 8.8 shows the average decline in the transit-sustaining population of the 20 cities studied. The average share of U.S. urban population that sustained public transport increased between 1910 and 1920 before it began its continuous decline. The percentage of the population living at transit-sustaining densities was historically very high. In 1910, 89 percent lived at densities that could support modern-day transit. In 1930 this percentage increased for some cities and decreased for others, ultimately resulting in a net decrease. Eighty percent of the cities' populations were transit sustaining in 1930; in New York, this figure hovered around 97 percent.

A negative exponential curve fitted to the data shows a high degree of fit ($R^2 = 0.95$). It suggests that the transit-sustaining population declined at the long-term rate of 1.5 percent per annum during the period studied, a slower decline than that of average density. This suggests that new urban development at the metropolitan periphery may have been at densities that were too low to sustain public transit. This may have led to a rapid increase in the share of the urban area that cannot sustain transit. Still, it may have contained too small a share of the total metropolitan population to affect the share of the urban population living in transit-sustaining areas.

Figure 8.9 shows the annual rate of change in transit-sustaining population in every decade. The rate was stable at almost 0 percent between 1910 and 1930. It began to decline rapidly after 1940 at accelerating rates, reaching a rate of almost 3.5 percent per annum in the 1970s. The decline then began to slow down, reaching an annual rate 1.5 percent in the 1990s. In other words, the transit-sustaining area in U.S. cities has always declined, but at slower rates beginning in 1980.

Finally, we compared the annual rates of change in the three metrics (see figure 8.10). This comparison is instructive. It shows that the general pattern of change was similar in all three metrics: the rate of decline began to increase in 1930, then from 1980 on it decreased. The metrics reached their lowest rates of decline in different periods—average density in the 1950s and the other two later, possibly in the 1980s.

Transit-Sustaining Densities in U.S. Metropolitan Areas in 2000

Figures 8.11–8.13 broaden the investigation of transit-sustaining population and area to all census-defined urbanized areas in the year 2000.

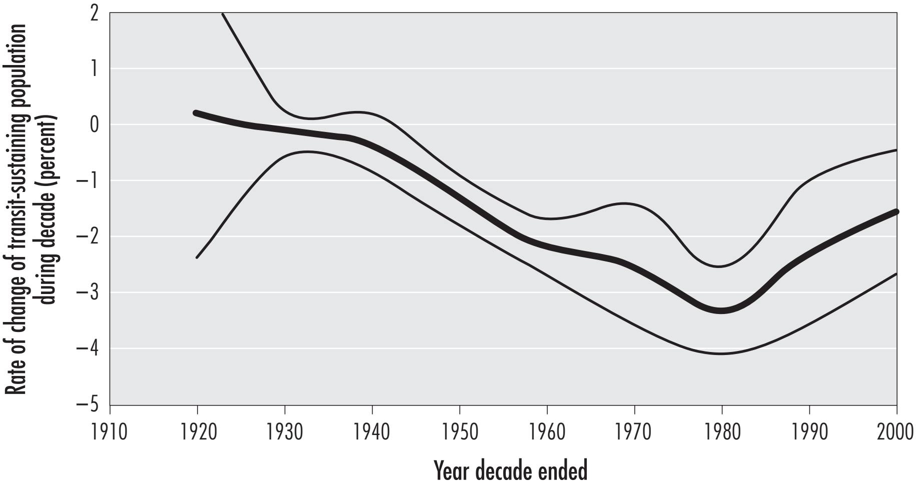
Figure 8.11 shows the distribution of U.S. urbanized areas by their transit-sustaining populations. Our analysis is based on 447 of 453 urbanized areas. Data loss resulted in the omission of 6 areas from this analysis: Anchorage, Alaska; Cumberland, Maryland–West Virginia–Pennsylvania; Fairbanks, Alaska; Hanford, California; Honolulu, Hawaii; and Kailua-Kaneohe, Hawaii.

Nearly 47 percent of all urbanized areas had 0 percent transit-sustaining population, 67 percent had less than 10 percent transit-sustaining population, 13 percent had more than 20 percent transit-sustaining population, and 2 percent had more than 50 percent transit-sustaining population. The top five urbanized areas for transit-sustaining population were San Francisco–Oakland, California—71.4 percent; Los Angeles–Long Beach–Santa Ana, California—67.7 percent; State College, Pennsylvania—65.3 percent; New York City–Newark, New Jersey—64.7 percent; and San Jose, California—54.7 percent.

Figure 8.12 shows total U.S. urban population by density range. Nearly 73 percent of the U.S. urban population lived at population densities below 30 persons per hectare. Nearly a quarter of the U.S. urban population lived at a population density of less than 10 persons per hectare.

Figure 8.13 shows the amount of urban land (in thousands of hectares) associated with each density range. More than half of all urban land (52 percent) had

Figure 8.9
Annual Rate of Change in Transit-Sustaining Population, 1910–2000



Note: Thin lines show upper and lower error range at 0.05 level of significance (two-tailed).

Figure 8.10
Comparison of the Annual Rates of Change in the Three Metrics, 1910–2000

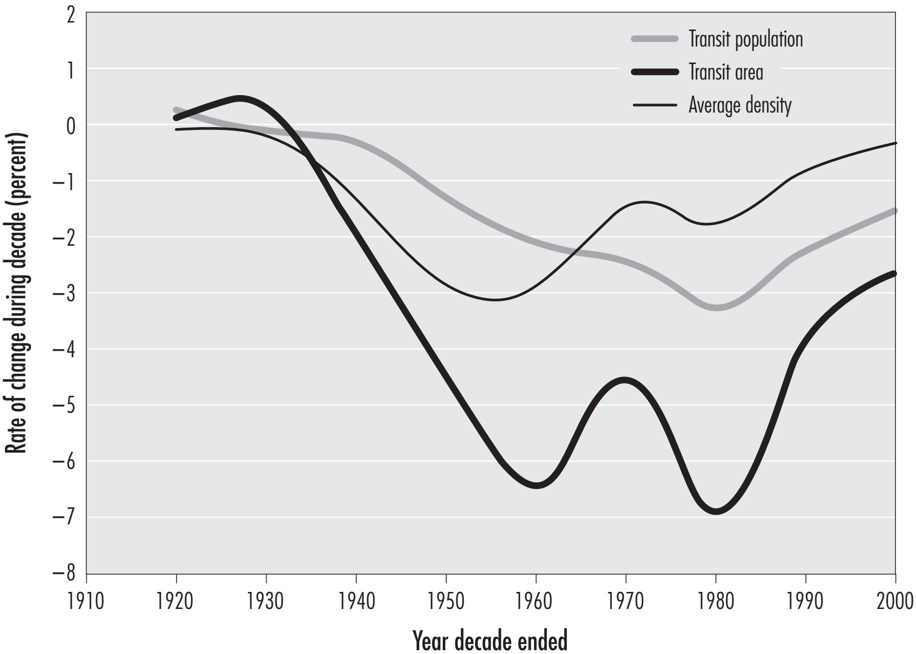


Figure 8.11
Distribution of Urbanized Areas, by Transit-Sustaining Population, 2000

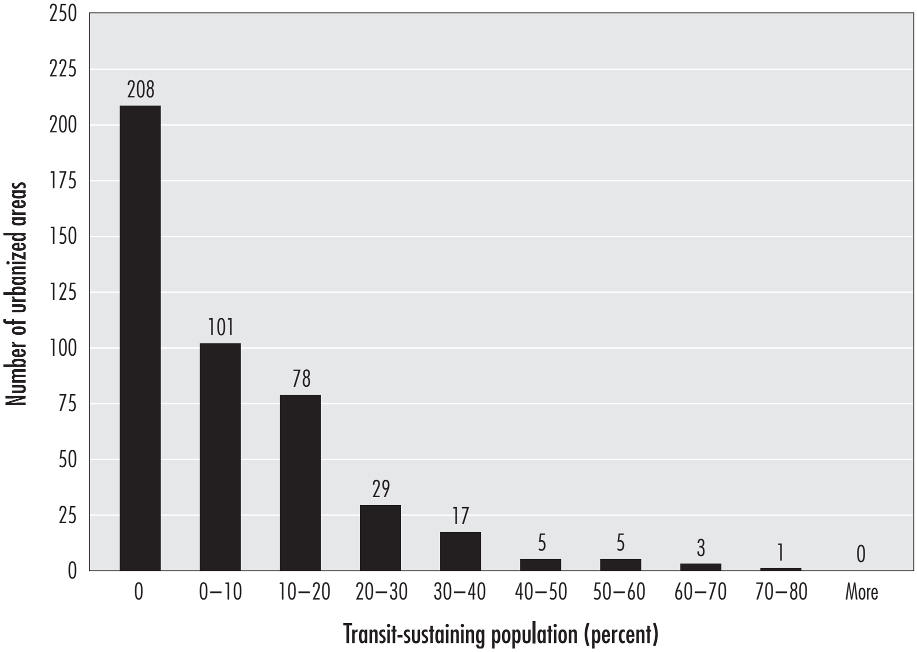


Figure 8.12
Distribution of Total U.S. Urban Population, by Density Range, 2000

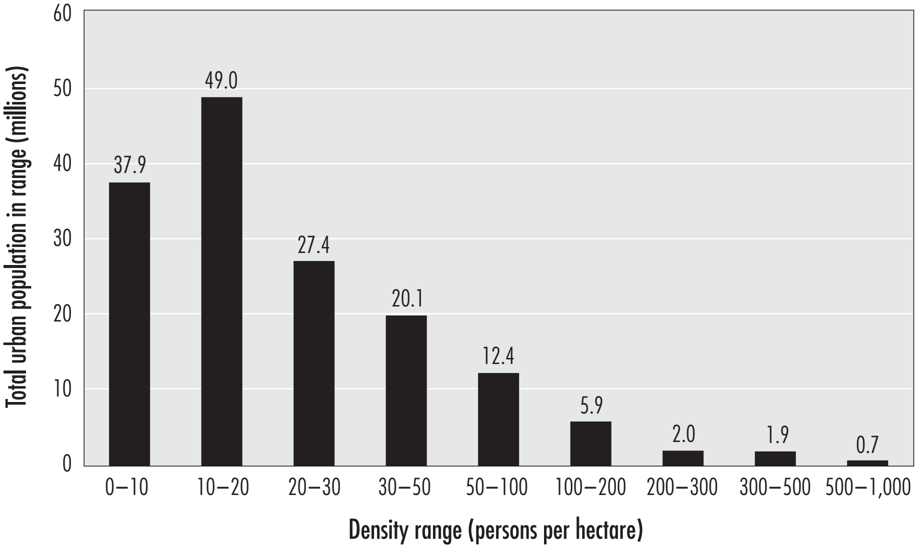
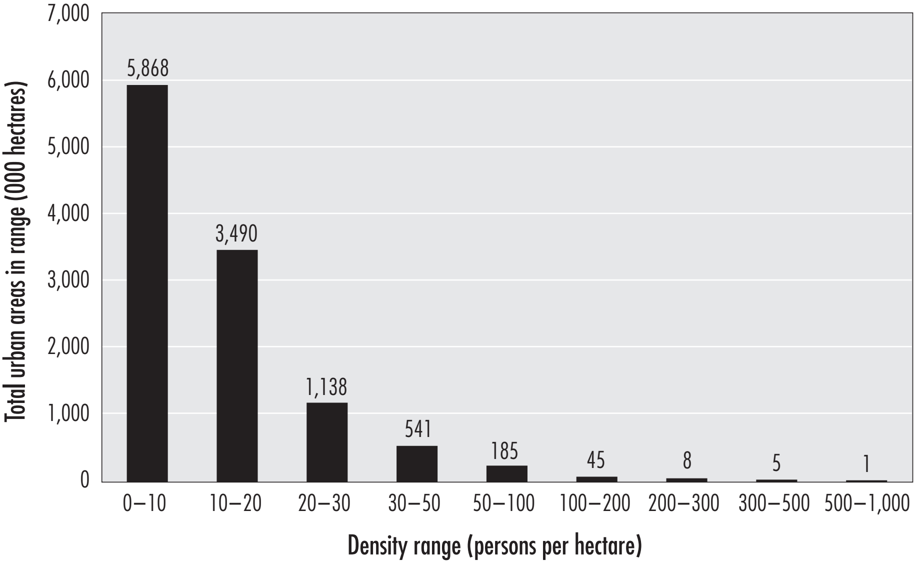


Figure 8.13
Distribution of Urban Land, by Population Density, 2000



a population density in the 0–10 persons per hectare range. Nearly 93 percent of all urban land had a density below 30 persons per hectare.

Conclusions and Policy Implications

Transit fulfills vitally important mobility needs of cities across the United States. A long list of positive externalities, including lower household spending and benefits to public health, real estate prices, and personal safety are associated with transit as well. We support and encourage densification within urban areas so that the preconditions for attractive and affordable transit may thrive.

We also recognize widespread structural challenges to the provision of transit in U.S. metropolitan areas. Although it is true that several neighborhoods, corridors, and central business districts have population densities that can sustain frequent and attractive transit service, most urban Americans live at densities that are too low to make transit a realistic mobility alternative. Current debates over transit's ability to achieve broader societal goals, such as combating climate change, must acknowledge the pervasiveness of density decline. In the year 2000, for instance, 27.3 percent of the population of urbanized areas in the United States lived at transit-sustaining densities. Meanwhile, cities' transit-sustaining areas are also, on average, declining. Interestingly, New York City–Newark, the nation's most populous urbanized area, boasts the highest rate of transit use among commuters (51 percent), but it is not the most transit sustaining in terms of metropolitan population density. That distinction belongs to the Los Angeles–Long Beach–Santa Ana urbanized area, where only 11 percent of commuters use public transportation. The overall transit picture is challenging, but examples such as Los Angeles bode well for transit proponents. It appears that the conditions exist to attract a portion of commuters to transit in a few urbanized areas.

Research indicates that the likelihood that individuals will adopt transit is linked to population density. Conventional wisdom suggests that policies and programs that raise densities to meet prescribed thresholds can be put into effect, but a century of continuous density decline, however, makes this difficult to achieve. Existing policies and regulations at the local level—such as minimum lot sizes, mandated parking minimums, and even the number of kitchens allowed in residential buildings—promote low densities. The preponderance of low population density forces us to rethink what our hopes and goals for public transit should be, as well as the size and type of benefits we can expect transit to deliver.

If current thinking considers public transit as a way to significantly decrease greenhouse gas emissions, expectations should be based on the number of people realistically projected to adopt transit. To be sure, densification of some areas within metropolitan regions may lead to higher rates of transit use, but it is unlikely that density increases will be sufficient to address the scale of the problem posed by carbon emissions from passenger vehicles. Both the average density of urbanized areas and the share of urbanized area populations that are transit sustaining are declining.

Efforts to increase population density would be a welcome development nevertheless, and particular consideration must be placed on the policy instruments available. Strategies aimed at limiting the fragmented spatial structure of low-density developments, such as leapfrog development, can be conflated with strategies designed to increase the density of built-up areas. Current discussions often lump fragmented development and low-density development together under the banner of sprawl, thus promoting the misconception that strategies designed to address one aspect of sprawl will also address the other. Research suggests that fragmentation and density can be quite independent of each other and that the policy instruments for increasing the density of built-up areas can be different from those that address fragmentation (Angel, Parent, and Civco 2010).

There may be compelling reasons to limit fragmented urban development. Leapfrog development can lead to high public infrastructure costs, and uncoordinated development can jeopardize farmland, wetlands, and fragile ecological areas. Metro, the regional government entity for the Portland, Oregon, metropolitan area, has had great success in decreasing fragmentation with its urban growth boundary. Since the boundary was instated in 1973, Portland has experienced a dramatic filling in of its built-up area and a concurrent preservation of open space beyond the boundary.

Although Portland's growth boundary has been effective in shaping a contiguous built-up area, it has not, strictly speaking, succeeded in increasing population density in its built-up areas. More to the point, Portland's growth boundary has successfully reduced fragmentation, making the city more compact, but, to the surprise of many, the density of its built-up area has declined. Possible explanations might include the relatively large size of new construction versus old construction and decreasing average household size.

Densification proponents might, therefore, favor a different set of policies and regulations, such as removing restrictions on higher-density development; allowing the subdivision of homes into two or more units and the renting of one or more units; offering incentives for building on small lots and disincentives for building on large ones; and encouraging apartment house construction.

But the aim might be both an increase in the density of the built-up area and a decrease in fragmentation—as is likely the case for transit—and there may be a need to address these issues separately. High-density development that is fragmented in its spatial structure will meet the density threshold in theory, but its spatial structure will also increase the distance between locations (thus increasing the walking distance to transit stations), increase travel times and VMT, and increase energy use and pollution. More compact (or less fragmented) spatial structure should, in theory, have the opposite effect on walking distance and travel times, and generally speaking it should strengthen transit's viability as a mobility alternative. The appropriate density metric for assessing transit's potential should therefore extend beyond a strict reading of the population density of built-up areas. The appropriate density metric should also account for open spaces, or the level of fragmentation, surrounding built-up areas. This type of metric may prove more useful in conveying information about urban spatial structure that is favorable to transit. The spatial structure of transit-sustaining density is a topic that deserves further attention from researchers and policy makers.

The role of fuel technology must, of course, be addressed in any discussion about urban mobility and greenhouse gases. If the main argument for transit were environmental, one could argue that the real problem was one of finding less polluting fuel sources for passenger vehicles. Certainly, advances in fuel and automotive technology will be beneficial to the natural environment and should be pursued. However, we also believe that the combined benefits of transit extend well beyond a purely environmental focus, and this helps justify the pursuit of policies and regulations that are conducive to transit.

The reality of density decline does not mean that transit is a lost cause. Transit provides billions of trips each year and delivers enormous economic and social benefits. Our intent here is to offer new insights into transit's potential benefits based on our evaluation of population density. We hope that all discussions about population growth, urban spatial structure, urban mobility, and greenhouse gas emissions accurately assess what is known about the transit-density relationship. A full understanding of the problems and causes of this relationship will lead to more meaningful and lasting solutions.

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