Population Density in the Urban Core and Suburban Periphery of Large Urban Areas in the U.S., 1980-2010

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Abstract

To provide a more consistent definition than the traditional central city-suburb division, the urban core is defined as the extent of the built-up urban area in 1950 with the suburban periphery being the area added to the urban area thereafter. Population density in the urban core and suburban periphery is examined for 59 large urban areas from 1980 to 2010. Mean densities have not changed much over the period. Densities are, of course, higher in the urban core than the suburban periphery. The striking finding is the extremely high degree of variation in core and suburban density and density change. The population of the entire urban area, the growth of urban area population over time, and the presence of mountains as a barrier to urban expansion are related to density and density change in the urban core and suburban periphery.

Introduction

An earlier paper examined densities in large urban areas in the United States over multiple decades (Ottensmann 2015). But neither that paper nor others have systematically examined densities in the inner and outer parts of urban areas over an extended period of time.

Leichenko (2001) looked at the development of central cities and the suburban portions of metropolitan areas over time, from 1970 to 1997. He examined the growth of both population and employment in those areas, but did not consider density. Frey (2005) likewise looked at changes in population in central cities of metropolitan areas (using his own definition), with limited consideration of the suburbs. He focused on the period from 2000 to 2004, comparing that to the changes in the 1990s. Fee and Harley (2012) looked at growing and shrinking Metropolitan Statistical Areas (MSAs). They found population density near the central business district (CBD), defined as the area within 5 miles from the center, declined most rapidly for the shrinking MSAs. Densities beyond that were not considered.
Population change in metropolitan areas (not density, however), has been widely addressed by authors looking at decentralization and suburbanization and the decline and possible resurgence of central cities. For example, Guest (1975) and Palumbo, Sacks, and Wasylenko (1990) considered the decentralization of the population within metropolitan areas. Some have addressed the changes as representing flight from central cities to the suburbs for reasons varying from race to escape from urban blight (Frey 1979; Mieszkowski and Mills 1993). Voith (1992) raised the question as to whether central city and suburban growth are substitutes or complements. And Kasarda, et al. (1997) speculated as to whether a reversal of migration patterns between central cities and suburbs might be possible.

The decline of central cities specifically has been another focus of research (Howe, et al, 1998; Goodman 2005). This has included studies of whether and how much there has been a resurgence of central city populations more recently, for example by Furdell, Wolman, and Hill (2005).

The density of urban areas over time has been addressed by Bryan, Minton, and Sarte (2007), who looked at the densities of all cities in the United States with populations of 25,000 or more from 1940 to 2000. No separate consideration was given to the central cities of metropolitan areas. They also examined the densities of the census Urbanized Areas and MSAs. They did acknowledge the problem with densities for MSAs given the arbitrary and varying nature of county boundaries. They found a general decline of densities over the period studied. They did not, however, consider the densities of the portions of either Urbanized Areas or MSAs outside of central cities that might be considered to be the suburban portions of the urban areas. Kim (2007) also looked at the densities of cities over 25,000, over the longer period since 1890. He found density increasing in the first part of the twentieth century and then falling in the latter period, consistent with Bryan, Minton, and Sarte. He looked at densities of metropolitan areas from 1940 to 1980, describing a “precipitous” decline in densities in the later decade. However, he failed to note the problem with MSA densities resulting from the effect of county boundaries and the very different sizes of counties making metropolitan area densities problematic. He likewise did not consider the effect of the addition of outlying counties with very low densities expanding metropolitan area boundaries especially in the more recent decades. Kim further estimated density gradients, finding decline but admitting that the estimates were “somewhat fictitious.”

Clark (1951) showed that population densities within different urban areas at different times has tended to decline as a negative exponential function of distance from the center. Muth (1969) and Mills (1972) presented the basic monocentric model, at the heart of urban economics, providing an explanation for this decline as the result of the tradeoff between accessibility to the center and space. The density gradient is the rate of the density decline with distance estimated assuming this model. The change in the gradient over time has then been used as a measure of change in densities within urban
areas. Decline in the density gradient for an urban area over time has been seen as a measure of the decentralization of the population from the center to the periphery. Mills (1972) presented estimates of the density gradient for urban areas over time showing such decline. Many studies of density gradients have followed, with reviews of that literature from very different perspectives provided by Thrall (1988), McDonald (1989), and Smith (1997). The article by Mieszkowski and Mills (1993) referenced earlier as examining flight from the center to the suburbs (among other explanations of decentralization) relied on estimates of density gradients to support their analysis. There are, however, limitations to the density gradient and its change over time in providing a picture of densities in the central part of an urban area and in the suburban periphery. The gradient at a single point in time provides information about the relative difference between the core and the suburbs. Two urban areas with the same density gradients could have very different densities, high or low in both the center and the suburbs. The decline in the density gradient over time likewise provides information on the relative changes in the inner and outer areas with respect to one another. A decline in the density gradient could result from a decrease in density near the center, an increase in density at the periphery, or some combination.

This paper examines population densities in the urban core and suburban periphery of 59 large urban areas from 1980 to 2010. The next section describes the data, including the urban patterns data used to define the urban areas, the definition of the urban core and suburban periphery used in this research as an alternative to the central city-suburb distinction most often seen, and the choice of using population density and the time period covered. The following sections present the results. The first looks at the densities in the urban area core and suburban periphery for each census year. The relationship between density in the periphery and density in the core is then considered. Next comes the examination of the changes in density from 1980 to 2010. The final section looks at a few characteristics of the urban areas as a whole associated with core and suburban density and change.

Data

This research begins with a dataset for 59 large urban areas in the United States, defining the extent of those areas for each census year from 1950 to 2010 using census tract data. To distinguish the inner and outer portions of those urban areas, consistent definitions of the urban core and suburban periphery have been developed. Population density from 1980 to 2010 are used in the analysis of density in the core and periphery.
The starting point for this research is a dataset for the analysis of urban patterns over time that was developed with data on numbers of housing units in census tracts for large urban areas in the United States from 1950 to 2010. The tracts for the urban portions of metropolitan areas were identified within the Combined Statistical Areas (CSAs) as delineated by the Office of Management and Budget for 2013 (U.S. Bureau of the Census 2013). CSAs were used rather than the more commonly employed Metropolitan Statistical Areas (MSAs) as it was felt they better represented the full extent of the metropolitan areas, including those instances in which 2 or 3 MSAs should more properly be considered to be parts of a single area (Ottensmann 2017). For those MSAs which were not included in a CSA, the MSA was used.

The 59 CSAs and MSAs with 2010 populations over one million were selected for the creation of the dataset. A number of these areas had multiple large centers associated with separate urban areas that had grown together. This posed the issue of identifying those cases in which a second or third urban area could be considered sufficiently large in relation to the largest area to be included as an additional center around which urban development occurred. The decision was made by comparing the populations of census Urbanized Areas (either from the current census or the last census in which the areas were separate) with the largest area. An area was considered to be an additional center if its population were greater than 28 percent of the population of the largest area. The three areas included with the lowest percentages were Akron (with Cleveland), Tacoma (with Seattle), and Providence (with Boston). Areas with multiple centers have each center included in the name of the urban area.

The primary data source for this research was the Neighborhood Change Database developed by the Urban Institute and Geolytics (2003). This unique dataset provides census tract data from the 1970 through 2000 censuses, with the data for 1970 through 1990 normalized to the 2000 census tract boundaries. Population and housing unit data from the 2010 census were added by aggregating the counts from the 2010 census block data (U.S. Bureau of the Census 2012).

Housing units and housing unit densities—the numbers of housing units divided by the land areas of the tracts in square miles—are used for this dataset rather than the more commonly employed population and population density measures for two reasons. Housing units better represent the physical pattern of urban development as they are relatively fixed, while the population of an area can change without any changes in the stock of housing. Other studies of urban patterns have made similar arguments for choosing housing units over population, for example Galster, et al. (2001), Theobald (2001), Radeloff, Hammer, and Stewart (2005), and Paulsen (2014).

Using housing units also allows the extension of the analysis to census years prior to 1970. The census provides data on housing units classified by the year in which
the structure was built, and these data are included in the Neighborhood Change Database. The 1970 year-built data can be used to estimate the numbers of housing units present in the census tracts for 1940, 1950, and 1960. Several prior studies have used the housing units by year-built data to make estimates for prior years in this manner, though they have used more recent census data to make the estimates, not the earlier 1970 census data (Radeloff, et al. 2001; Theobald 2001; Hammer, et al. 2004; Radeloff, Hammer, and Stewart 2005).

Sources of error in these housing unit estimates for earlier years from the year-built data arise from imperfect knowledge of the year in which the structure was built and from changes to the housing stock due to demolitions, subdivisions, and conversions to or from nonresidential uses. These errors increase for estimates farther back in time. Numbers of housing units for 1970 to 1990 were estimated from the 2000 year-built data and compared with the census counts in the Neighborhood Change Database. The judgment was made that estimates 2 decades back involved acceptable levels of error, but this was not the case for 3 decades back. As a result, the decision was made to use the housing unit estimates for 1950 and 1960 but not for 1940.

Urban areas have been defined for the broader urban patterns research for each census year since 1950 consisting of those tracts contiguous to an urban center meeting a minimum housing unit density threshold. (This is comparable to the way in which the census defines Urbanized Areas using blocks and larger units and Paulsen (2012) defined urban areas using block groups.) For the definition of Urbanized Areas for the 2000 and 2010 censuses, a minimum population density of 500 persons per square mile was required for an area to be included (U.S. Bureau of the Census 2002, 2011). Using the ratio of population to housing units for the nation as a whole in both 2000 and 2010 of 2.34 persons per unit, a density of 500 persons per square mile is almost exactly equivalent to 1 housing unit per 3 acres or 213.33 units per square mile. This was used as the minimum urban density threshold. Note that this is a measure of gross density, not lot size, as the areas of roads, nonresidential uses, and vacant land are included.

To provide for a set of urban areas that represents the cumulative expansion of the urban areas over time, a further condition was imposed that if a census tract does not exceed the minimum housing unit density and has not been included in the urban area in any given year, it will not be included in urban areas delineated in earlier years even if the density exceeds the minimum. The rule has been imposed in this direction—if rural, then not urban earlier—rather than in the opposite direction—if urban, then urban later—because the more recent data are considered to be generally more accurate.1

1 More detail on the construction of the dataset and the delineation of the urban areas is provided in Ottensmann (2014).
Defining the Urban Core and Suburban Periphery

Central cities have been defined for Metropolitan Areas (MSAs) and their predecessors since the middle of the last century. They have frequently been used to identify the older urban core at the center of MSAs. The remainder of an MSA was then seen as encompassing the more recently developed suburban periphery that has generally been referred to as the “suburbs.”

The problem with using the central city-suburb delineation to distinguish the older and newer portions of metropolitan areas is that central cities encompass widely varying proportions of metropolitan area populations and these differences are not necessarily related to the proportions of the metropolitan areas that are older and newer.

Some of the older central cities have had their boundaries fixed before the end of the nineteenth century. They had been surrounded by other incorporated municipalities and have generally been unable to expand in area through annexation of adjacent territory. Many of the older central cities had been more-or-less completely developed by the early decades of the twentieth century. Some of the inner suburbs of these metropolitan areas likewise date back to the nineteenth and early twentieth centuries.

Other central cities have been able to continue to expand their boundaries through annexation as their metropolitan areas have grown in the twentieth century. Some central cities have continued to see extensive new development within their boundaries, in some instances literally up to the present. As a result, some of these central cities can have large areas of new development that could be described as being suburban in character. This new development can be virtually indistinguishable from development that has occurred in the suburban areas outside of the central cities of other metropolitan areas. This means that the traditional central city-suburb distinction becomes a quite crude and fraught way of distinguishing the older, inner cores of metropolitan areas from the newer suburban areas at the periphery.

Using central cities creates even more problems when attempting to examine differences within metropolitan areas over time. Some central cities annex territory from one census to the next. As a result, differences observed in populations or population characteristics for their metropolitan areas may or may not have resulted from actual changes and may reflect the population annexed. Furthermore, the cities designated as central cities can change from one census to the next, with cities being added or dropped due to their population changes or changes in other cities.

The definition of Metropolitan Statistical Areas used for 1990 and later censuses included a completely new definition for central cities that designated central cities as cities having significant concentrations of employment, with no limit on the number or location of central cities for a metropolitan area (Ottensmann 1996). This change resulted in more central cities being identified for some metropolitan areas (and some
being dropped). And some of those added would clearly be considered to be “suburban” cities.

As a result of these problems, an alternative approach is taken for the identification of the older and newer portions of urban areas that is consistent across the 59 urban areas. These subareas are denoted as the urban core and suburban periphery. This was inspired by the approach taken in defining suburban areas for an earlier paper proposing an alternative approach to the measurement of urban sprawl (Ottensmann 2018). The distinction between urban core and suburban periphery has been used in a paper examining racial and ethnic diversity in those areas (Ottensmann 2019c).

Using the delineations of the urban areas for each census year developed for the urban patterns dataset, the urban core is defined as the urban area in 1950. This is a fixed area, constituting the urban core for each successive census year. It is an area defined in a consistent manner for all of the urban areas and is an area that does not change over time. The urban core does not specifically refer to the population or its characteristics in 1950. The urban core is a fixed area that does not change over time, so one can just as readily consider the population of the urban core in 2010.

The suburban periphery is then the portion of the urban area in each succeeding census year that is outside of the urban core. Note, of course, that this means that there is no urban periphery for 1950, since the entire 1950 urban area constitutes the urban core. The urban periphery expands over time as the urban area as a whole expands. But like the urban core, the urban periphery is being defined in a consistent manner for all urban areas.

No doubt some will complain that this is an overly generous specification of the urban core. By central cities they may be thinking about considerably older portions of some metropolitan areas that were developed by the early twentieth century. This is the case for many of the central cities of metropolitan areas in the Northeast and Midwest. This is emphatically not true for many central cities in the South and West. An earlier paper (Ottensmann 2019a) compared the populations of the urban cores and the central cities in 2000. The distributions of those populations is not too dissimilar and the urban cores had, on average, actually a smaller proportion of the urban area populations than the central cities for the large urban areas being studied. This paper included a more extensive discussion of the use and problems with the central city-suburb distinction and comparison of the urban cores with the central cities.

Using Population Density

As discussed above, housing unit density was used in the delineation of the urban areas both because it was considered a better measure of urban patterns and because housing units by census tract could be estimated for census years back to 1950. Likewise, the density of housing units was the focus of the first paper resulting from
this research, which examined the density of the urban areas over time from 1950 to 2010 (Ottensmann 2015). In contrast, the research in this paper focuses on population density in these urban areas from 1980 to 2010.

The decision to begin the analysis of core and periphery density at 1980 rather than 1950 results from the observed densities for the earlier years. From 1960, the first year for which there is density for the periphery, to 1980, housing unit densities in the suburban periphery increased sharply. The mean across the 59 large urban areas jumped from 492 to 797 units per square mile. Changes after that year were much smaller. The patterns of development over time in the areas added to the urban areas in each census year accounts for this, as shown in the paper on urban development over time (Ottensmann 2019). When development in census tracts results in the density exceeding the minimum density threshold, the tracts are added to the urban area. However, at that point, tracts are generally far from being completely developed. Indeed, on average, development and increases in density in the following several decades exceeds the development that first resulted in the tract being considered as urban.

The definition of the urban core and suburban periphery means that the urban periphery for 1960 consisted only of those tracts added to the urban area in that year, many of which were far from being completely developed. Densities in those tracts increased significantly, especially in the following decades, contributing to the increases in the densities of the suburban peripheries from 1960 to 1980. Additional increases in density to 1980 were contributed by development in the tracts that became urban in 1970.

Of course this process of newly urban tracts being only partially development and seeing increases in density with development in later decades did not cease in 1980. However, by 1980 the disproportionate effect that resulted from the inclusion of only these newly added urban areas was reduced. As a result, the dramatic declines in densities in the peripheral areas tapered off after that year. This pattern of density change for those suburban areas in the early decades formed the basis for the decision to begin the analysis of density at 1980.

For the urban patterns data, only housing unit counts and densities are available for 1950 and 1960. The first year for which population is available, from the Neighborhood Change Database, is 1970. Starting the analysis with 1980 made the option of using population density a possibility. As discussed above, housing unit density was chosen in part because housing units are more permanent than population, representing a more fixed aspect of the urban pattern. But analysis of the changes in the urban cores over time showed that exactly this aspect of housing units made housing density a less satisfactory measure of change in density in the urban core. Declines in population density for some of the urban core areas were substantially greater than declines in housing unit density. This makes sense, for when population leaves an area,
the housing units may be abandoned but are not necessarily eliminated from the stock, at least in the short run. It was felt that population densities more promptly and accurately captured the changes occurring in some of these declining urban core areas.

**Population Density in the Urban Core and Suburban Periphery**

The population densities of the 59 large urban areas varied widely, from less than 1,250 persons per square mile for Greenville-Spartanburg in 2010 to 5,600 for the Los Angeles urban area. The mean population density for all of the urban areas declined from nearly 3,000 in 1980 to less than 2,600 by 2010, a drop of about 14 percent. These findings are comparable to those obtained using housing unit densities in an earlier paper (Ottensmann 2015). This section breaks down those results for the urban cores and suburban peripheries of these urban areas.

Table 1 presents the mean, minimum, and maximum population density for the urban core and suburban periphery for each census year from 1980 to 2010. The mean density for the urban core remained fairly steady, with only a small decline from about 5,000 persons per square mile to 4,800 per square mile. Note that since the areas of the urban cores are unchanged over time, an increase or decrease in density implies an increase or decrease in the population. The densities of the core ranged from a low of about 2,300 in 2010 to a maximum density greater than 12,000. The minimum core density dropped from 2,700 to 2,300 from 1980 to 2010. The maximum increased only slightly over the period.

As expected, densities for the suburban periphery were much lower than for the urban core. The mean suburban population density for the large urban areas in 2010 was about 2,100 persons per square mile. Again, the range was large, from 1,100 to 4,300. The mean and minimum changed little over the period from 1980 to 2010. The maximum value varied somewhat but with no consistent trend.

**Table 1. Population Density in the Urban Core and Suburban Periphery of Large Urban Areas, 1980 to 2010**

<table>
<thead>
<tr>
<th>Year</th>
<th>Urban Core</th>
<th></th>
<th></th>
<th>Suburban Periphery</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Minimum</td>
<td>Maximum</td>
<td>Mean</td>
<td>Minimum</td>
<td>Maximum</td>
</tr>
<tr>
<td>1980</td>
<td>5,036</td>
<td>2,737</td>
<td>11,017</td>
<td>2,144</td>
<td>1,069</td>
<td>4,511</td>
</tr>
<tr>
<td>1990</td>
<td>4,917</td>
<td>2,451</td>
<td>11,101</td>
<td>2,168</td>
<td>1,035</td>
<td>3,872</td>
</tr>
<tr>
<td>2010</td>
<td>4,831</td>
<td>2,270</td>
<td>12,164</td>
<td>2,121</td>
<td>1,114</td>
<td>4,291</td>
</tr>
</tbody>
</table>
A more complete picture of the variation in population density across the urban areas comes from looking at the densities of the highest and lowest areas for both the urban core and suburban periphery in 2010. Table 2 lists the top and bottom 6 areas, about the 10 percent highest and lowest, for the core and periphery. As expected the urban areas with the highest core densities were among the largest urban areas. The list was led by the New York area with a density exceeding 12,000 persons per square mile. The Los Angeles core was not that far behind, however, having a density over 10,000. That Los Angeles is that close to New York may surprise many. But remember that the urban core is defined as the area that constituted the urban area (meeting the minimum density threshold) in 1950. The New York urban core is far larger than New York City, including older suburban areas north of the city extending into Connecticut, areas on Long Island, and extensive territory in New Jersey. The population density of New York City alone is more than twice the density of the New York urban core.

Table 2. Urban Areas with the Highest and Lowest Population Density in the Urban Core and Suburban Periphery in 2010.

<table>
<thead>
<tr>
<th>Area</th>
<th>Density 2010</th>
<th>Area</th>
<th>Density 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Areas with Highest Population Density</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New York</td>
<td>12,164</td>
<td>Las Vegas</td>
<td>4,291</td>
</tr>
<tr>
<td>Los Angeles</td>
<td>10,267</td>
<td>Los Angeles</td>
<td>4,043</td>
</tr>
<tr>
<td>San Francisco-Oakland-San Jose</td>
<td>9,481</td>
<td>San Francisco-Oakland-San Jose</td>
<td>3,715</td>
</tr>
<tr>
<td>San Diego</td>
<td>8,198</td>
<td>San Diego</td>
<td>3,363</td>
</tr>
<tr>
<td>Chicago</td>
<td>7,873</td>
<td>Miami-Ft Lauderdale-W Palm Beach</td>
<td>3,232</td>
</tr>
<tr>
<td>Miami-Ft Lauderdale-W Palm Beach</td>
<td>7,169</td>
<td>Sacramento</td>
<td>3,127</td>
</tr>
<tr>
<td><strong>Areas with Lowest Population Density</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greenville-Spartanburg</td>
<td>2,270</td>
<td>Albany-Schenectady-Troy</td>
<td>1,114</td>
</tr>
<tr>
<td>Knoxville</td>
<td>2,379</td>
<td>Greenville-Spartanburg</td>
<td>1,130</td>
</tr>
<tr>
<td>Birmingham</td>
<td>2,392</td>
<td>Pittsburgh</td>
<td>1,188</td>
</tr>
<tr>
<td>Oklahoma City</td>
<td>2,895</td>
<td>Knoxville</td>
<td>1,223</td>
</tr>
<tr>
<td>Nashville</td>
<td>2,905</td>
<td>Harrisburg-York</td>
<td>1,270</td>
</tr>
<tr>
<td>Greensboro--Winston-Salem--High Point</td>
<td>2,915</td>
<td>Greensboro--Winston-Salem--High Point</td>
<td>1,294</td>
</tr>
</tbody>
</table>
The areas with the lowest urban core densities were led by Greenville-Spartanburg. All were located in the South and most were among the smaller urban areas in the set of 59 large areas. Nashville and Oklahoma City were the largest of the six but still had urban area populations less than one million in 2010.

Las Vegas and Los Angeles led the list of areas with the highest population densities in the suburban periphery in 2010. Their suburban densities of 4,300 and 4,000 far exceeded the mean density of less than 2,600 for the entire urban areas. Five of the six areas with the highest densities in the periphery were in the West. Four were also among the six urban areas with the highest densities in the urban core. Notably New York and Chicago, while having high core densities, were not among the areas with high densities in the suburban periphery.

The list of areas having the lowest population densities in their suburban peripheries was a mixed group. Three were in the Northeast and three were in the South. Five of the six were among the smallest of the urban areas being considered. Pittsburgh was the larger exception.

The lists of urban areas with the highest and lowest densities in the core and periphery suggest regional variation, with higher densities for areas in the West and lower densities in the South. Table 3 gives the mean urban core and suburban periphery densities for the urban areas in each of the census regions. Population density in the core was highest for areas in the West with a mean of 6,300, with the Northeast areas next at about 5,800. Core densities were the lowest in the South, averaging 3,800. The Midwest fell in between.

A somewhat different regional pattern was found for density in the suburban periphery. The urban areas in the West again were highest, with a mean density of 3,100. But the areas in the Northeast had the lowest average peripheral density, under 1,500, less than half the value for the West. The Midwest and South clustered together with

Table 3. Mean Population Density for the Urban Core and Suburban Periphery by Region in 2010.

<table>
<thead>
<tr>
<th>Region</th>
<th>Urban Core*</th>
<th>Suburban Periphery*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northeast</td>
<td>5,763</td>
<td>1,447</td>
</tr>
<tr>
<td>Midwest</td>
<td>4,592</td>
<td>1,813</td>
</tr>
<tr>
<td>South</td>
<td>3,847</td>
<td>2,008</td>
</tr>
<tr>
<td>West</td>
<td>6,298</td>
<td>3,091</td>
</tr>
</tbody>
</table>

*Differences significant at the 0.001 level*
means of 1,800 and 2,000, higher than the areas in the Northeast but far below the suburban densities in the West.

**Relationship of Suburban Periphery Density to Urban Core Density**

The previous section looked at population densities in the urban core and suburban periphery independently. But to what extent is the density in the suburbs related to the density in the core for an individual urban area? Do areas with higher density urban cores also have higher density suburban peripheries? This section examines these relationships.

Figure 1 shows the relationship with a scatterplot of population density in the suburban periphery versus density in the urban core, both for 2010. It clearly shows a positive relationship. As core density goes up, suburban density also tends to increase. The line on the graph is the regression line. The correlation is 0.56, highly significant. The outlier on the far right is the New York urban area, with the highest core population density but below average density in the suburban periphery. The outlier at the top

![Figure 1. Plot of Suburban Periphery Population Density versus Urban Core Population Density in 2010.](image-url)
middle is the Las Vegas area. It had the highest suburban density while the core density, still well above average, was relatively lower.

The ratios of density in the suburban periphery to density in the urban core for the urban areas is summarized in Table 4, which gives the mean, minimum, and maximum for each of the 4 census years. The ratios reflect the lower densities in the suburban peripheries than in the urban cores. On average, the suburban density is less than half the core density, with the mean ratios ranging from 0.44 to 0.47, slightly increasing over time. The range in the ratios, however, was huge—from 0.15 to 0.99 in 2010. Population density in the suburbs could be anywhere from one-sixth the density in the core to virtually equal to core density. And this range had increased over time, with drops in the minimum ratio and increases in the maximum.


<table>
<thead>
<tr>
<th>Year</th>
<th>Mean</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>0.443</td>
<td>0.191</td>
<td>0.753</td>
</tr>
<tr>
<td>1990</td>
<td>0.461</td>
<td>0.175</td>
<td>0.842</td>
</tr>
<tr>
<td>2000</td>
<td>0.460</td>
<td>0.164</td>
<td>0.901</td>
</tr>
<tr>
<td>2010</td>
<td>0.465</td>
<td>0.153</td>
<td>0.990</td>
</tr>
</tbody>
</table>

The El Paso urban area had by far the highest ratio of 0.99, with the suburbs essentially as dense as the core. It was followed by Albuquerque, Oklahoma City, and Jacksonville, with ratios of 0.65 to 0.66. At the other extreme, the New York urban area had the smallest ratio of suburb to core density of 0.15 as a result of the area’s extremely high core density. But not that far behind were Boston, Philadelphia, and Albany-Schnectady-Troy with ratios ranging from 0.24 to 0.26.

The suburban-core density ratios were highest in the South and West, with means of 0.54 and 0.51. Urban areas in the Northeast had by far the least dense suburban peripheries relative to their urban cores, with a mean ratio of 0.27, half the value for the South. Once again, the Midwest fell in the middle.

Change in Population Density from 1980 to 2010

Attention now turns to how the population densities in the urban core and suburban periphery of the urban areas changed over time. For this, the change in the
population density from 1980 to 2010 is considered. Absolute change—the 2010 density minus the 1980 density—is the metric rather than percentage change, as the large variations in initial density leads to misleading values when using percentage change.

Table 5 gives the basic summary statistics for the change in density from 1980 to 2010 for the urban core and suburban periphery. The mean changes for both core and periphery are quite small. Mean density for the urban cores fell by about 200 persons per square mile, not a trivial decline but still rather small compared to the mean density of about 5,000 in 1980. The change in density for the suburban peripheries was a drop of only 23 persons per square mile, an insignificant decline.


<table>
<thead>
<tr>
<th>Area</th>
<th>Mean</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban Core</td>
<td>-206</td>
<td>-3,559</td>
<td>2,109</td>
</tr>
<tr>
<td>Suburban Periphery</td>
<td>-23</td>
<td>-1,627</td>
<td>1,152</td>
</tr>
</tbody>
</table>

Despite the modest average changes in densities, the experiences of individual urban areas were very different. The ranges for the density changes from 1980 to 2010 were extremely large, with large decreases and increases for both urban cores and suburban peripheries. The greatest decline in urban core density was a drop of over 3,500 persons per square mile. At the other extreme was an increase in core density of 2,100. The extremes for the suburban peripheries were smaller but still large relative to the lower suburban densities. Suburban densities dropped by 1,600 in one area and increased by over 1,100 in another.

The great differences in density changes in the urban cores and suburban peripheries raise the question of which urban areas were experiencing these dramatic shifts. Table 6 lists the areas with the greatest density increases and declines for the urban core and suburban periphery. High density increases in the core came in urban areas that were growing. Five of the top six areas were in the West, led by Los Angeles with an increase in core density over 2,000 persons per square mile. The New York area also made the list with a core density jump of over 1,100, showing the resurgence in the core of the New York area.

Density increase in the suburban periphery was greatest in Las Vegas, with an increase of over 1,100 persons per square mile which made Las Vegas the area with the highest peripheral density in 2010. This could have been the product of the area’s rapid growth combined with constraints on spatial expansion due either to mountainous
terrain and/or limits to the expansion of water service. Second in terms of suburban density increase was Portland with a jump of 970 persons per square mile. This may have resulted at least in part to Portland’s urban growth boundary. All of the urban areas with the highest density increases in the suburban periphery were in the West.

The greatest declines in population density in both the urban core and suburban periphery occurred in the New Orleans area, with drops greater than 3,500 and 1,600 in the core and periphery respectively. While Hurricane Katrina was obviously a major contributing factor, significant declines in in both core and periphery density had been occurring in the earlier decades. High levels of density decline in the urban cores took place in rustbelt urban areas such as Detroit and Buffalo. Memphis was an exception. Large declines in density in the suburban periphery took place in Buffalo and Pittsburgh, which also saw the large declines in the core density.

Table 6. Urban Areas with the Highest and Lowest Change in Population Density in the Urban Core and Suburban Periphery from 1980 to 2010.

<table>
<thead>
<tr>
<th>Urban Core Area</th>
<th>Density Change</th>
<th>Urban Core Area</th>
<th>Density Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td></td>
<td>Area</td>
<td></td>
</tr>
<tr>
<td>Areas with Greatest Density Increase</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Los Angeles</td>
<td>2,109</td>
<td>Las Vegas</td>
<td>1,152</td>
</tr>
<tr>
<td>San Diego</td>
<td>1,863</td>
<td>Portland</td>
<td>970</td>
</tr>
<tr>
<td>San Francisco-Oakland-San Jose</td>
<td>1,662</td>
<td>San Antonio</td>
<td>518</td>
</tr>
<tr>
<td>Fresno</td>
<td>1,660</td>
<td>Fresno</td>
<td>470</td>
</tr>
<tr>
<td>Las Vegas</td>
<td>1,222</td>
<td>Seattle-Tacoma</td>
<td>436</td>
</tr>
<tr>
<td>New York</td>
<td>1,148</td>
<td>San Diego</td>
<td>399</td>
</tr>
<tr>
<td>Areas with Greatest Density Decline</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Orleans</td>
<td>-3,559</td>
<td>New Orleans</td>
<td>-1,627</td>
</tr>
<tr>
<td>Detroit</td>
<td>-2,042</td>
<td>Buffalo</td>
<td>-767</td>
</tr>
<tr>
<td>Memphis</td>
<td>-1,483</td>
<td>Pittsburgh</td>
<td>-436</td>
</tr>
<tr>
<td>Buffalo</td>
<td>-1,433</td>
<td>Philadelphia</td>
<td>-361</td>
</tr>
<tr>
<td>St Louis</td>
<td>-1,314</td>
<td>Hartford</td>
<td>-359</td>
</tr>
<tr>
<td>Pittsburgh</td>
<td>-1,291</td>
<td>Tulsa</td>
<td>-344</td>
</tr>
</tbody>
</table>
Factors Associated with Core and Periphery Density and Change

The examination of population density and change in the urban core and suburban periphery suggests some factors that might be associated with those values. The size of the urban area has been shown to be related to the density of the entire urban area (Ottensmann 2015) and appeared to be related to density in at least the core, as the list of the areas with the densest cores included many of the largest areas. The correlation between the population density of the core and the population of the urban area in 2010 was 0.79.

The urban areas with the highest densities in the suburban periphery were rapidly growing areas. This also tended to be the case for the urban areas with the greatest increases in density in both the core and suburbs. And the areas with the steepest density declines, especially in their urban cores, were areas that were growing slowly or declining. The correlations of population change in the urban area from 1980 to 2010 with suburban density and core density change were 0.48 and 0.57 respectively. The correlation with suburban density change was lower.

The paper on density in the entire urban areas (Ottensmann 2015) found that density was significantly related to the presence of mountains or wetlands as barriers to urban expansion. One-way analysis of variance showed that the mean core and suburban densities and core density changes varied greatly whether mountains were present as a potential barrier to urban expansion. Core and suburban densities were about 1,000 or more higher on average for areas with mountains. These differences were statistically significant.²

The size of the urban area, the growth in the area population over time, and the presence of mountains as a barrier were associated with population density and density change in the urban cores and suburban peripheries. But since these effects are not independent, it is reasonable to examine their combined influence on density and change using basic multiple regression models. Table 7 presents the results for 4 regression models. The dependent variables are population density in 2010 and density change from 1980 to 2010 in the urban core and in the suburban periphery. The first

² The determination as to whether mountains served as a barrier to urban expansion was a subjective judgment as to whether the majority of the urban area was adjacent to mountains (or water that would also serve as a barrier to urban expansion). The presence of public lands as a barrier to urban expansion and an arid climate that could affect the manner in which water was provided were also considered and found to be significantly related. However these additional factors were so highly correlated with the presence of mountains and each other that independent effects could not be ascertained. The presence of wetlands as a barrier to urban expansion was significant in the earlier studies as well. However, only 2 urban areas were identified as being so constrained—Miami-Fort Lauderdale-West Palm Beach and New Orleans. Given the special circumstances (Hurricane Katrina) affecting New Orleans, it was not surprising that wetlands were not significant here and this factor was not included. Further information is provided in Ottensmann (2015, 2019).
predictors are the population of the entire urban area, in 2010 for 2010 densities and in 1980 for density change from 1980 to 2010. The change in the population of the urban area from 1980 to 2010 is the second predictor. The final is a dummy variable representing whether the urban area had mountains as a barrier to urban expansion.

Overall the models did reasonably well in their predictions, with \( R^2 \) values ranging from 0.23 to 0.71, all statistically significant at least at the 0.01 level. Each of the predictors was statistically significant in at least one model and 2 were significant in 3 of the 4 models.

The prediction of density in the urban core in 2010 accounted for the greatest proportion of the variation in the dependent variable with the \( R^2 \) value of 0.71. The urban area population was a highly significant predictor of core density, which was


<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Urban Core</th>
<th>Suburban Periphery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban Area Population 2010 (millions)</td>
<td>555 *** (77)</td>
<td>—</td>
</tr>
<tr>
<td>Urban Area Population Change 1980-2010 (millions)</td>
<td>-460 (251)</td>
<td>549 *** (131)</td>
</tr>
<tr>
<td>Mountains a Barrier to Urban Expansion</td>
<td>1,554 *** (389)</td>
<td>885 ** (267)</td>
</tr>
<tr>
<td>Constant</td>
<td>3,540 *** (188)</td>
<td>-747 *** (129)</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>0.713 ***</td>
<td>0.463 ***</td>
</tr>
</tbody>
</table>

* Differences significant at 0.05 level
** Differences significant at 0.01 level
*** Differences significant at 0.001 level
over 500 persons per square mile greater for each million in urban area population. Population change over the past 3 decades, on the other hand, was not significantly related to core density. The presence of mountains as a barrier to development was not merely statistically significant; urban areas with those barriers had population densities averaging over 1,500 persons per square mile higher than other urban areas.

The model predicting the change in density from 1980 to 2010 in the urban core accounted for nearly half of the variation with $R^2$ equal to 0.46. The size of the urban area did not have much effect on core density change; the regression coefficient was not statistically significant. However the change in the urban area population from 1980 to 2010 was a significant predictor of the change in density in the urban core. An increase in urban area population over the period of one million people was associated with a core density increase of over 500 persons per square mile. The presence of mountains as a barrier to urban expansion was associated with greater increase in core density of nearly 900 persons per square mile, which was statistically significant.

The model predicting population density in the suburban periphery also did well with an $R^2$ of 0.55. In contrast to the prediction of density in the urban core, the size of the urban area—population in 2010—was not statistically significant. But population change in the urban area from 1980 to 2010 was significant. A population increase of 1 million was associated with over 300 more persons per square mile in suburban population density. While this value is substantially less than effects associated with density and change in the urban core, peripheral densities are much lower on average, making this a quite substantial difference. The presence of mountains as a barrier to development had a large effect of population density in the suburban periphery, with population densities over 1,100 persons per square mile greater in those urban areas, even slightly greater than the effect on density in the urban core. This very large effect on suburban density does seem reasonable, as the presence of the mountains would literally be constraining the expansion of the suburban portions of the urban areas.

Finally, the prediction of the change in population density from 1980 to 2010 in the suburban periphery was the least successful, with the smallest $R^2$ value of 0.23. The size of the urban area had a small negative effect on suburban density change, predicting change being 60 persons per square mile less for each million more in urban area population. This was significant at the 0.05 level. The change in the urban area population had a somewhat larger effect with suburban densities increasing by about 180 persons per square mile for each additional million added to the urban area. So the increase in demand associated with greater urban area growth was reflected in increased suburban densities. The presence of mountains did not have a significant
effect, perhaps because they affected suburban densities in both 1980 to 2010 and therefore not density change.³

Conclusion

Results for population densities in the urban core and suburban periphery for the average large urban area were not surprising. The urban cores experienced a modest decline in density between 1980 and 2010, though the mean density in the periphery did not change much over the period. Mean densities were higher in the core than in the suburbs. The average ratio of suburban density to core density for individual urban areas was less than 0.5 and decreased some over the period studied.

More interesting was the great variation across the urban areas, especially the areas at the extremes. Urban core population density in 2010 ranged from less than 2,300 for Greenville-Spartanburg to over 12,000 for New York. But in second place, just behind New York, was Los Angeles with a core density over 10,000. This shows how a comparison made using areas defined in a consistent manner—the areas urban in 1950—yield very different results from central city comparisons showing New York to be far, far more dense.

Equally diverse results were obtained for densities in the suburban peripheries. Las Vegas topped the list with a density of nearly 4,300 compared to Albany-Schenectady-Troy at 1,100. The ratio of highest to lowest density is over 5 for the urban cores and nearly 4 for the suburban peripheries.

The ratio of suburban to core densities for individual urban areas also varied tremendously. The mean value for 2010 was 0.47. But the urban area ratios ranged from a low of 0.15 for New York to 0.99 for El Paso. The virtually equal densities for the core and suburbs of El Paso resulted from below average core density and above average peripheral density, both a little more than 3,100. The extremely low ratio for New York of course was primarily the product of the area’s very high core density. But the New York suburban periphery density was also somewhat below average.

While the mean core and suburban densities showed little to no change, this was certainly not reflected in individual urban areas. Los Angeles saw an increase in population density in the core exceeding 2,100 from 1980 to 2010. Population density in the Las Vegas suburban periphery jumped by 1,100. The large increases in density in some urban areas were balanced by large declines in other areas. New Orleans saw extreme drops in both core and suburban densities, attributable to the effects of Hurricane Katrina adding to earlier declines. Older urban areas—especially industrial

³ A regression of 1980 urban area population and the presence of mountains on 1980 suburban density showed nearly the same effect of mountains on density in that year as in 2010. Population change in the preceding decades could not be included as those data were not available.
centers—in the Northeast and Midwest were among the other areas seeing larger decreases in core and suburban population density.

Simple models were used to examine characteristics of the urban areas associated with the population density in the core and suburbs in 2010 and the change in density from 1980 to 2010. The urban area characteristics considered were the population size of the urban area, the change in the population from 1980 to 2010, and the presence of mountains that might serve as a barrier to the expansion of an urban area. Urban area population was positively and significantly related to core density but not to suburban density. The change in the urban area population was associated with both core and suburban density as was the presence of mountains as a barrier to urban expansion. So increased demand both in terms of population and population change and restrictions in supply due to mountains accounted for over half of the variation in both core and suburban densities.

The starting population in 1980 was negatively and significantly related to the change in suburban population density. Population change was positively related to change in both the core and periphery. Urban areas that started off smaller and grew more rapidly tended to have the greatest increases in density in the suburban periphery. Mountains were significant for density change in the core but not the suburbs.

Population density is a fundamental characteristic of urban areas. The urban cores and suburban peripheries can have very different densities and experience differing changes over time. But the most important lesson from this analysis is that one cannot conclude a great deal looking just at the averages. Densities in the urban core and suburban periphery of large urban areas and the changes over time vary tremendously across the areas, making any attempt to describe a “typical” large urban area a futile task.

References


