MEASURING SPRAWL AND ITS IMPACT

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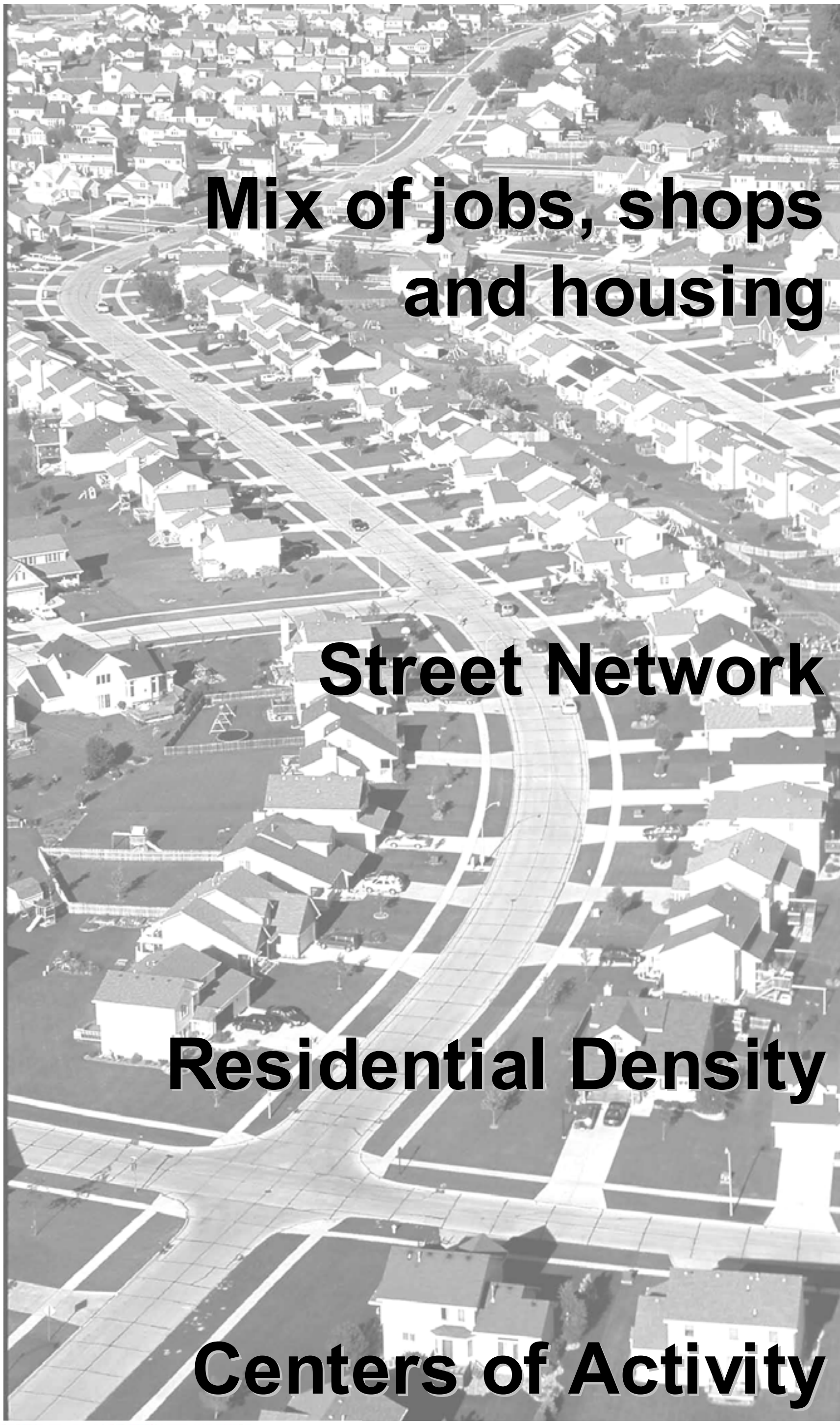

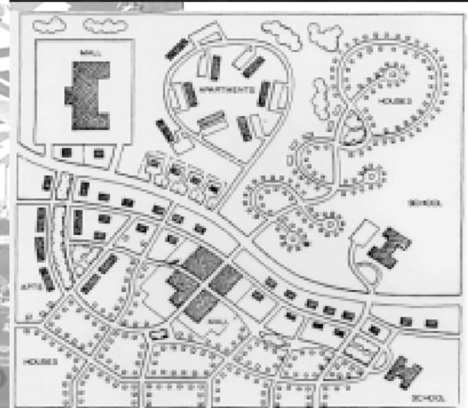

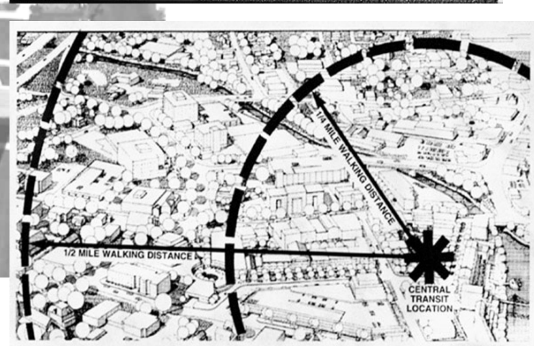

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Smart Growth America is a nationwide coalition promoting a better way to grow: one that protects farmland and open space, revitalizes neighborhoods, keeps housing affordable, and provides more transportation choices.

This report, as well as metro area fact sheets and the full technical report, are available online at www.smartgrowthamerica.org.

Executive Summary: Measuring Sprawl & Its Impact

Much as Justice Potter Stewart said of pornography, most people would be hard pressed to define urban sprawl, but they know it when they see it.

> This study is the first to create a multidimensional picture of the sprawl phenomenon and analyze related impacts.

Increasingly, however, that is not good enough. As more and more metropolitan areas debate the costs and consequences of poorly managed expansion, there is an increasing need to be clear about the terms of the discussion. Politicians and planners aiming to contain sprawl also must have an agreed-upon way to define and measure it in order to track their progress. Beyond that, it is important for policy makers to be able to demonstrate how, and to what degree, sprawl has real implications for real people.

The study underlying this report, the product of three years of research by Reid Ewing of Rutgers University, Rolf Pendall of Cornell University, and Don Chen of Smart Growth America represents the most comprehensive effort yet undertaken to define, measure and evaluate metropolitan sprawl and its impact. This report is the first in a series of findings to be issued based on the ongoing analysis of that work.

Sprawl Defined

Beginning with an exhaustive review of the existing academic and popular literature, the researchers identified sprawl as the process in which the spread of development across the landscape far outpaces population growth. The landscape sprawl creates has four dimensions: a population that is widely dispersed in low-density development; rigidly separated homes, shops, and workplaces; a network of roads marked by huge blocks and poor access; and a lack of well-defined, thriving activity centers, such as downtowns and town centers. Most of the other features usually associated with sprawl—the lack of transportation choices, relative uniformity of housing options or the difficulty of walking—are a result of these conditions.

The Four Factor Sprawl Index

Based on this understanding, the researchers set about creating a sprawl index based on four factors that can be measured and analyzed:

- Residential density;
- Neighborhood mix of homes, jobs, and services;
- Strength of activity centers and downtowns;
- Accessibility of the street network.

Each of these factors is in turn composed of several measurable components, a total of 22 in all. Residential density, for example, includes the proportion of residents living in very spread-out suburban areas, the portion of residents living very close together in town centers, as well as simple overall density and other measures. Before being included, each variable was tested through technical analysis to ensure that it added something unique to the overall portrait of sprawl.

The information assembled for each of 83 metropolitan areas (representing nearly half of the nation's population) produced a richly textured database that offers the most comprehensive assessment of metropolitan development patterns available to date. This study is the first to create such a multidimensional picture of the sprawl phenomenon and analyze related impacts.

Comparing and Evaluating Metropolitan Regions

Based on its performance, each metro area earned a score in each of the four factors, indicating where it falls on the spectrum relative to other regions. Much of the value of this study is in this ability to look at the particular ways in which individual regions sprawl.

Some metro areas were found to sprawl badly in all dimensions. These include Atlanta, Raleigh and Greensboro, NC. A few metros did better than other regions in all four factors; among them are San Francisco, Boston, and Portland, Oregon. Other metro areas are more of a mixed bag; in those cases, the individual factor scores can tell us more about the characteristics of individual metro areas. For example, while the Columbia, SC or Tulsa, OK metro areas contain large swaths of low-density development, the presence of a number of strong centers bring them up in the overall ranking. And while San Jose, California, has slightly higher density than most metro areas, its lack of centers of activity pulls it down in the overall ranking.

The scores for the four factors were combined to calculate the overall Four Factor Sprawl Index, ranking the most and least sprawling metropolitan areas. On the Index, the average is 100, with lower scores indicating poorer performance and more sprawl, while higher scores show less sprawl. Using this Index, the most sprawling metro area of the 83 surveyed is Riverside, California, with an Index value of 14.22. It received especially low marks because:

- it has few areas that serve as town centers or focal points for the community: for example, more than 66 percent of the population lives over ten miles from a central business district;
- it has little neighborhood mixing of homes with other uses: one measure shows that just 28 percent of residents in Riverside live within one-half block of any business or institution;
- its residential density is below average: less than one percent of Riverside's population lives in communities with enough density to be effectively served by transit;
- its street network is poorly connected: over 70 percent of its blocks are larger than traditional urban size.

In the overall national ranking, Riverside is followed by Greensboro, NC; Raleigh, NC; Atlanta, GA; Greenville, SC; West Palm Beach, FL; Bridgeport, CT; Knoxville, TN; Oxnard-Ventura, CA; and Ft. Worth, TX.

Most Sprawling Metropolitan Regions

Metropolitan Region	Overall Sprawl Index Score	Rank
Riverside—San Bernardino, CA PMSA	14.2	1
Greensboro—Winston-Salem—High Point, NC MSA	46.8	2
Raleigh—Durham, NC MSA	54.2	3
Atlanta, GA MSA	57.7	4
Greenville—Spartanburg, SC MSA	58.6	5
West Palm Beach—Boca Raton—Delray Beach, FL MSA	67.7	6
Bridgeport—Stamford—Norwalk—Danbury, CT NECMA	68.4	7
Knoxville, TN MSA	68.7	8
Oxnard—Ventura, CA PMSA	75.1	9
Fort Worth—Arlington, TX PMSA	77.2	10

People living in more sprawling regions tend to drive greater distances, own more cars, breathe more polluted air, face a greater risk of traffic fatalities and walk and use transit less

At the other end of the scale, the metro area with the highest overall score is, not surprisingly, New York City, closely followed by Jersey City just across the Hudson River. (New York and Jersey City are such extreme "outliers" that they were excluded from most of the comparative analysis discussed later in the report.) Providence, San Francisco, and Honolulu round out the top five most compact metros, followed by Omaha, NE, Boston, Portland, OR, Miami, and New Orleans.

Sprawl's Impact on Quality of Life

This initial report examines several transportation-related measures and impacts and finds that people living in more sprawling regions tend to drive greater distances, own more cars, breathe more polluted air, face a greater risk of traffic fatalities and walk and use transit less. Although this study was not designed to prove that land-use patterns cause those conditions, sprawl and its component factors were found to be a greater predictor than numerous demographic control variables that were also tested.

Among the impacts of sprawl found:

- **Higher rates of driving and vehicle ownership.** The research indicates that in relatively sprawling regions, cars are driven longer distances per person than in places with lower-than-average sprawl. Over an entire region, that adds up to millions of extra miles and tons of additional vehicle emissions. Also, the study found that in the ten most sprawling metropolitan areas, there are on average 180 cars to every 100 households; in the least sprawling metro areas (excluding New York City and Jersey City, which are outliers), there are 162 cars to every 100 households. The research indicates that this is not simply a matter of greater or lesser affluence; even controlling for income, households are more likely to bear the expense of additional vehicles in more sprawling areas.

- **Increased levels of ozone pollution**. The study found that the degree of sprawl is more strongly related to the severity of maximum ozone days than per capita income or employment levels. The difference in ozone peaks appears significant enough to potentially mean the difference between reaching or failing to meet federal health-based standards. Failing to reach the standard not only imperils the health of children and other vulnerable populations, but also subjects regions to a raft of rigorous compliance measures.

- **Greater risk of fatal crashes.** Residents of more sprawling areas are at greater risk of dying in a car crash, the research indicates. In the nation's most sprawling region, Riverside CA, 18 of every 100,000 residents die each year in traffic crashes. The eight least sprawling metro areas all have traffic fatality rates of fewer than 8 deaths per 100,000. The higher death rates in more sprawling areas may be related to higher amounts of driving, or to more driving on high-speed arterials and highways, as opposed to driving on smaller city streets where speeds are lower. Speed is a major factor in the deadliness of automobile crashes.

- **Depressed rates of walking and alternative transport use.** In more sprawling places, people on their way to work are far less likely to take the bus or train or to walk. Twice the proportion of residents take public transit to work in relatively non-sprawling metro areas versus those with below-average scores. Likewise, thousands more residents walk to work in regions that sprawl less.

- **No significant differences in congestion delays** The research found that sprawling metros exhibited the same levels of congestion delay as other regions. This finding challenges claims that regions can sprawl their way out of congestion.

Policy Recommendations

This study shows that sprawl is a real, measurable phenomenon with real implications for peoples' everyday lives. Regions wishing to improve their quality of life should consider taking steps to reduce sprawl and promote smarter growth. Based on this research, Smart Growth America offers six policy recommendations:

1) Reinvest in Neglected Communities and Provide More Housing Opportunities

2) Rehabilitate Abandoned Properties

3) Encourage New Development or Redevelopment in Already Built Up Areas

4) Create and Nurture Thriving, Mixed-Use Centers of Activity

5) Support Growth Management Strategies

6) Craft Transportation Policies that Complement Smarter Growth

Introduction: Measuring Sprawl

Across the nation, growing numbers of communities are discovering links between urban sprawl and a wide range of problems, from traffic and air pollution to central city poverty and the degredation of scenic areas. As more civic leaders take steps to ameliorate these costs, they are in increasing need of meaningful information about the characteristics, extent and consequences of sprawl.

To help meet these needs, Smart Growth America (SGA) has sponsored this groundbreaking research by Rutgers University Professor Reid Ewing and Cornell University Professor Rolf Pendall. It represents a rigorous effort to measure the characteristics of sprawl and their impacts on quality of life. We define sprawl as low-density development with residential, shopping and office areas that are rigidly segregated; a lack of thriving activity centers; and limited choices in travel routes. These features constitute *four factors* that can then be measured and analyzed: 1) Residential density; 2) Neighborhood mix of homes, jobs, and services; 3) Strength of centers, such as business districts; and 4) accessibility via the street network. All of these are well-established descriptors of urban sprawl in the relevant academic literature, but this study represents the first effort to attempt to measure sprawl in all of these dimensions.

The heart of this project is an extensive database that allows for both the careful measurement of urban sprawl as well as the assessment of its relationship to a wide variety of quality-of-life indicators. The database contains two sets of variables. The first set includes 22 variables grouped into the four factors that characterize sprawl. The second set of data includes dozens of indicators of community quality of life, including everything from how much people drive every day to the consumption of farmland and forests. This report is the first of several that will assess the impact of sprawl on these important outcomes.

This research is significant for two main reasons. First, it is by far the most comprehensive attempt to define and quantify urban sprawl in the U.S. Some studies have defined sprawl simply in terms of the amount of land used as the population grows, but ignoring the form in which that growth occurs. This study shows that sprawl is not just growth, but is a specific, and dysfunctional, style of growth. By evaluating metropolitan growth patterns based on four factors, we present a highly detailed portrait of sprawl that will enable decision-makers to target their growth management strategies more effectively. Second, and perhaps more importantly, the research analyzes how growth patterns and affect everyday things that people value. In other words, the researchers have demonstrated that sprawl is a real, measurable phenomenon, and it has real, measurable consequences for people.

This first volume presents sprawl measures for 83 of the largest metropolitan areas in the United States and examines the relationships between urban sprawl and transportation-related measures, including vehicle miles traveled, traffic fatalities, the extent of walking and public transit use, roadway congestion and air quality. Future volumes will address how sprawl may be influencing other outcome measures, such as the decline of central cities, the loss of open space and impacts on public health. Also, some data will be examined at the county level to explore the variation of development patterns within different metropolitan areas.

Previous Attempts to Define and Measure Urban Sprawl

In recent years, a number of academics, advocates, and journalists have sought to define and measure sprawl. Previous attempts to measure or "operationalize" urban sprawl have mostly used only one or two variables. The best-known effort may be *USA Today's* sprawl index published in 2001, which measured the proportion of the metropolitan population living outside the Census-defined urbanized area and the change in that proportion over time.

Unfortunately, the inherent complexity of sprawl cannot be captured by one or two variables. The result has been not only highly simplistic characterizations of urban sprawl, but also wildly different estimates of which regions sprawl the worst. In one study, for example, Portland, Oregon is ranked as the most compact region while Los Angeles appears to be very sprawling. In another, their rankings are essentially reversed. A third study characterizes certain Northeastern metros as very sprawling, while a fourth finds them to be relatively compact. There are only a few consistent performers, such as Atlanta, which always appears to be among the most sprawling.

Previous studies also fall short by equating sprawl with density. Leading scholars and practitioners emphatically reject the notion that the degree of density is equivalent to the degree of sprawl, and contend that other characteristics, such as the strength of city and town centers, the neighborhood mix of uses and the degree of street accessibility, also play a significant role.

Finally, past studies of metropolitan area sprawl have also paid little attention to the impacts of sprawl on daily life. With the exception of a few studies focusing on a single outcome each, the literature is nearly devoid of such analysis. Most comparisons of metropolitan regions simply presume that sprawl has negative consequences. Smart Growth America, as well as Professors Ewing and Pendall, believe that such impacts need to be proven, and that ultimately, sprawl can only be judged according to its outcomes.

A brief summary of previous sprawl indices can be found in Appendix I.

Characterizing Sprawl: The Four Factor Sprawl Index

The presence of sprawl may seem obvious when driving past a suburban strip mall, but actually measuring development patterns for empirical analysis is a highly challenging and complex undertaking because of the multifaceted nature of sprawl. To be investigated empirically, sprawl must be "operationalized"; that is, it must be represented by variables that can be objectively measured.

In this study, the researchers operationalized, or measured, sprawl using 22 variables that represent different aspects of development patterns. Among these variables are several measures of residential density from the U.S. Census; land use data from the National Resource Inventory (from the Department of Agriculture); and data on the proximity among homes, offices, and retail stores from the American Housing Survey. Variables and their sources are listed in Appendix II. The 22 variables were grouped into four factors of sprawl:

- Residential density;
- Neighborhood mix of homes, jobs, and services;
- Strength of activity centers and downtowns;
- Accessibility of the street network.

The use of four factors to define sprawl means we get a more detailed picture of how sprawling development looks in different metro areas.

How to Read the Index

For the sake of comparability and ease of understanding, the scores for the four factors have been standardized so that the average of each factor is represented by a score of 100. This means that the metro areas that are more compact than average have scores above 100, while those that are less compact have scores below 100. Two-thirds of the metro areas fall between 75 points and 125 points on the scale, in other words, 25 points below and 25 points above 100. In statistical terms, this 25-unit increment is known as a "standard deviation."

To construct the overall Four Factor Sprawl Index, these factors were combined and standardized for the population size of the surrounding metropolitan region. It is important to note that this ranking is relative, not absolute: U.S. cities tend to be much more sprawling than metro areas in Europe, for example, and in an international ranking most U.S. metro areas would fall to the bottom of the scale.

Residential Density

Residential density is the most widely recognized indicator of sprawl. Spread-out suburban subdivisions are a hallmark of sprawl, and can make it difficult to provide residents with adequate nearby shopping or services, civic centers, or transportation options. Yet higher density does not necessarily mean high-rises. Densities that support smart growth can be as low as six or seven houses per acre, typical of many older urban single-family neighborhoods. Such densities allow neighborhoods that can support convenience stores, small neighborhood schools, and more frequent transit service. In this study, this factor is an attempt to measure the efficiency of land use in a metro area. It quantifies the amount of land used per person and measures the degree to which housing is spread out or compact.

The measure of residential density used in this study is a composite of variables from the U.S. Census, the American Housing Survey, the Natural Resources Inventory, and the Claritas Corporation.[1] A list of all the variables is available in Appendix 2.

Rankings

The places where housing is most spread-out include a number of medium-size metro areas in the Southeast. The place with the lowest housing density is Knoxville, TN, with a score of 71.22, followed by Greenville, SC; Greensboro, NC; Columbia, SC; Raleigh-Durham, NC; and Birmingham, AL. These are places where growth has mostly occurred during the automobile era, and have been without topographic or water-related constraints that otherwise restrict development. The prevalence of low residential densities in this particular region is striking and merits further investigation.

Most Sprawling: Residential Density

Metropolitan Region	Density Score	Rank
Knoxville, TN MSA	71.2	1
Greenville—Spartanburg, SC MSA	71.9	2
Greensboro—Winston-Salem—High Point, NC MSA	74.2	3
Columbia, SC MSA	74.6	4
Raleigh—Durham, NC MSA	76.2	5
Birmingham, AL MSA	77.1	6
Little Rock—North Little Rock, AR MSA	77.5	7
Baton Rouge, LA MSA	80.8	8
Worcester—Fitchburg—Leonminster, MA NECMA	81.2	9
Grand Rapids, MI MSA	82.7	10

Scattered, low density development is a hallmark of sprawl

The other end of the density scale shows that New York City and neighboring Jersey City are simply off the scale. New York is in a class by itself, with a score of 242 in terms of residential density, while the average is 100. While the smaller Jersey City metro area ranks second, most of the other metros with high density scorings are the central cities of large urbanized regions: San Francisco, Los Angeles, Chicago, and Miami. The secondary metro areas of these same regions also score high on this factor: Anaheim, San Jose, Newark, Oakland, and Ft. Lauderdale.

Neighborhood Mix of Homes, Shops, and Offices

One of the characteristics of sprawl is the strict segregation of different land uses. In sprawling regions, housing subdivisions are typically separated—often by many miles—from shopping, offices, civic centers, and even schools. This separation of uses is what requires every trip to be made by car, and can result in a "jobs-housing imbalance" in which workers cannot find housing close to their place of work. More traditional development patterns tend to mix different land uses, often placing housing near shops, or offices above storefronts. Measuring the degree of mix is therefore an important descriptor of sprawl.

The mixed-use variables came from the American Housing Survey and the Census Transportation Planning Package, and represent the balance between jobs and population, the mix of land uses within communities, and the accessibility of housing to shops and schools. Higher densities tend to support more mixed uses, so the mix factor is moderately correlated with the density factor. Yet, the rankings show that the mix factor is

Most Sprawling: Mix of Uses

Metropolitan Region	Mix Score	Rank
Raleigh—Durham, NC MSA	39.5	1
Riverside—San Bernardino, CA PMSA	41.5	2
Greensboro—Winston-Salem—High Point, NC MSA	46.7	3
Greenville—Spartanburg, SC MSA	50.4	4
West Palm Beach—Boca Raton—Delray Beach, FL MSA	54.7	5
Orlando, FL MSA	60.8	6
Birmingham, AL MSA	62.2	7
Knoxville, TN MSA	62.9	8
Columbia, SC MSA	67.1	9
Little Rock—North Little Rock, AR MSA	68.3	10

clearly capturing something distinct from density.

Rankings

The place with the poorest mix of homes, jobs, and other land uses is Raleigh, NC; followed by Riverside, CA; Greensboro, NC; Greenville, SC; and West Palm Beach, FL, all of which appear in the top ten in the ranking of most sprawling metros. The mixed-use ranking is consistent with low scores in residential density. The metros with the greatest degree of land-use mixing are medium-sized and mostly concentrated in the Northeast. In descending order, the top five are: Jersey City, NJ; New Haven, CT; Providence, RI; Oxnard, CA; and Bridgeport, CT.

Strength of Metropolitan Centers

Metropolitan centers, be they downtowns, small towns, or so-called "edge cities," are concentrations of activity that help businesses thrive, and support alternative transportation modes and multipurpose trip making. They foster a sense of place in the urban landscape.[ii] Centeredness can be represented by concentrations of either population or employment. It can also reflect a single dominant center or multiple subcenters. The academic literature associates compactness with centers of all types, and sprawl with the absence of centers of any type.

Most Sprawling: Strength of Centers

	Centeredness Score	Rank
Vallejo—Fairfield—Napa, CA PMSA	40.9	1
Riverside—San Bernardino, CA PMSA	41.4	2
Tampa—St. Petersburg—Clearwater, FL MSA	51.9	3
West Palm Beach-Boca Raton-Delray Beach, FL MSA	53.9	4
Oxnard—Ventura, CA PMSA	55.5	5
Oakland, CA PMSA	57.6	6
Gary—Hammond, IN PMSA	61.2	7
Detroit, MI PMSA	63.0	8
Greensboro—Winston-Salem—High Point, NC MSA	69.1	9
Anaheim—Santa Ana, CA PMSA	72.1	10

The centers factor was determined using variables from the Census and the Claritas Corporation, as well as from a Brookings Institution study that used the U.S. Department of Commerce's Zip Code Business Patterns. The centers factor measures two distinct conditions: the focus of development on the downtown and central city, and the presence of important subcenters within the metropolitan area. The former dominates the latter in the resulting rankings. Centering appears to operate quite independently of residential density; metro areas can have strong centers with or without high density. In fact, this is the only factor that bears no relationship to density, and therefore makes a unique contribution to the characterization of sprawl.

Sprawling regions often lack strong centers, such as downtowns or main streets.

Rankings

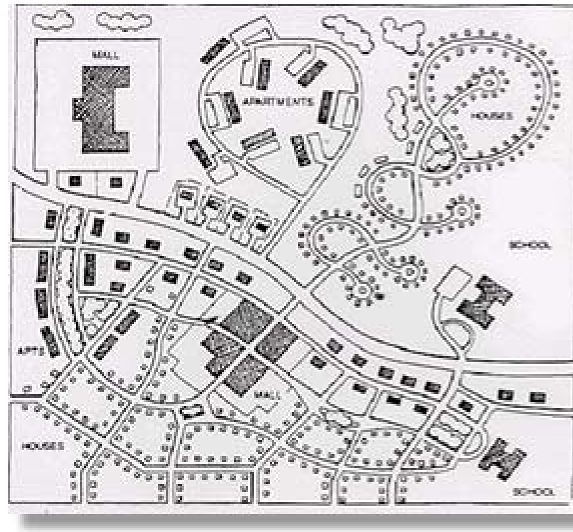
The metro areas ranking lowest in the strength of their metropolitan centers are: Vallejo, CA; Riverside, CA; Oakland, CA; and Gary, IN. Most of the metros with a low score in this factor are close to larger metropolitan regions, where strong centers may exist not too far beyond their borders. Two of the bottom ten are metro areas that stand on their own, but have exceptionally weak downtowns: Tampa, FL and Detroit. Los Angeles, whose downtown is also weak, just misses the bottom ten in this ranking.

With the exception of New York, the metros scoring highest on this factor are medium-sized and are focused on one major center, downtown. In descending order, they are: Honolulu; Columbia, SC; Springfield, MA;

and Providence. Others in the top ten include Colorado Springs, Omaha, NE, and Wichita, KS. Other than New York, the only large, multi-centered metro near the top is San Francisco.

Accessibility of the Street Network

Street networks can be dense or sparse, interconnected or disconnected. Blocks carved out by streets can be short and small, or long and large. Busy arterials that are fed by residential streets that end in cul-de-sacs are typical of sprawl; they create huge super-blocks that concentrate automobile traffic onto a few routes and hamper accessibility via transit, walking and biking. Compact development generally includes a network of interconnected streets with shorter blocks that allow greater accessibility and a broader choice of routes for drivers, pedestrians, and cyclists.



Top shows poorly connected street network; bottom shows well-connected streets.

Two data sources enable us to measure the size of blocks, which captures both block lengths and the extent to which streets are interconnected. These sources are the Census and Census TIGER files.

Rankings

The metro areas that got the poorest ranking for street accessibility were Rochester, Syracuse, Atlanta, Hartford, and Greenville-Spartanburg, where blocks are long and many streets end in cul-de-sacs or otherwise fail to connect. Places with the smallest blocks and most accessible street networks rank high on the streets factor, and most are older metropolitan areas: New York, Jersey City, San Francisco, and New Orleans. Behind them come some younger metropolitan areas that are developing at relatively high densities within their urbanized areas: Ft. Lauderdale, Anaheim, and Miami.

What the Four Factors Can Tell Us

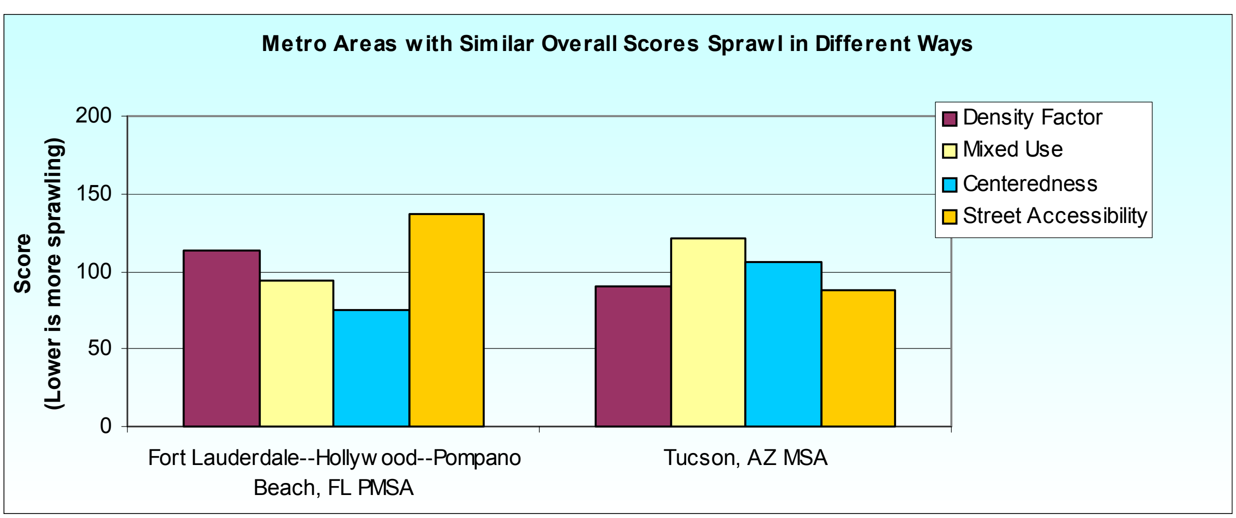
Much of the value of this study is in the ability to go beyond a single ranking to look at the factors that create sprawl within a particular metro area. In particular, this research underscores the notion that sprawl is not merely density. In these rankings, some metro areas sprawl badly in all dimensions. These include Atlanta, Raleigh, NC and Greensboro, NC. A few metros are compact in all dimensions, such as New York, San Francisco, Boston, and Portland, Oregon. Yet other metro areas are more of a mixed bag; in these cases, the individual factor scores can tell us more about the characteristics of individual metro areas. For example, while the Columbia, SC and Tulsa, OK metro areas contain large swaths of low-density development, the presence of a number of strong centers brings them up in the overall ranking. And while San Jose, California has slightly higher density, its lack of centers pulls it down in the overall ranking.

Case Study: Tucson, Arizona, and Ft. Lauderdale, Florida

A closer comparison of two metropolitan areas with a similar overall ranking shows just how different "sprawl" can be in these areas. Tucson, Arizona, and Ft. Lauderdale, Florida have very similar overall sprawl scores: Tucson at 109, and Ft. Lauderdale at 108, meaning that both are a bit more compact than average for their size. Yet they arrive at this score in very different ways. Tucson scores above average in the mix of neighborhood uses and focus on activity centers, while Ft. Lauderdale does much better than average in terms of street accessibility and residential density.

Tucson has large blocks and very low-density housing. Tucson's score for street accessibility is 88, ranking it 29th most sprawling in terms of its street layout. One indication of poor street accessibility is the size of its blocks: in Tucson only 45 percent of blocks are less than a hundredth of a square mile, or about 500 feet on a side. Tucson's housing is also extremely spread out: the metro area scored 90 on the residential density factor in part because its average urban density is only 1,767 persons per square mile, one of the lowest of all metros in our sample. Tucson's growth has remained focused on its own centers (rather than relating to centers in neighboring counties, as in Ft. Lauderdale); and the presence of mountains ringing the Tucson valley has kept nearly all employment within 10 miles of downtown. In degree of centering, Tucson gets an above-average score of 106. Tucson also does well in its mix of homes, offices, stores, and other uses; scoring 121 on this scale.

Ft. Lauderdale's blocks are smaller than Tucson's, and its housing is denser. Ft. Lauderdale scores 137 on the street index; 68 percent of its blocks are less than one hundredth of a square mile, one of the highest percentages in our sample. It also has higher-than-average residential density, with an average urban density of 4,837 persons per square mile, way above average for our sample. But, offsetting these factors, Ft. Lauderdale's degree of centering is below average; the metro area scored just 75 on this measure, making it the 14th most sprawling place in this regard. It has a weaker than average downtown for its size, few significant subcenters, and more than a third of its population relating to centers outside the metropolitan area. Only 15 percent of its employment falls within a three-mile ring of the central business district. It also keeps homes and workplaces farther apart than average, scoring 94 on the mixed-use factor.



Overall Sprawl Rankings

The four factors were combined to produce an overall *Sprawl Index*. The Index ranking shows which metro areas are most sprawling overall, and which factors make them that way. The most sprawling metro area of the 83 surveyed is Riverside, California, with an Index value of 14.22. It received especially low marks because:

- it has few areas that serve as town centers or focal points for the community: for example, more than 66 percent of the population lives over ten miles from a central business district;
- it has little neighborhood mixing of homes with other uses: one measure shows that just 28 percent of residents in Riverside live within one-half block of any business or institution;
- its residential density is below average: less than one percent of Riverside's population lives in communities with enough density to be effectively served by transit;
- its street network is poorly connected: over 70 percent of its blocks are larger than traditional urban size.

In the overall national ranking, Riverside is followed by Greensboro, NC; Raleigh, NC; Atlanta, GA; Greenville, SC; West Palm Beach, FL; Bridgeport, CT; Knoxville, TN; Oxnard, CA; and Ft. Worth, TX.

At the other end of the scale, the metro area with the highest overall score is, not surprisingly, New York City, closely followed by Jersey City just across the Hudson River. Providence, San Francisco, and Honolulu round out the top five most compact metros, followed by Omaha, NE, Boston, Portland, OR, Miami, and New Orleans. The table on pages 15 and 16 presents all of the Sprawl Index values for metro areas in 2000, and is ranked in order from most to least sprawling. The overall Index score appears in the first column, and the individual dimensions of sprawl are displayed in columns three through six.

It is important to point out that metropolitan areas that look less sprawling should not assume that sprawl is not a problem. According to our analysis of impacts, which is presented below, sprawl is strongly associated with a wide range of problems. Therefore, even policy makers in the least sprawling metros should not be complacent and should ensure that their decisions avoid the spread of sprawl.

Ten Most Sprawling Metropolitan Regions

	Overall Sprawl Index Score	Rank
Riverside—San Bernardino, CA PMSA	14.2	1
Greensboro—Winston-Salem—High Point, NC MSA	46.8	2
Raleigh—Durham, NC MSA	54.2	3
Atlanta, GA MSA	57.7	4
Greenville—Spartanburg, SC MSA	58.6	5
West Palm Beach—Boca Raton—Delray Beach, FL MSA	67.7	6
Bridgeport—Stamford—Norwalk—Danbury, CT NECMA	68.4	7
Knoxville, TN MSA	68.7	8
Oxnard—Ventura, CA PMSA	75.1	9
Fort Worth—Arlington, TX PMSA	77.2	10

Sprawl Scores for 83 Metropolitan Regions

The average score for each factor is 100. The table is ranked in order from most sprawling to least sprawling on the overall Four-Factor Sprawl Index.

Metropolitan Region	Overall Sprawl Score	Street Connectivity Score	Centeredness Score	Mixed Use Score	Density Score
Riverside--San Bernardino, CA PMSA	14.2	80.5	41.4	41.5	93.5
Greensboro--Winston-Salem--High Point, NC MSA	46.8	66.3	69.1	46.7	74.2
Raleigh--Durham, NC MSA	54.2	80.8	77.2	39.5	76.2
Atlanta, GA MSA	57.7	57	82.3	73.7	84.5
Greenville--Spartanburg, SC MSA	58.6	62.1	98.5	50.4	71.9
West Palm Beach--Boca Raton--Delray Beach, FL MSA	67.7	104.7	53.9	54.7	94
Bridgeport--Stamford--Norwalk--Danbury, CT NECMA	68.4	80.7	94.8	137.5	92.5
Knoxville, TN MSA	68.7	75.5	97.8	62.9	71.2
Oxnard--Ventura, CA PMSA	75.1	106.5	55.5	139.4	103.9
Fort Worth--Arlington, TX PMSA	77.2	97.5	73.9	89.1	90.3
Gary--Hammond, IN PMSA	77.4	100.5	61.2	123.7	86.4
Rochester, NY MSA	77.9	37.2	120.7	82.3	91.4
Dallas, TX PMSA	78.3	90.2	81.1	82.6	99.5
Vallejo--Fairfield--Napa, CA PMSA	78.4	109.7	40.9	116.3	97.4
Detroit, MI PMSA	79.5	93	63	102.5	97.3
Syracuse, NY MSA	80.3	52.6	124.9	72	85.8
Newark, NJ PMSA	81.3	115.4	82.2	120.4	118.9
Little Rock--North Little Rock, AR MSA	82.3	88.2	105.9	68.3	77.5
Albany--Schenectady--Troy, NY MSA	83.3	73.2	98.5	89.3	82.9
Hartford--New Britain--Middletown--Bristol, CT NEC	85.2	59.6	84.6	119.4	86.3
Oklahoma City, OK MSA	85.6	69.1	95.6	101.3	84.5
Tampa--St. Petersburg--Clearwater, FL MSA	86.3	133.6	51.9	80	93.6
Birmingham, AL MSA	88	104	112.5	62.2	77.1
Baton Rouge, LA MSA	90.1	76.2	106.2	95.9	80.8
Worcester--Fitchburg--Leonminster, MA NECMA	90.5	74.5	122.7	82.3	81.2
Washington, DC--MD--VA MSA	90.8	98	97.8	78.7	106.9
Columbus, OH MSA	91.1	97.2	101.5	76.5	91.5
Jacksonville, FL MSA	91.6	104.6	102.1	72.9	85.6
Kansas City, MO--KS MSA	91.6	88.8	89	100	90.9
Cleveland, OH PMSA	91.8	66.8	100.9	107.4	99.7
Memphis, TN--AR--MS MSA	92.2	76.5	104.2	97	88.9
Houston, TX PMSA	93.3	95.6	87	110.1	95.3
Indianapolis, IN MSA	93.7	84.5	102.4	96.2	89.3
Columbia, SC MSA	94.2	79.5	147.3	67.1	74.6
St. Louis, MO--IL MSA	94.5	106	76.2	107.4	90.3
Grand Rapids, MI MSA	95.2	63.7	110.3	115.7	82.7

Metropolitan Region	Overall Sprawl Score	Street Connectivity Score	Centeredness Score	Mixed Use Score	Density Score
Norfolk--Virginia Beach--Newport News, VA MSA	95.6	113.1	82	87.2	95
Minneapolis--St. Paul, MN--WI MSA	95.9	87.7	107.8	94.7	94.7
Cincinnati, OH--KY--IN PMSA	96	85.4	110.2	95.8	88.8
Orlando, FL MSA	96.4	120.6	103.5	60.8	93.8
Anaheim--Santa Ana, CA PMSA	97.1	136.4	72.1	121.5	128.8
Oakland, CA PMSA	98.8	133.4	57.6	106.3	116.6
Tulsa, OK MSA	99.1	96.2	115	88	82.7
Seattle, WA PMSA	100.9	117.1	98	79.4	103.6
Los Angeles--Long Beach, CA PMSA	101.8	123.3	72.4	123.1	151.5
San Diego, CA MSA	101.9	106	74.4	105.4	113.4
Sacramento, CA MSA	102.6	98.4	87.4	110.9	99.1
Las Vegas, NV MSA	104.7	108.8	99.8	80.1	110
Akron, OH PMSA	105.9	84.2	119.5	118.7	86.8
Tacoma, WA PMSA	105.9	111.2	122.7	85.6	90.8
Pittsburgh, PA PMSA	105.9	124.2	104.5	86.8	90.4
New Haven--Waterbury--Meriden, CT NECMA	107	86.5	78.9	144.3	91.6
Toledo, OH MSA	107.2	77.6	112.2	119.6	91.3
San Antonio, TX MSA	107.8	103	108.4	100.6	95
Fort Lauderdale--Hollywood--Pompano Beach, FL PMSA	108.4	137.2	75	94.7	113.9
Tucson, AZ MSA	109.1	88	106.4	121.8	90.4
San Jose, CA PMSA	109.7	125.2	93.9	96.6	124.8
Wichita, KS MSA	110.1	78.6	131.4	113.1	84.4
Austin, TX MSA	110.3	94.4	115.8	111.9	89
Fresno, CA MSA	110.3	73	112.6	130.1	93.5
Salt Lake City--Ogden, UT MSA	110.9	117	93.8	103.2	99.5
Phoenix, AZ MSA	110.9	107.2	92.6	116	106.8
Philadelphia, PA--NJ PMSA	112.6	113	95.9	119.5	114.7
Baltimore, MD MSA	115.9	105.2	115.6	106.8	104.3
El Paso, TX MSA	117.2	102.3	119.5	103.4	100.1
Milwaukee, WI PMSA	117.3	93.9	117.7	117.9	101.4
Buffalo, NY PMSA	119.1	70.6	135.2	124.7	102.1
Chicago, IL PMSA	121.2	134.9	85.8	115.1	142.9
Springfield, MA NECMA	122.5	87.3	148.6	115.7	86.3
Allentown--Bethlehem--Easton, PA--NJ MSA	124	131	91.7	133.4	86.2
Colorado Springs, CO MSA	124.4	96.7	135.2	119	91.2
Albuquerque, NM MSA	124.5	117.8	124	103.7	97
Denver, CO PMSA	125.2	125.7	108.9	115.7	103.7
New Orleans, LA MSA	125.4	138.6	123.7	80.4	105.9
Miami--Hialeah, FL PMSA	125.7	136.4	92.7	104.7	129.1
Portland, OR PMSA	126.1	128	121.8	102.3	101.3
Boston--Lawrence--Salem--Lowell--Brockton, MA NECM	126.9	119.1	109.4	124.4	113.6
Omaha, NE--IA MSA	128.4	104.6	132.3	119.3	96.4
Honolulu, HI MSA	140.2	114.3	167.3	84.3	116.5
San Francisco, CA PMSA	146.8	139.8	128.6	107.3	155.2
Providence--Pawtucket--Woonsocket, RI NECMA	153.7	135.9	140.3	140.5	99.1
Jersey City, NJ PMSA	162.3	166.8	98.7	172.9	195.7
New York, NY PMSA	177.8	154.9	144.6	129.8	242.5

Measuring Sprawl's Impact

Ultimately, sprawl must be judged by its consequences. No development pattern is inherently good or bad. Citizens and policy makers will decide whether one development pattern is preferable to another based on the conditions they create for people and the environment. It is in evaluating these outcomes that this study is likely to prove most useful. As noted above, future work will include measuring sprawl against a wide variety of measures, including public health, infrastructure expenditures, loss of resource lands and racial segregation, among others. Correlational studies, of which this is one, cannot be used to establish cause-effect relationships. But they can establish statistically significant associations, a necessary condition for causality. This study has also controlled for potentially confounding influences, such as population size, average size of households, per capita income, and the proportion of the population of working age.

For this initial report, researchers compared the overall Sprawl Index and the four sprawl factors to outcome measures related to transportation because the effect of sprawl on transportation has been relatively well researched. Finding relationships between sprawl and transportation that agree with the existing literature helps to validate this measurement of sprawl.

The outcome measures came from a variety of sources, including the U.S. Census Bureau, the Texas Transportation Institute, the Federal Highway Administration's Highway Performance Monitoring System, and the National Highway and Traffic Safety Administration's Fatal Accident Reporting System. Outcome measures are listed in Appendix II.

Overview: Sprawl Affects Daily Life

This analysis found that for nearly all of these travel and transportation outcomes, sprawling regions perform less well than compact ones. The degree to which a region sprawls, as represented by the Index, bears strong relationships to six of the travel-related outcome variables.

As sprawl increases, so do the number of miles driven each day (daily vehicle-miles traveled, or DVMT); the number of vehicles owned per household; the annual traffic fatality rate; and concentrations of ground-level ozone, a component of smog. At the same time, the number of commuters walking, biking or taking transit to work decreases to a significant extent. Interestingly, the Index is not significantly related to two indicators of traffic congestion, either average commute time or annual traffic delay per capita. That is important to note because defenders of sprawl often ar-

The Impact of Sprawl on Quality-of-Life Outcomes

For this report, the four factors and the overall Sprawl Index were compared to the following travel and transportation outcomes:

- Distance Driven per Person per Day (Daily Vehicle-Miles Traveled Per Capita)
- Average Vehicle Ownership per Household
- Percent of Commuters Taking Transit to Work
- Percent of Commuters Walking to Work
- Average Commute Times
- Average Annual Traffic Delay
- Traffic Fatalities per 100,000 People
- Ozone Pollution Levels.

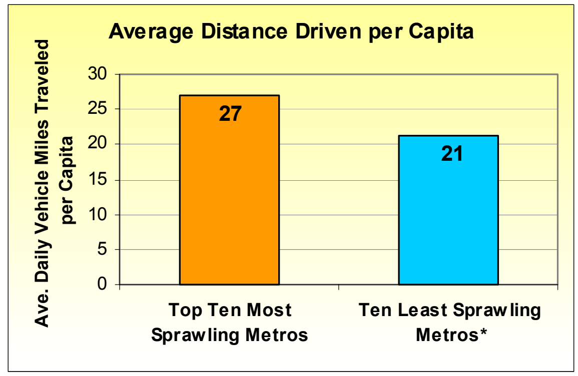
The study controlled for several demographic and socioeconomic variables that might have an independent influence on the outcome measures: This helps ensure that the relationships between sprawl and the above outcomes are genuine associations, and not driven by other factors.

- Metropolitan Area Population
- Average Household Size
- Percent of the Population of Working Age (20-64)
- Per Capita Income

gue that spreading out reduces congestion and travel times. This report's findings undermine that claim.

People in Sprawling Metros Drive More and Own More Cars

Compared with all of the control variables, the degree of sprawl was the strongest influence on vehicle-miles traveled per person. This was somewhat surprising, because some scholars contend that metropolitan population and per capita income have the greatest influence on the amount of vehicle travel within a metro area.

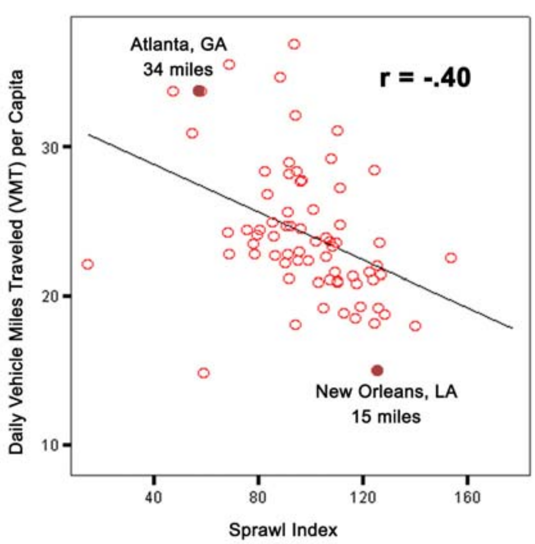


The statistical relationships we found show that vehicle use rises quite noticeably as sprawl increases. For every 25-unit decline (one standard deviation) in the Sprawl Index, there is an almost two-mile increase (1.96) in daily vehicle-miles traveled (DVMT) per person. While the numbers may appear modest, transportation planners will recognize the enormity of the implications, since even a small rise in per capita miles of travel represents a sizeable increase in traffic, emissions and fuel expenditures when viewed across an entire metro region.

With a range on the Sprawl Index of 5.5 standard deviations (excluding the two extreme outliers, New York City and Jersey City), this represents a difference of approximately 10.8 DVMT per capita between the most sprawling and most compact regions. Some metro area comparisons illustrate this difference. In highly sprawling metropolitan Atlanta (Index score of 58), for example, vehicles rack up 34 miles each day for every person living in the region. On the other end of the scale, in Portland, Oregon (Index score of 126), vehicles are driven fewer than 24 miles per person, per day.

An analysis of the individual sprawl factors reveals that residential density also strongly influences the amount of driving per person. A 25-unit increase in this factor is associated with a decrease of 5.4 miles driven per day, per person. With the wide range on the residential density factor, (3.4 standard deviations, excluding the two extreme outliers, New York City and Jersey City), residential density is associated with a difference of roughly 18 daily vehicle miles of travel per capita between lowest density and highest density areas.

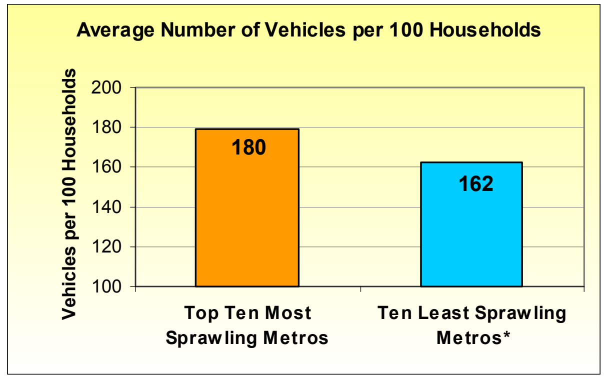
People in more sprawling metros drive further each day



Average household vehicle ownership is an indicator of the degree to which a region's population is dependent on automobiles for basic transportation. The assumption is that in sprawling areas where driving is the only way to get around, more households feel compelled to have a vehicle for each licensed driver. This appears to be the case, even after controlling for income. Sprawl is associated with higher levels of automobile ownership. The overall Sprawl Index is associated with a difference of 26 vehicles per 100 households between the extreme cases (5.5 standard deviations). Some of the control variables also had an impact on the number of cars per household. There were more cars per household in places where the average household is larger, and in larger metropolitan areas. But the number of cars per household was more strongly related to the degree of sprawl than to the propor-

* New York City and Jersey City Excluded

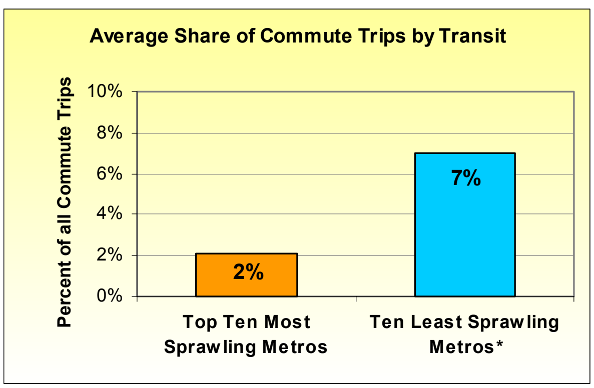
tion of the population of working age or per capita income. This finding suggests that in sprawling regions, automobile ownership may be more a matter of survival than a matter of personal choice.



Among the individual factors, residential density has a far stronger association with average household vehicle ownership than does overall sprawl. A 25-unit increase in the compactness factor score is associated with a 0.13 drop in average number of vehicles per household. That is, controlling for other factors, each standard deviation increase in housing compactness has every 100 household shedding an average of 13 cars. Residential density alone is associated with a difference of over 44 cars per 100 households between the most sprawling and least sprawling metro areas (the range on this factor is 3.4 standard deviations). Again, viewed in the aggregate across a metro area, such increases in vehicle ownership represent significantly more cars that must be supplied with parking, fuel, insurance and road capacity, to say nothing of the associated air emissions and roadway runoff.

In Sprawling Areas, Fewer Get to Work by Taking Public Transit and Walking

This study also found that in more sprawling places, people on their way to work are far less likely to take the bus or train or to walk. The metro areas that are more sprawling than average have only 2.3 percent of workers taking public transportation to work, while the places that are less sprawling than average have 5.1 percent of workers taking public transportation (comparing metros 25 points above the average Sprawl Index to those 25 points below the average Sprawl Index).



The residential density factor was found to have a highly significant association with the share of public transit trips to work. A 25-unit increase in this factor is associated with a nearly 3 percentage point increase in public transportation mode share on the journey to work. That is, controlling for other factors, every 25-point rise in the density factor score increases public transportation mode share by almost 3 percentage points. With a range on this factor of about 85 points (3.4 standard deviations), density alone is associated with a 10 percentage point increase in public transportation use between more and less sprawling metros.

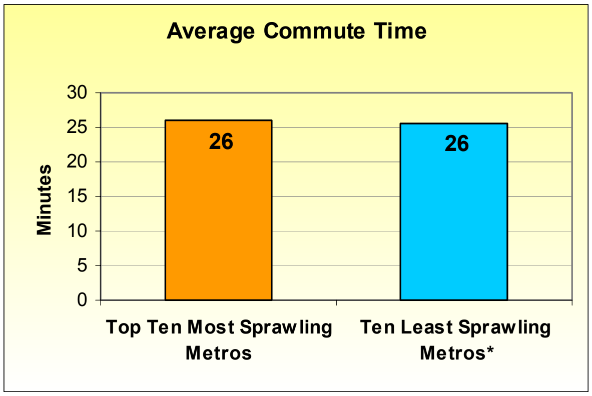
In examining whether people walk to work, the degree of sprawl is by far the most powerful predictor; associations with all of the control variables were insignificant. Roughly 2 percent of commuters walk to work in more sprawling places (those with scores 25 points below average), and 3.1 percent walk to work in less sprawling places (25 points above the average sprawl index). Between extreme cases, there is a difference of 3 percentage points in walk share to work. The residential density factor shows a comparable association with regard to walk share to work. Regions with the lowest residential density can be expected to have 2.7 percent fewer people walking to work than metros with the highest residential density. The relationship

* New York City and Jersey City Excluded

with the centers factor was also significant, but less so, with a 2.5 percent difference between extreme cases.

No Effect on Travel Delays

Surprisingly, the analysis did not find statistically significant relationships between sprawl and either the amount of travel delay that drivers experience or the average travel time for commuters. Both outcomes were found to be primarily a function of metropolitan area population, and secondarily of other demographic variables. In other words, big metro areas tend to generate long trips to work and high levels of traffic congestion. After controlling for population size and other demographic variables, sprawl does not appear to have a marginal effect on either outcome.



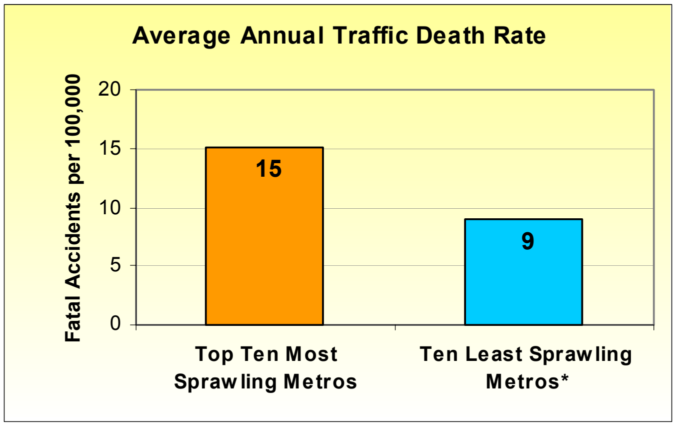
Why not? Some contend that in sprawling regions, a greater proportion of jobs and housing are dispersed into suburban areas that do not suffer from traffic gridlock. The findings with regard to the individual factors may shed some light. The centers factor showed an inverse relationship to annual delay per capita, so regions with stronger centers tend to have fewer traffic delays. The mix factor was similar, showing a significant inverse relationship with travel time to work, so regions with a better mix of uses shows lower levels of traffic delay. However, the streets factor was found to have direct relationships with both average commute times and annual delay per capita. When combined, these three dimensions of sprawl appear to cancel each other.

Therefore, one of the strongest purported benefits of sprawling development, lower traffic congestion, is not borne out by this study. Those who believe that metropolitan regions can sprawl their way out of congestion appear to be wrong.

Those who believe that metropolitan regions can sprawl their way out of congestion appear to be wrong.

More Sprawl, More Traffic Fatalities

Sprawling places are likely to have more traffic fatalities per capita than more compact regions due to higher rates of vehicle use and perhaps more aggressive driving. For example, in Riverside CA, the most sprawling region according to the Index, 18 of every 100,000 residents die each year in traffic crashes. The eight least sprawling metro areas all have traffic fatality rates of fewer than 8 per 100,000. This difference of 10 fatalities per 100,000 is approximately what can be expected between extremely sprawling and extremely compact regions. This relationship is statistically significant, outweighing the effect of all the control variables, including per capita income.

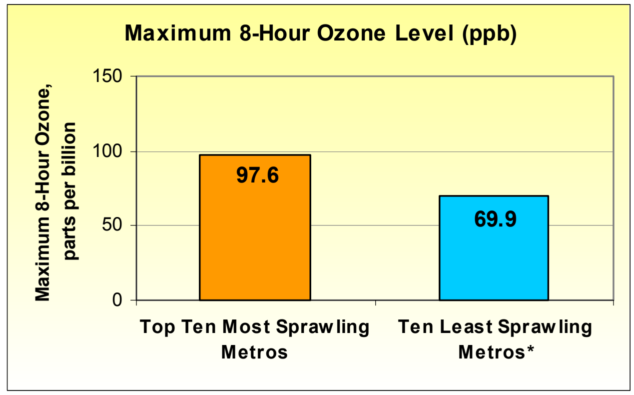


* New York City and Jersey City Excluded

The residential density factor was also found to be statistically significant with regard to traffic fatalities. Areas of the highest residential densities can be expected to have up to 18 fewer fatalities per 100,000 than their low-density counterparts. The mix factor and the centers factor shows a similar relationship, though less strong; for example, regions with the strongest centers exhibit nearly 5 fewer fatalities per 100,000 than regions with the weakest centers.

Air Quality Poorer in Sprawling Areas

This analysis found a strong relationship between maximum ozone levels (based on the Environmental Protection Agency's standard of 80 parts per billion, averaged over an 8-hour period) and the overall Sprawl Index. Of all the variables tested, the degree to which a region sprawls was the best indicator of a metro area's ozone levels. Every shift of 25 points upwards on the Sprawl Index is related to a 7.5 parts per billion decrease in maximum ozone levels. Looking at the range on the Sprawl Index (5.5 standard deviations), Ozone levels between the most sprawling and least sprawling areas can differ by 41 parts per billion.



Residential density appears to have the strongest impact on maximum ozone levels, with areas of the highest density expected to have 51 ppb lower ozone levels than the lowest density metros, quite significant relative to the ozone standard of 80 ppb. Elevated levels of ozone have been shown to be dangerous for children, the elderly, asthma sufferers and other vulnerable populations.

* New York City and Jersey City Excluded

Surprisingly, the mix factor appears to have an aggravating effect on maximum ozone level, though the relationship is just barely statistically significant, and may be spurious. If it is valid, it may be because a fine-grained mix of land uses encourage more short vehicle trips, and therefore more “cold starts” and “hot soaks” that contribute to air pollution.

Conclusion

The relationships found between urban sprawl and the quality of life outcomes show that traffic and transportation-related problems appear to increase in more sprawling areas. Even when controlling for income, household size, and other variables, people drive more, have to own more cars, breathe more polluted air, face greater risk of traffic fatalities, and walk and use transit less in places with more sprawling development patterns. While these findings may seem obvious, this is the first study to explicitly measure sprawl and explicitly relate sprawl, so measured, to an important set of transportation outcomes. This study suggests that if Houston, for example, were only somewhat more compact, thousands more people would walk to work, residents would drive less, and children would breathe cleaner air.

Generalizing to other transportation-related outcomes, these findings suggest that even after controlling for numerous demographic factors, urban sprawl has a major influence on energy (gasoline) consumption and other outcomes that are tied to vehicle-miles traveled. Future reports will further quantify the costs in health, safety, time and money associated with this phenomenon.

Policy Recommendations

Even for metropolitan regions that appear relatively compact, urban sprawl is a serious problem because of its strong association with numerous societal problems. For the nation’s most sprawling regions, it is even more urgent to devise strategies that can reduce sprawl. Advocates and practitioners associated with the Smart Growth movement have devised a wide array of techniques and policies to manage growth and help regions avoid haphazard sprawl. The following recommendations, however, are focused on the specific issues examined in this report, namely the four factors and the transportation outcomes measures. For more information, see “Getting to Smart Growt,” published by the Smart Growth Network (www.smartgrowth.org).

This study found strong evidence that at the regional scale, increased residential density has the potential to diminish the need to own and drive automobiles, which in turn can help protect air quality and reduce traffic fatalities, while increasing the share of commuters who use transit or walk. That is not a prescription for high rises in every neighborhood – far from it. The research indicates that even modest increases in average density, from one or two houses per acre to as few as six or seven, can offset the negatives examined in this report.

There are many strategies that can result in attractive communities with higher densities. Some of these strategies tend to fall under the general heading of community economic development. At the same time, the development of compact, walkable neighborhoods is gaining momentum in the real estate market, with growing numbers of retiring baby boomers expressing a preference for in-town living, greater conveniences and a stronger sense of community.

1. Reinvest in Neglected Communities and Provide More Housing Opportunities

For decades, thousands of community-based organizations have sought to use policy and financing tools to improve the quality of life in distressed communities. These tools include state and local low-income housing tax credit, the Community Reinvestment Act, Community Development Block Grants, state affordable housing trust funds, and a whole range of state and local programs. Such strategies infuse badly needed resources into long neglected neighborhoods and may reverse the abandonment of such neighborhoods. To reduce the impacts of sprawl, these reinvestment and housing programs should at least be maintained at current funding levels and preferably increased. In particular, a federal proposal to create a national affordable housing trust fund should be enacted into law.

2. Rehabilitate Abandoned Properties

A related strategy is the rehabilitation of individual abandoned properties, be they old vacant buildings, tax-delinquent homes, empty historic buildings, or other potentially useful properties. New Jersey, for example, passed a new rehabilitation code to facilitate the restoration of older buildings. Such measures have led to a large increase in rehab investment in New Jersey cities, and have been adopted by Maryland, Rhode Island and other states. Other states have reformed tax foreclosure laws and initiated improved inventory and tracking systems to more quickly identify negligent owners of abandoned properties and transfer them to new investors.

3. Encourage New Development or Redevelopment in Already Built Up Areas

Smart growth is not about stopping growth or even slowing growth; rather it is about focusing growth in places where it can properly be accommodated. Chief among those would be areas that already are within the urban footprint. Most metro regions contain ample redevelopment opportunities, which may include old industrial sites (brownfields), empty shopping malls (greyfields), and vacant lots. Such properties tend to have existing infrastructure (roads, water, sewer and other utilities), are large enough to accommodate entire new neighborhoods with a mix of homes, shops, offices, civic buildings and parks, linked together by a grid of streets and sidewalks.

4. Create and Nurture Thriving, Mixed-Use Centers of Activity

This study found that strong urban and suburban downtowns and other centers of activity are associated with fewer traffic fatalities, lower vehicle mileage, and more transit use and walking to work. As such, the fostering of such centers is an essential smart growth strategy. One of the most promising approaches to accomplishing this is to concentrate mixed-income housing, shops and offices around train stations and bus stops, which is commonly referred to as transit-oriented development (TOD).

Another important strategy involves rezoning to permit multifamily housing in and around the jobs-rich "edge cities". This can make it possible for more people to live near work while also introducing the residents needed to support neighborhood retail.

5. Support Growth Management Strategies

The low scores for the overall Sprawl Index (indicating more sprawl) were associated with more driving, vehicle ownership, traffic fatalities, peak ozone levels, and lower levels of transit use and walking to work. Key strategies for curbing sprawl include planning and zoning tools that help regions better manage growth. Portland, Oregon has developed one oft-cited model, wherein a regional growth framework is established and managed by an elected regional council in concert with local governments. Another method is the strategic preservation of prime farmland, sensitive environmental lands, forests and other green spaces, in conjunction with careful planning for development in designated areas.

6. Craft Transportation Policies that Complement Smarter Growth

In the coming year, Congress will consider the reauthorization of the nation's transportation law, the Transportation Equity Act for the 21st Century (TEA-21). This reauthorization is not only the means by which states receive federal gas tax dollars for much needed transportation projects, but it is also the main federal opportunity to improve the interaction between local and regional development plans and transportation planning and programming. In keeping with the previous five recommendations, this reauthorization should:

- Support "fix-it-first" state and federal transportation infrastructure policies, which favor the maintenance of existing streets and highways over the construction of new ones,
- Prioritize and increase funding that serves community development goals in lower-income neighborhoods,
- Create incentives for transit-oriented development, particularly mixed-use development and mixed-income housing, and
- Maintain important funding programs for historic preservation, walking and cycling facilities, and Main Street and streetscape improvement projects.

In addition, the new law should include resources that enable communities to better coordinate transportation and land use, including:

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[1] Census tracts with very low densities, less than 100 persons per square mile, were excluded from the calculation of these variables to eliminate rural areas, desert tracts, and other undeveloped tracts that happen to be located within metro area boundaries.

[2] Reid Ewing, "Is Los Angeles-Style Sprawl Desirable?" *Journal of the American Planning Association*, Winter 1997, pp. 107-126.

- Funds to support more sophisticated scenario planning for both corridors and regions,
- Better predictive models that cover not only transportation outcomes but also community impacts, and
- Tools for improved community involvement in the planning process.

Appendix One: Previous Attempts to Measure Sprawl

This is a brief overview of previous studies measuring and analyzing sprawl. For a more complete discussion, see the full research paper.

Studies Simply Measuring Sprawl[1]

USA Today

The sprawl index to receive the most attention, despite its limitations, was developed by *USA Today*.[2] The *USA Today* index assigned a score to each of 271 metropolitan areas based on two density-related measures:

- Percentage of a metro area's population living in urbanized areas. For the years in question, the Census Bureau defined "urbanized" as those parts of a metro with 1,000 or more residents per square mile.

- Change in the percentage of metropolitan population living in urbanized areas between 1990 and 1999.

Metropolitan areas were ranked 1 through 271 on each measurement (with lower numbers representing less sprawl). The two rankings were summed to produce each metro area's sprawl score. The highest possible score was 542, the lowest 2. The advantage of the *USA Today* index is its simplicity, which makes it easy to explain. The big disadvantage is its total reliance on density as an indicator of sprawl, and density measured in a way that fails to distinguish between development at low suburban densities (as low as 1,000 persons per square mile, something less than one dwelling unit per acre) and development at high urban densities. Based on this index, USA Today 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 anti-growth laws, sprawls more." Indeed, according to USA Today's index, Los Angeles is less sprawling than even the New York metropolitan area.

Sierra Club

In a report titled *The Dark Side of the American Dream: The Costs and Consequences of Suburban Sprawl*, the Sierra Club ranked U.S. metropolitan areas on the degree to which they sprawl.[3] Sprawl was defined as "low-density development beyond the edge of service and employment, which separates where people live from where they shop, work, recreate and educate—thus requiring cars to move between zones."

Metros were subjectively rated as more or less sprawling based on population shifts from city to suburb, growth of land area vs. growth of population, time wasted in traffic, and loss of open space. Sprawl was thus defined not only by its characteristics but its effects. Among the largest metros (1 million or more people), Atlanta, St. Louis, and Washington, D.C. were rated most sprawling. Among medium size metros (500,000-1,000,000 population), Orlando, Austin, and Las Vegas shared that distinction.

Galster et al.

Galster et al. developed the most complex and multi-faceted sprawl index to date.[4] Sprawl was characterized in eight dimensions: density, continuity, concentration, clustering, centrality, nuclearity, mixed use, and proximity. The condition, sprawl, was defined as pattern of land use that has low levels in one or more of these dimensions. Variables representing causes and consequences of sprawl, such as fragmented governance and auto dependence, were explicitly excluded from the definition. 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. The main drawback of Galster et al.'s index is its availability for only 13 areas.

Studies Measuring Sprawl and Relating It Outcomes

Kahn

Kahn explored one potential benefit of sprawl, increased housing affordability and greater equality of housing opportunity across racial lines.[5] Using 1997 American Housing Survey data, Kahn measured housing consumption for blacks and whites in metropolitan areas characterized as more or less sprawling. Housing consumption was represented by number of rooms, unit square footage, homeownership rates, and year of construction. For his measure of sprawl, Kahn drew upon his research with Glaeser (see below). Sprawl was represented by the degree of employment decentralization in a metro area, specifically, by the proportion of metropolitan employment located more than 10 miles from the central business district. If all employment were located inside a 10-mile ring around the CBD, Kahn's "sprawl level" would be zero. If all were located outside the 10-mile ring, the sprawl level would be 1. As it is, values of this index varied from 0.196 for Portland to 0.786 for Detroit.

Downs

In Chapter 13 of *The Cost of Sprawl Revisited*, Anthony Downs reviewed his earlier research on sprawl and its effects on urban decline.[6] His conclusion: No meaningful and significant statistical relationship exists between specific traits of sprawl and measures of urban decline. He tested for statistically significant relationships between suburban sprawl and urban decline, and found none. Sprawl was defined in terms of an assortment of land use patterns, root causes of these patterns, and specific consequences of these patterns. Thus, Downs' conception of sprawl failed to distinguish causes and consequences from characteristics of sprawl. In addition to mixing characteristics, causes, and effects of sprawl, Downs' index suffers from: reliance on political, and hence economically arbitrary, boundaries of central cities to define centeredness; reliance on the urbanized area definition of 1,000 residents per square mile to define the worst of all sprawl. In this last respect, Downs' index is subject to the same criticism as *USA Today's* (see above).

Studies Measuring Sprawl and Exploring Causes

Glaeser et al.

Edward Glaeser et al. related sprawl to the degree of decentralization of employment using data from the U.S. Department of Commerce's Zip Code Business Patterns for 1996.[7] For the 100 largest U.S. metropolitan areas, the share of overall metropolitan employment within a three-mile ring of the Central Business District was computed, as were the shares inside and outside a 10-mile ring. The share within three miles reflects the presence or absence of a well-defined employment core, while the share beyond 10 miles captures the extent of job sprawl. Metros were then divided into four categories, based on values of these indices. Dense employment metros like New York have at least one quarter of their employment within three miles of the city center. Centralized employment metros like Minneapolis-St. Paul have between 10 and 25 percent of employment within three miles of the city center, and more than 60 percent within 10 miles. Decentralized employment metros like Washington D.C. have 10 to 25 percent of employment within the three-mile ring, and less than 60 percent within 10 miles. Finally, extremely decentralized employment metros like Los Angeles have less than 10 percent of their employment within the three-mile ring.

Pendall

Pendall sought to explain the incidence of sprawl for large metropolitan areas in terms of land values, metropolitan political organization, local government spending, traffic congestion, and various local land use policies.[8] Among land use policies, adequate public facilities requirements, which force new development to pay its own way, were found to discourage sprawl, while low-density zoning and building caps were associated with more sprawl. Among control variables, high valued farmland and expensive housing reduced sprawl, while jurisdictional fragmentation increased it.

Fulton et al.

Building on Pendall's earlier work, Fulton et al. studied urban land consumption relative to population change for every U.S. metropolitan area.[9] If land is consumed at a faster rate than population is growing, sprawl is said to be increasing. As with Pendall's earlier work, this concept of sprawl is strictly density-related. By this criterion, the West is home to some of the least sprawling metropolitan areas in the nation. By contrast, the Northeast and Midwest are in some ways the nation's biggest sprawl problems since they add few new residents, yet consume large amounts of land. In this study, Honolulu and Los Angeles were rated most compact in 1997, and Las Vegas and Phoenix (often characterized as sprawling ~~badly) were both in the top 20 in~~ compactness. Las Vegas and Phoenix were first and third in density gain over the 15 years studied, 1982 to 1997.

[1] Sprawl has been measured in other ways for individual metropolitan areas. This literature survey is limited to studies which, like this one, use a comparative index to rank metros in terms of sprawl. For examples of individual area studies, see Cameron Speir and Kurt Stephenson, "Does Sprawl Cost Us All? Isolating the Effects of Housing Patterns on Public Water and Sewer Costs," *Journal of the American Planning Association*, Vol. 68, No. 1, Winter 2002, pp. 56-70; and Lance Freeman, "The Effects of Sprawl on Neighborhood Social Ties: An Exploratory Analysis," *Journal of the American Planning Association*, Vol. 67, No. 1, Winter 2001, pp. 69-77.

[2] *USA Today*, February 22, 2001.

[3] Sierra Club, *The Dark Side of the American Dream: The Costs and Consequences of Suburban Sprawl*, Challenge to Sprawl Campaign, College Park, MD, undated.

[4] George Galster, Royce Hanson, Michael Ratcliffe, Harold Wolman, Stephan Coleman, and Jason Freihage, "Wrestling Sprawl to the Ground: Defining and Measuring an Elusive Concept," *Housing Policy Debate*, Vol. 12, no. 4, 2001, p. 685.

[5] Matthew Kahn, "Does Sprawl Reduce the Black/White Housing Consumption Gap?" *Housing Policy Debate*, Vol. 12, No. 1, 2001, pp. 77-86.

[6] Robert Burchell et al., *Costs of Sprawl Revisited*, Transit Cooperative Research Program, Transportation Research Board, Washington, D.C., 2001, Chapter 13.; Anthony Downs, "Some Realities About Sprawl and Urban Decline," *Housing Policy Debate*, Vol. 4, No. 4, 1999, pp. 955-974.

[7] Edward Glaeser, Matthew Kahn, and Chenghuan Chu, *Job Sprawl: Employment Location in U.S. Metropolitan Areas*, Center for Urban & Metropolitan Policy, The Brookings Institution, Washington, D.C., July 2001.

[8] Rolf Pendall, "Do Land-Use Controls Cause Sprawl?" *Environment and Planning B*, Vol. 26, No. , 1999, pp.

[9] William Fulton, Rolf Pendall, Mai Nguyen, and Alicia Harrison, *Who Sprawls Most? How Growth Patterns Differ Across the U.S.*, Center for Urban & Metropolitan Policy, The Brookings Institution, Washington, D.C., July 2001.

Appendix Two: Brief Methodology

This report is intended as a layperson's introduction to a complex academic study. The first technical research paper based on this research is available as a companion to this document, and is recommended reading for those with a strong interest in methodology. In fact, for researchers, the painstaking methodology may be of primary interest. The paper, *Measuring Urban Sprawl and Its Impacts* has undergone an academic review process and versions of it are being submitted to academic journals.

Metropolitan Area Data and Definitions

The study began with 139 metro areas, but many metro areas had to be dropped because of a lack of complete data. A listing of all 139 metro areas, as well as the missing data components that prevented the inclusion of some areas in the final analysis, can be found in the research paper.

Our final sample of U.S. metropolitan areas consists of 83 metropolitan areas. This includes every metro over 500,000 population for which we could obtain a complete dataset. Our basic unit of analysis is a piece of geography created by the Census Bureau and known as metropolitan statistical area or a primary metropolitan statistical area, or PMSA. PMSAs are generally larger than political jurisdictions such as cities, but smaller than the entire metropolitan region; some regions may include several PMSAs, which are then combined to form a Combined Metropolitan Statistical Area (CMSA). For a listing of PMSA and CMSA boundaries, visit www.census.gov.

Variables Used to Define Sprawl

Factor	Variable	Source
Residential Density	Gross Population Density in persons per square mile	US Census
	Percentage of population living at densities less than 1,500 persons per square mile (low suburban density)	US Census
	Percentage of population living at densities greater than 12,500 persons per square mile (urban density)	US Census
	Estimated density at the center of the metro area	US Census
	Gross population density of urban lands	USDA Natural Resources Inventory
	Weighted average lot size for single family dwellings (in square feet)	American Housing Survey
	Weighted density of all population centers within a metro area	Claritas Corporation

Factor	Variable	Source
Neighborhood Mix of Homes, Shops and Offices	Percentage of residents with businesses or institutions within 1/2 block of their homes	American Housing Survey
	Percentage of residents with satisfactory neighborhood shopping within 1 mile	American Housing Survey
	Percentage of residents with a public elementary school within 1 mile	American Housing Survey
	Balance of jobs to residents	Census Transportation Planning Package
	Balance of population serving jobs to residents. Population serving jobs include retail, personal services, entertainment, health, education, and professional services	Census Transportation Planning Package
	Mix of population-serving jobs	Census Transportation Planning
Strength of Metropolitan Centers	Variation of population density by census tract	US Census
	Rate of decline in density from center (density gradient)	US Census
	Percentage of population living within 3 miles of the central business district	Edward Glaeser, Brookings Institution
	Percent of the population living more than 10 miles from the CBD	Edward Glaeser, Brookings Institution
	Percentage of the population relating to centers within the same metropolitan statistical area	Claritas
	Ratio of population density to the highest density center in the metro area	Claritas
Accessibility of the Street Network	Average block length in urbanized portion of the metro area	Census TIGER files
	Average block size in square miles	Census TIGER files
	Percentage of small blocks	Census TIGER files

The table below and on the next page lists the variables included in each of the four sprawl factors, and their source. For a more detailed discussion of the variables, please refer to the research paper.

Combination of the 22 variables to create four sprawl factors

Twenty-two variables were combined into four sprawl factors using a technique known as principal component analysis. Seven variables contributed to the residential density factor, six to the land use mix factor, six to degree of centering factor, and three to the street accessibility factor. The principal component selected to represent each set of variables was the component explaining the greatest variation in the original dataset. We reasoned that the single factor that captures the greatest variance among multiple variables is likely to be a valid and reliable measure of density, mix, centers, or streets.

The Question of Size

These four factors could simply be summed to obtain an overall Sprawl Index for the 83 metropolitan areas, but there is a problem with this approach. As metro areas grow, so do their labor and real estate markets, and their land prices. Their density gradients accordingly shift upward, and other measures of compactness (street density, for example) follow suit. Thus, the largest metro areas, perceived as the most sprawling by the public, actually appear less sprawling than smaller metros when sprawl is measured strictly in terms of the four factors, with no consideration given to size.

Some of the technical literature on sprawl includes size in the definition.5 Certainly, sheer geographic size is central to popular notions of sprawl. Despite their relatively high densities, metro areas such as Los Angeles and Phoenix, and even Chicago and Philadelphia, are perceived as sprawling because they “go on forever.” A Sprawl Index that disregarded this aspect of urban form would never achieve face validity.

Accordingly, as a last step prior to creating the overall Sprawl Index, we used regression analysis [to transform the sum of the four sprawl factors into a Sprawl Index that is neutral with respect to population size. As a result, this index is uncorrelated with population. The degree of sprawling development measured is consistent whether looking at Los Angeles or Wichita, Kansas.

Outcome Variables

This report only provides correlations for a few of the dozens of outcome measures that have been collected for the sprawl database. The table below lists the outcome variables and their source; for a more thorough discussion, please see the full research paper.

Outcome Measure	Explanation/Notes	Source
Maximum Ozone levels in parts per million	fourth highest daily maximum 8-hour ozone level	US Environmental Protection Agency
Annual fatal traffic accidents	Deaths per 100,000 residents	NHTSA's Fatal Accident Reporting System
Daily Vehicle Miles Traveled Per Capita	Divides total distance driven in a region by total population (not just drivers)	Federal Highway Administration Highway Performance Monitoring System
Average Vehicles Per Household	Number of vehicles reported per household	US Dicentennial Census
Percentage of Commuters Using public transportation		US Dicentennial Census
Percentage of Commuters walking to work		US Dicentennial Census
Annual Hours of Delay per capita	Modeled calculation of total hours of delay experienced	Texas Transportation Institute
Mean Journey-to-Work time in minutes	Average commuting time; includes travel by all modes	US Dicentennial Census

Relations to Outcomes

Correlational studies, of which this is one, cannot be used to establish cause-effect relationships between dependent and independent variables. But they can establish statistically significant associations, a necessary condition for causality. If studies, in addition, control for other influences on dependent variables, and still find strong associations with independent variables, then it becomes easier to justify the contention that one variable causes or contributes to another.

Given the aggregate nature of this analysis, the statistical method of choice, used to test for significant relationships, is multiple regression analysis. We tested for significant relationships by running a series of regressions for travel and transportation outcomes in 2000. In the first set of regressions, an outcome was regressed on the overall Sprawl Index and a standard set of control variables to establish the existence of a relationship between sprawl and the outcome.

The challenge in this kind of research is to control for confounding influences. These are variables that are not of primary interest, and may not even be measured, but influence outcomes in ways that may confound results. Multiple regression analysis captures the independent effect of each variable on the outcome of interest, controlling for the effects of all other variables in the regression equation. The use of multiple regression analysis allows us to control for confounding influences, provided that they are measured and included in the regression equation.

MSA/PMSA Name	Complete Sprawl Index Scores and Rankings									
	Sprawl Index	Sprawl Index Rank (from most to least sprawling)	Density	Density Rank	Mix	Mix Rank	Centeredness	Centeredness Rank	Street Factor	Street Rank
Akron, OH PMSA	105.88	49	86.82	22	118.69	63	119.50	65	84.17	23
Albany--Schenectady--Troy, NY MSA	83.28	19	82.93	12	89.30	29	98.45	38	73.21	12
Albuquerque, NM MSA	124.45	72	96.96	49	103.69	44	123.97	72	117.80	64
Allentown--Bethlehem--Easton, PA--NJ MSA	124.03	70	86.25	18	133.39	78	91.70	27	131.02	72
Anaheim--Santa Ana, CA PMSA	97.14	41	128.84	77	121.51	70	72.15	10	136.43	78
Atlanta, GA MSA	57.66	4	84.50	15	73.70	13	82.31	21	57.00	3
Austin, TX MSA	110.26	59	89.01	25	111.87	54	115.76	63	94.36	35
Baltimore, MD MSA	115.86	64	104.28	64	106.84	48	115.64	62	105.22	50
Baton Rouge, LA MSA	90.13	24	80.84	8	95.89	33	106.16	50	76.16	15
Birmingham, AL MSA	87.97	23	77.12	6	62.25	7	112.48	59	104.00	46
Boston--Lawrence--Salem--Lowell--Brockton, MA NECM	126.93	77	113.59	70	124.45	74	109.43	55	119.07	65
Bridgeport--Stamford--Norwalk--Danbury, CT NECMA	68.39	7	92.46	38	137.46	79	94.76	32	80.65	21
Buffalo, NY PMSA	119.09	67	102.14	60	124.67	75	135.20	78	70.57	10
Chicago, IL PMSA	121.20	68	142.90	79	115.06	56	85.81	23	134.87	75
Cincinnati, OH--KY--IN PMSA	96.04	39	88.78	23	95.83	32	110.15	56	85.42	25
Cleveland, OH PMSA	91.75	30	99.66	56	107.42	50	100.91	42	66.77	8
Colorado Springs, CO MSA	124.40	71	91.22	33	118.95	64	135.18	77	96.72	38
Columbia, SC MSA	94.17	34	74.57	4	67.12	9	147.34	81	79.51	19
Columbus, OH MSA	91.13	27	91.48	36	76.52	14	101.47	43	97.16	39
Dallas, TX PMSA	78.26	13	99.50	55	82.60	22	81.06	18	90.23	32
Denver, CO PMSA	125.22	73	103.70	62	115.67	57	108.87	54	125.72	70
Detroit, MI PMSA	79.47	15	97.31	50	102.54	41	62.97	8	92.95	33
El Paso, TX MSA	117.18	65	100.05	57	103.45	43	119.53	66	102.31	44
Fort Lauderdale--Hollywood--Pompano Beach, FL PMSA	108.44	55	113.93	71	94.71	31	74.96	14	137.23	79
Fort Worth--Arlington, TX PMSA	77.23	10	90.33	28	89.15	28	73.92	12	97.48	40
Fresno, CA MSA	110.28	60	93.49	39	130.12	77	112.55	60	73.00	11
Gary--Hammond, IN PMSA	77.37	11	86.41	21	123.72	73	61.25	7	100.51	43
Grand Rapids, MI MSA	95.18	36	82.69	10	115.73	58	110.32	57	63.71	6
Greensboro--Winston-Salem--High Point, NC MSA	46.78	2	74.16	3	46.70	3	69.08	9	66.26	7

MSA/PMSA Name	Complete Sprawl Index Scores and Rankings									
	Sprawl Index	Sprawl Index Rank (from most to least sprawling)	Density	Density Rank	Mix	Mix Rank	Centeredness	Centeredness Rank	Street Factor	Street Rank
Greenville--Spartanburg, SC MSA	58.56	5	71.92	2	50.39	4	98.51	39	62.09	5
Hartford--New Britain--Middletown--Bristol, CT NEC	85.17	20	86.33	20	119.36	66	84.57	22	59.57	4
Honolulu, HI MSA	140.21	79	116.52	73	84.34	23	167.29	83	114.33	60
Houston, TX PMSA	93.30	32	95.26	47	110.13	52	86.96	24	95.64	36
Indianapolis, IN MSA	93.73	33	89.29	26	96.22	34	102.37	45	84.52	24
Jacksonville, FL MSA	91.58	28	85.61	16	72.88	12	102.14	44	104.58	47
Jersey City, NJ PMSA	162.27	82	195.65	82	172.87	83	98.68	40	166.79	83
Kansas City, MO--KS MSA	91.64	29	90.88	32	100.05	37	89.04	26	88.83	31
Knoxville, TN MSA	68.68	8	71.22	1	62.91	8	97.75	35	75.52	14
Las Vegas, NV MSA	104.74	48	110.03	68	80.10	18	99.75	41	108.82	55
Little Rock--North Little Rock, AR MSA	82.27	18	77.50	7	68.27	10	105.86	49	88.17	30
Los Angeles--Long Beach, CA PMSA	101.79	45	151.51	80	123.08	72	72.37	11	123.30	67
Memphis, TN--AR--MS MSA	92.15	31	88.87	24	97.01	36	104.24	47	76.52	16
Miami--Hialeah, FL PMSA	125.68	75	129.09	78	104.69	45	92.68	29	136.37	77
Milwaukee, WI PMSA	117.29	66	101.42	59	117.91	62	117.74	64	93.86	34
Minneapolis--St. Paul, MN--WI MSA	95.86	38	94.74	44	94.69	30	107.81	52	87.66	28
New Haven--Waterbury--Meriden, CT NECMA	106.97	52	91.56	37	144.27	82	78.89	17	86.52	26
New Orleans, LA MSA	125.39	74	105.90	65	80.38	19	123.70	71	138.56	80
New York, NY PMSA	177.78	83	242.49	83	129.81	76	144.59	80	154.87	82
Newark, NJ PMSA	81.32	17	118.88	75	120.39	69	82.17	20	115.38	61
Norfolk--Virginia Beach--Newport News, VA MSA	95.63	37	95.01	45	87.17	26	81.98	19	113.06	59
Oakland, CA PMSA	98.81	42	116.61	74	106.34	47	57.60	6	133.44	73
Oklahoma City, OK MSA	85.58	21	84.49	14	101.29	39	95.61	33	69.12	9
Omaha, NE--IA MSA	128.35	78	96.38	48	119.29	65	132.31	76	104.64	48
Orlando, FL MSA	96.39	40	93.77	42	60.81	6	103.48	46	120.60	66
Oxnard--Ventura, CA PMSA	75.12	9	103.94	63	139.39	80	55.52	5	106.45	53
Philadelphia, PA--NJ PMSA	112.61	63	114.73	72	119.52	67	95.86	34	113.00	58
Phoenix, AZ MSA	110.93	62	106.84	66	115.98	60	92.64	28	107.23	54
Pittsburgh, PA PMSA	105.94	51	90.44	30	86.80	25	104.47	48	124.16	68
Portland, OR PMSA	126.12	76	101.34	58	102.28	40	121.81	68	127.97	71

MSA/PMSA Name	Complete Sprawl Index Scores and Rankings									
	Sprawl Index	Sprawl Index Rank (from most to least sprawling)	Density	Density Rank	Mix	Mix Rank	Centeredness	Centeredness Rank	Street Factor	Street Rank
Providence--Pawtucket--Woonsocket, RI NECMA	153.71	81	99.10	52	140.46	81	140.34	79	135.91	76
Raleigh--Durham, NC MSA	54.17	3	76.19	5	39.48	1	77.23	16	80.76	22
Riverside--San Bernardino, CA PMSA	14.22	1	93.53	40	41.50	2	41.42	2	80.52	20
Rochester, NY MSA	77.93	12	91.37	35	82.31	21	120.70	67	37.23	1
Sacramento, CA MSA	102.64	47	99.12	53	110.90	53	87.37	25	98.41	42
Salt Lake City--Ogden, UT MSA	110.92	61	99.50	54	103.16	42	93.84	30	117.04	62
San Antonio, TX MSA	107.76	54	95.04	46	100.62	38	108.39	53	102.97	45
San Diego, CA MSA	101.86	46	113.41	69	105.45	46	74.41	13	105.97	51
San Francisco, CA PMSA	146.83	80	155.19	81	107.34	49	128.62	74	139.82	81
San Jose, CA PMSA	109.70	57	124.80	76	96.63	35	93.87	31	125.22	69
Seattle, WA PMSA	100.91	44	103.62	61	79.42	16	98.01	37	117.07	63
Springfield, MA NECMA	122.49	69	86.29	19	115.74	59	148.60	82	87.29	27
St. Louis, MO--IL MSA	94.51	35	90.29	27	107.44	51	76.16	15	105.99	52
Syracuse, NY MSA	80.27	16	85.83	17	71.97	11	124.92	73	52.58	2
Tacoma, WA PMSA	105.88	50	90.76	31	85.62	24	122.67	69	111.20	57
Tampa--St. Petersburg--Clearwater, FL MSA	86.26	22	93.61	41	79.97	17	51.85	3	133.61	74
Toledo, OH MSA	107.19	53	91.32	34	119.63	68	112.17	58	77.57	17
Tucson, AZ MSA	109.13	56	90.38	29	121.77	71	106.42	51	88.04	29
Tulsa, OK MSA	99.06	43	82.71	11	88.00	27	114.97	61	96.20	37
Vallejo--Fairfield--Napa, CA PMSA	78.38	14	97.44	51	116.26	61	40.86	1	109.69	56
Washington, DC--MD--VA MSA	90.83	26	106.88	67	78.72	15	97.85	36	98.02	41
West Palm Beach--Boca Raton--Delray Beach, FL MSA	67.75	6	93.96	43	54.72	5	53.93	4	104.70	49
Wichita, KS MSA	110.09	58	84.37	13	113.06	55	131.37	75	78.56	18
Worcester--Fitchburg--Leonminster, MA NECMA	90.48	25	81.16	9	82.28	20	122.72	70	74.54	13

MSA/PMSA Name	Metro Area Outcome Variables* (Control Variables below)							
	Vehicles per 100 HH	Transit to Work (%)	Walk to Work (%)	Commute Time (min.)	Annual Delay per Capita (hours)	Distance Driven (VMT) per Capita	Fatal Accidents per 100,000	8-hr. Ozone (ppb)
Akron, OH PMSA	179	1.43	2.03	23	---	23.9	8.78	97
Albany--Schenectady--Troy, NY MSA	160	3.32	3.89	23	5.8	26.9	9.41	85
Albuquerque, NM MSA	174	1.54	2.65	21	20.6	28.4	10.78	71
Allentown--Bethlehem--Easton, PA--NJ MSA	175	1.33	3.63	25	---	21.1	12.83	102
Anaheim--Santa Ana, CA PMSA	188	2.92	2.07	27	---	---	5.69	69
Atlanta, GA MSA	181	3.92	1.31	31	32.7	33.8	13.86	120
Austin, TX MSA	172	2.83	2.20	25	28.3	31.1	15.43	87
Baltimore, MD MSA	160	6.40	3.03	30	20.5	21.4	9.67	106
Baton Rouge, LA MSA	168	1.07	2.02	25	---	22.2	20.73	93
Birmingham, AL MSA	180	0.79	1.21	27	14.3	34.8	16.43	90
Boston--Lawrence--Salem--Lowell--Brockton, MA NECM	152	12.88	4.97	29	28.1	21.5	5.67	83
Bridgeport--Stamford--Norwalk--Danbury, CT NECMA	178	8.50	2.39	28	---	22.8	8.16	93
Buffalo, NY PMSA	147	4.17	2.73	21	5.0	19.3	7.26	89
Chicago, IL PMSA	144	15.39	3.62	32	27.4	20.5	7.90	83
Cincinnati, OH--KY--IN PMSA	171	3.60	2.31	24	19.8	27.7	8.04	89
Cleveland, OH PMSA	160	4.89	2.21	25	8.5	21.2	6.71	89
Colorado Springs, CO MSA	186	0.99	3.86	22	12.7	18.2	13.73	54
Columbia, SC MSA	175	1.35	3.79	23	---	18.1	20.31	89
Columbus, OH MSA	175	2.32	2.43	23	17.1	25.7	9.55	94
Dallas, TX PMSA	172	2.59	1.57	28	37.1	31.1	11.99	102
Denver, CO PMSA	179	4.80	2.19	27	34.6	22.1	11.00	69
Detroit, MI PMSA	171	1.83	1.44	27	25.2	24.1	10.07	89
El Paso, TX MSA	168	2.27	2.23	23	9.7	18.6	10.15	62
Fort Lauderdale--Hollywood--Pompano Beach, FL PMSA	151	2.36	1.34	27	28.5	23.3	13.55	71
Fort Worth--Arlington, TX PMSA	178	0.56	1.41	27	---	---	12.16	102
Fresno, CA MSA	165	1.79	2.46	22	11.1	20.9	15.51	103
Gary--Hammond, IN PMSA	172	2.77	2.07	27	---	---	12.99	98
Grand Rapids, MI MSA	182	0.99	2.31	20	---	22.4	13.04	92
Greensboro--Winston-Salem--High Point, NC MSA	185	0.97	1.62	22	---	33.8	16.78	96

MSA/PMSA Name	Metro Area Outcome Variables* (Control Variables below)							
	Vehicles per 100 HH	Transit to Work (%)	Walk to Work (%)	Commute Time (min.)	Annual Delay per Capita (hours)	Distance Driven (VMT) per Capita	Fatal Accidents per 100,000	8-hr. Ozone (ppb)
Greenville--Spartanburg, SC MSA	179	0.46	2.08	22	---	14.8	20.02	97
Hartford--New Britain--Middletown--Bristol, CT NEC	170	2.96	2.56	23	10.6	25.0	10.36	97
Honolulu, HI MSA	161	8.56	5.75	27	11.1	18.0	7.30	48
Houston, TX PMSA	166	3.68	1.64	29	35.8	36.9	12.84	102
Indianapolis, IN MSA	176	1.43	1.68	24	20.2	32.1	10.65	94
Jacksonville, FL MSA	167	1.56	1.71	27	14.6	28.3	16.17	79
Jersey City, NJ PMSA	93	34.22	8.71	33	---	---	5.91	106
Kansas City, MO--KS MSA	175	1.34	1.41	23	8.7	29.0	12.58	81
Knoxville, TN MSA	184	0.53	1.99	23	---	35.6	22.44	100
Las Vegas, NV MSA	159	4.53	2.38	24	18.0	19.2	13.45	73
Little Rock--North Little Rock, AR MSA	169	0.87	1.32	23	---	28.4	18.33	83
Los Angeles--Long Beach, CA PMSA	162	6.82	3.03	29	62.5	22.7	7.75	77
Memphis, TN--AR--MS MSA	162	1.78	1.34	24	15.9	24.7	14.73	97
Miami--Hialeah, FL PMSA	150	5.38	2.21	30	33.0	19.2	13.27	74
Milwaukee, WI PMSA	160	4.43	2.94	22	14.9	20.8	7.00	91
Minneapolis--St. Paul, MN--WI MSA	176	4.78	2.50	23	25.5	24.5	7.53	73
New Haven--Waterbury--Meriden, CT NECMA	161	3.28	3.27	23	---	21.1	7.65	98
New Orleans, LA MSA	144	5.90	2.81	27	10.3	15.0	12.25	85
New York, NY PMSA	74	48.49	9.61	39	23.4	15.4	4.83	101
Newark, NJ PMSA	157	11.44	3.16	31	---	---	8.03	100
Norfolk--Virginia Beach--Newport News, VA MSA	172	1.97	2.81	24	11.6	23.0	7.21	94
Oakland, CA PMSA	177	10.37	2.65	32	---	---	7.31	73
Oklahoma City, OK MSA	173	0.62	1.73	22	5.8	24.0	10.71	81
Omaha, NE--IA MSA	176	1.22	1.92	19	11.3	18.8	7.94	72
Orlando, FL MSA	170	1.89	1.32	27	31.2	27.8	17.08	81
Oxnard--Ventura, CA PMSA	198	1.13	2.17	25	---	24.4	11.68	---
Philadelphia, PA--NJ PMSA	149	10.15	4.20	29	15.4	18.9	9.29	101
Phoenix, AZ MSA	166	2.17	2.13	26	27.9	27.3	13.96	81
Pittsburgh, PA PMSA	151	7.33	3.80	25	7.0	22.7	8.79	92
Portland, OR PMSA	173	7.62	3.46	24	22.9	23.6	7.72	57

MSA/PMSA Name	Metro Area Outcome Variables* (Control Variables below)							
	Vehicles per 100 HH	Transit to Work (%)	Walk to Work (%)	Commute Time (min.)	Annual Delay per Capita (hours)	Distance Driven (VMT) per Capita	Fatal Accidents per 100,000	8-hr. Ozone (ppb)
Providence--Pawtucket--Woonsocket, RI NECMA	162	2.64	3.76	23	18.7	22.5	7.69	88
Raleigh--Durham, NC MSA	179	1.97	2.58	24	---	31.0	12.39	108
Riverside--San Bernardino, CA PMSA	181	1.72	2.25	31	29.7	22.2	18.03	101
Rochester, NY MSA	165	2.16	3.63	21	3.5	23.5	8.96	89
Sacramento, CA MSA	176	2.83	2.26	26	19.5	20.9	10.35	91
Salt Lake City--Ogden, UT MSA	194	3.09	1.91	22	9.3	24.8	9.00	80
San Antonio, TX MSA	166	3.03	2.45	24	20.4	29.3	12.31	83
San Diego, CA MSA	175	3.52	3.55	25	24.1	23.7	9.31	71
San Francisco, CA PMSA	150	19.76	5.92	29	41.5	22.4	6.24	52
San Jose, CA PMSA	196	3.63	1.84	26	33.4	23.6	6.12	72
Seattle, WA PMSA	178	8.53	3.35	27	33.8	25.8	7.00	60
Springfield, MA NECMA	154	2.55	5.16	22	---	21.6	7.07	87
St. Louis, MO--IL MSA	170	2.54	1.68	25	20.4	28.4	12.76	89
Syracuse, NY MSA	158	2.15	4.25	21	---	24.4	8.92	84
Tacoma, WA PMSA	186	2.81	3.01	28	14.0	22.7	10.27	65
Tampa--St. Petersburg--Clearwater, FL MSA	154	1.45	1.77	26	21.2	22.8	17.65	84
Toledo, OH MSA	169	1.45	2.44	20	---	23.7	14.07	83
Tucson, AZ MSA	161	2.62	2.68	24	11.3	21.6	15.76	69
Tulsa, OK MSA	174	0.70	1.70	21	8.7	22.4	13.57	88
Vallejo--Fairfield--Napa, CA PMSA	191	2.44	2.31	30	---	22.8	11.56	78
Washington, DC--MD--VA MSA	167	12.38	3.19	33	34.6	22.8	8.60	96
West Palm Beach--Boca Raton--Delray Beach, FL MSA	153	1.46	1.42	26	20.4	24.3	15.12	61
Wichita, KS MSA	182	0.61	1.62	19	---	21.0	10.27	78
Worcester--Fitchburg--Leonminster, MA NECMA	165	1.71	3.09	26	---	24.7	8.66	93

*See page 30 for the source of the outcome variable data.

	Control/Other Variables			
MSA/PMSA Name	Metro Population	Household Size	Percent of Population Working Age (%)	Per Capita Income
Akron, OH PMSA	694,960	2.47	58.9	$22,314
Albany--Schenectady--Troy, NY MSA	892,196	2.40	58.8	$22,281
Albuquerque, NM MSA	556,678	2.47	60.1	$20,790
Allentown--Bethlehem--Easton, PA--NJ MSA	740,395	2.51	57.9	$21,864
Anaheim--Santa Ana, CA PMSA	2,846,289	3.00	60.4	$25,826
Atlanta, GA MSA	3,945,450	2.68	63.3	$25,303
Austin, TX MSA	1,159,836	2.55	64.3	$25,094
Baltimore, MD MSA	2,552,994	2.55	60.0	$24,398
Baton Rouge, LA MSA	602,894	2.63	59.3	$18,866
Birmingham, AL MSA	991,819	2.49	59.6	$20,992
Boston--Lawrence--Salem--Lowell--Brockton, MA NECM	4,001,752	2.52	61.3	$28,322
Bridgeport--Stamford--Norwalk--Danbury, CT NECMA	882,567	2.67	59.0	$38,350
Buffalo, NY PMSA	950,265	2.41	57.2	$20,357
Chicago, IL PMSA	6,540,979	2.69	59.8	$24,474
Cincinnati, OH--KY--IN PMSA	1,553,843	2.49	58.9	$23,487
Cleveland, OH PMSA	1,863,479	2.45	57.6	$22,818
Colorado Springs, CO MSA	516,929	2.61	60.7	$22,005
Columbia, SC MSA	536,691	2.49	61.5	$20,902
Columbus, OH MSA	1,581,066	2.46	61.4	$22,957
Dallas, TX PMSA	3,369,303	2.71	61.7	$24,639
Denver, CO PMSA	2,109,282	2.52	62.6	$26,206
Detroit, MI PMSA	4,598,502	2.59	59.1	$24,481
El Paso, TX MSA	679,622	3.18	55.0	$13,421
Fort Lauderdale--Hollywood--Pompano Beach, FL PMSA	1,623,018	2.45	58.2	$23,170
Fort Worth--Arlington, TX PMSA	1,661,525	2.68	60.4	$22,112
Fresno, CA MSA	799,407	3.09	54.6	$15,495
Gary--Hammond, IN PMSA	631,362	2.63	57.9	$20,643
Grand Rapids, MI MSA	812,649	2.69	58.0	$21,643
Greensboro--Winston-Salem--High Point, NC MSA	1,120,709	2.44	60.9	$21,626

MSA/PMSA Name	Control/Other Variables			
	Metro Population	Household Size	Percent of Population Working Age (%)	Per Capita Income
Greenville--Spartanburg, SC MSA	744,164	2.49	60.5	$20,249
Hartford--New Britain--Middletown--Bristol, CT NEC	1,148,618	2.48	59.2	$26,277
Honolulu, HI MSA	876,156	2.95	60.1	$21,998
Houston, TX PMSA	4,151,615	2.82	60.5	$21,818
Indianapolis, IN MSA	1,474,128	2.50	60.1	$23,480
Jacksonville, FL MSA	1,100,491	2.54	60.1	$21,763
Jersey City, NJ PMSA	608,975	2.60	63.5	$21,154
Kansas City, MO--KS MSA	1,757,083	2.51	59.5	$23,373
Knoxville, TN MSA	713,116	2.39	61.1	$20,105
Las Vegas, NV MSA	1,375,765	2.65	61.3	$21,785
Little Rock--North Little Rock, AR MSA	583,845	2.47	60.3	$20,263
Los Angeles--Long Beach, CA PMSA	9,519,338	2.98	59.3	$20,683
Memphis, TN--AR--MS MSA	1,106,808	2.62	58.9	$20,388
Miami--Hialeah, FL PMSA	2,253,362	2.84	59.2	---
Milwaukee, WI PMSA	1,500,741	2.50	58.3	$23,158
Minneapolis--St. Paul, MN--WI MSA	2,867,585	2.55	61.0	$26,406
New Haven--Waterbury--Meriden, CT NECMA	824,008	2.50	58.4	$24,439
New Orleans, LA MSA	1,289,753	2.58	59.0	$18,967
New York, NY PMSA	9,314,235	2.61	61.0	$24,076
Newark, NJ PMSA	1,930,552	2.74	60.0	$28,578
Norfolk--Virginia Beach--Newport News, VA MSA	1,512,416	2.60	60.2	$20,315
Oakland, CA PMSA	2,392,557	2.71	61.5	$28,241
Oklahoma City, OK MSA	1,083,346	2.47	59.7	$19,366
Omaha, NE--IA MSA	692,664	2.54	59.3	$22,215
Orlando, FL MSA	1,434,033	2.63	61.3	$21,383
Oxnard--Ventura, CA PMSA	753,197	3.04	58.6	$24,600
Philadelphia, PA--NJ PMSA	5,036,646	2.58	58.4	$23,912
Phoenix, AZ MSA	3,072,149	2.67	58.5	$22,251
Pittsburgh, PA PMSA	2,003,200	2.35	57.5	$21,176
Portland, OR PMSA	1,529,211	2.51	62.1	$23,836

MSA/PMSA Name	Control/Other Variables			
	Metro Population	Household Size	Percent of Population Working Age (%)	Per Capita Income
Providence--Pawtucket--Woonsocket, RI NECMA	962,886	2.48	58.3	$21,236
Raleigh--Durham, NC MSA	1,016,647	2.47	64.3	$25,472
Riverside--San Bernardino, CA PMSA	3,254,821	3.07	55.0	$17,726
Rochester, NY MSA	1,037,831	2.51	58.5	$21,809
Sacramento, CA MSA	1,796,857	2.65	58.6	$22,302
Salt Lake City--Ogden, UT MSA	1,333,914	3.04	56.8	$19,781
San Antonio, TX MSA	1,559,975	2.77	57.9	$18,544
San Diego, CA MSA	2,813,833	2.73	60.0	$22,926
San Francisco, CA PMSA	1,731,183	2.47	66.1	$36,651
San Jose, CA PMSA	1,682,585	2.92	63.1	$32,795
Seattle, WA PMSA	2,343,058	2.45	63.6	$27,942
Springfield, MA NECMA	608,479	2.49	57.7	$20,077
St. Louis, MO--IL MSA	2,540,138	2.52	58.1	$22,812
Syracuse, NY MSA	650,154	2.49	57.6	$20,254
Tacoma, WA PMSA	700,820	2.60	59.6	$20,948
Tampa--St. Petersburg--Clearwater, FL MSA	2,395,997	2.33	56.7	$21,784
Toledo, OH MSA	618,203	2.47	58.0	$20,565
Tucson, AZ MSA	843,746	2.47	57.9	$19,785
Tulsa, OK MSA	803,235	2.50	58.6	$20,092
Vallejo--Fairfield--Napa, CA PMSA	518,821	2.83	59.0	$22,848
Washington, DC--MD--VA MSA	4,544,944	2.61	63.4	$31,059
West Palm Beach--Boca Raton--Delray Beach, FL MSA	1,131,184	2.34	53.5	$28,801
Wichita, KS MSA	545,220	2.54	57.3	$20,692
Worcester--Fitchburg--Leonminster, MA NECMA	750,963	2.56	58.6	$22,983

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