Defining Exurban Areas for the Analysis of Urban Patterns Over Time

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Abstract

This paper addresses the issue of defining exurban areas around 59 large urban areas from 1950 to 2010. The ideal definition would include contiguous census tracts meeting a minimum density threshold and showing integration with the urban area based on commuting. Since data on the latter are not available throughout the period, only a density criterion could be used. A density minimum was selected such that the areas of contiguous exurban density in 2010 would be largely contained within the urban area's metropolitan area boundaries, indicating a likelihood of integration with the urban area. An assessment of the resulting exurban areas shows a high degree of containment for metropolitan areas. A brief examination of the 2010 exurban areas shows they vary greatly in terms of size.

Introduction

An aspect of urban settlement patterns are the exurban areas that lie beyond the more-or-less built-up urban and suburban areas. Many residents of these exurban areas have ties to and are integrated with the urban area. The term "exurbanite" is generally considered to have been first used by Spectorsky (1955) in a book of the same name. Others have come up with alternative terms to describe such areas including "metropolitan orbits" (Blumenfeld 1986), "penturbia" (1987), "periurban zone" (Taylor 2011), and for the area including both the urban and exurban area, "extended urban area" (Wolman, *et al.* 2005). The more common"exurban area" is used in this paper.

The issue of defining exurban areas arose in the course of developing the dataset for my research on urban patterns in 59 large metropolitan areas in the United States. The basic data are counts of housing units for census tracts for the census years from 1950 through 2010. Urban areas were delineated for each area and census year. The definition was patterned on that used by the Bureau of the Census for Urbanized Areas, so the decisions were relatively straightforward.

The subsequent objective was delineating exurban areas surrounding each of those urban areas. This proved to be considerably more difficult. While a fair number of studies of exurban areas have been published, they have defined the areas in very

different ways. In addition, the data available for the urban patterns research, using census tract data from 1950 to 2010, limited the options for how the exurban areas could be defined.

Sufficient issues were raised in this process of defining the exurban areas that warranted exposition in this paper. The next section looks at prior studies of exurban areas, focusing specifically on how those studies defined the areas (or exurban residents). Next comes the description of the urban patterns data and the definition of the urban areas, necessarily the starting point for delineating the exurban areas. The logic and procedure used for defining the exurban areas are described. Finally, an assessment of the resulting exurban areas for 2010 is presented, along with a very brief description of those areas. This paper is not intended as a comprehensive description or analysis of the exurban areas, which will be addressed in subsequent papers. The focus here is on how and why these areas have been defined as they have.

Studies of Exurban Areas and Their Definition

A modest number of studies of various aspects of exurban areas have been published over the years. These works have addressed varying aspects of exurban areas and residents. Some have focused on the social characteristics of exurbanites, for example, the original study by Spectorsky (1955) and a later articles by Davis and Nelson (1994) and Nelson and Sanchez (1999). Especially in the mid-2000's, numbers of articles examined the electoral politics of residents of exurban areas, including Brownstein and Rainey (2004) and Texeira (2006). Still other works looked at the settlement patterns of exurban areas. Lamb (1983) addressed what he called "exurban sprawl." Berube, *et al.* (2006) and Clark, *et al.* (2009) also examined exurban patterns. And a surprising number of studies looked at wildlife in exurban areas, such as the study of white-tailed deer by Storm, *et al.* (2007).

Most studies of exurban areas examined them using data from 1 or 2 points in time. One of the only authors considering a much longer time span has been Theobald (2001, 2005) who defined exurban areas from 1960 to 2000. He used housing unit density for block groups for the entire United States, with no consideration of the relationship to urban areas. So these are not studies of exurban areas in the sense being used here. For example, he identifies exurban areas in second-home resort areas such as northern Wisconsin.

A group at Brookings conducted the most comprehensive study of exurban areas (Berube, *et al.* 2006). They reviewed 19 prior works and included detailed information as to how each defined exurban areas or exurbanites for their studies. Their information, along with a number of articles published since that time, was used to identify the manner in which exurban areas have been defined.

To say that there is a lack of consistency in how exurban areas have been defined in the various works is an understatement. Very different spatial units have been employed in delineating the exurban areas. Many different criteria have been used to determine whether an area is to be included as exurban, with significant numbers of the studies using multiple criteria, as many as 4 or more. As mentioned above, a few studies have allowed exurban areas to be identified anywhere in the United States without reference to urban areas, including Lessinger (1987) as well as Theobald (2001, 2005).

The spatial units used for specifying exurban areas have been as large as counties, in the studies by Lamb (1983) and Blumenfeld (1986), for example. Census tracts, which will be used here, have been employed by Wolman, *et al.* (2005) and Berube, *et al.* (2006). Theobald (2001, 2005) was one of a number using the smaller census block groups. Using unique data from Oak Ridge National Laboratories, Clark (2009) worked with grid cells having areas of approximately 170 acres.

Perhaps the simplest criterion for identifying exurban areas was employed by Johnson and Shifferd (2016). They defined as exurban the area of a Metropolitan Statistical Area (MSA) that is outside the largest Urbanized Area. This presents problems especially for metropolitan areas that include very large counties. Another simple basis for identifying exurban areas is distance either from the Urbanized Area or the MSA, sometimes setting larger thresholds for larger urban areas. Lamb (1983) and Blumenfeld (1986) took this approach.

Above-average population growth was one of a number of criteria used by Berube *et al.* (2006) for delineating exurban areas. Lessinger (1987) also used such a standard, though additionally and confusingly also using low population growth.

A number of studies used commuting data in one form or another to identify areas that were integrated with the urban area. Wolman *et al.* (2005) and Berube, *et al.* (2006) used (different) percentages of the workers in a census tract commuting to the Urbanized Area.

By far the most often-included criteria were measures of population or housing unit density. These included both minimum and maximum density thresholds. Minimum densities were intended to distinguish exurban areas from lower-density rural areas. Maximum densities excluded areas considered to be urban. Examples of studies using densities include Theobald (2001), Wolman, *et al.* (2005), Berube, *et al.* (2006) and Clark, *et al.* (2009). The density thresholds used were literally all over the place. From the studies listed in the table presenting exurban definitions in Berube, *et al*. (2006), housing unit density criteria included 10 to 40 acres per unit, 5 to 40 acres per unit, greater than 60 units per square mile (about 10.7 acres per unit, and less than about 2.6 acres per unit. Population density criteria likewise varied and included less than 500 persons per square mile, 300 to 999 persons per square mile, and 100 to 1,000 persons per square mile.

Data derived from satellite imagery have been employed in other studies. Sutton, Cova, and Elvidge (2006) used nighttime lights in delineating exurban areas. Green (2011) employed measures of impervious surface. And recognizing the uncertainty associated with the definition of exurban areas using such a variety of criteria, Ban and Ahlqvist (2009) proposed the use of fuzzy sets to identify exurban areas.

Urban Patterns Data

Understanding the definition and delineation of exurban areas requires knowledge of the data to be used and the definition of the urban areas that represent the starting point. The urban patterns research uses a dataset 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 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 more properly 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. For those MSAs which were not incorporated into 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 seen as sufficiently large in relation to the largest area to be considered an additional center. 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. A center 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).

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 unit densities—the numbers of housing units divided by the land areas of the tracts in square miles—are used in this research rather than the more commonly employed population density measure 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 includes 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 were defined for each census year from 1950 to 2010 consisting of those contiguous tracts meeting a minimum housing unit density threshold. 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 a block or larger area to be added to an Urbanized Area (U.S. Bureau of the Census 2002, 2011). Using the ratio of population to housing units for the nation in 2000 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.[1]

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

Defining Exurban Areas

In considering the criteria for the definition of exurban areas, both the ideal criteria and the possible criterion are addressed. This discussion examines the criteria that have been used in other studies. Those criteria that can be dismissed most quickly are addressed first. The remainder of the MSA outside of the Urbanized Area depends on arbitrary county boundaries and does not take into account any characteristics of the census tracts. Likewise, distance is an arbitrary standards that also fails to consider characteristics of the areas and poses the additional problem of the choice of distance for urban areas of varying size. Nightime lights and impervious surface from satellite imagery seem idiosyncratic and indirect.

Berube, *et al.* (2006) used a minimum rate of population growth criterion. Their objective was to identify emerging exurban areas. However, they acknowledged the limitations of this by also including analysis of the more slowly growing exurban areas. For a study focused on a particular time period, this could make sense. But for a longitudinal study extending over many decades, this would not be especially workable. What happens to areas that experienced the above average growth in an early decade and then no longer continue to grow as rapidly? It would not make sense to consider those tracts to be exurban at one point in time and then no longer exurban at a subsequent period. More reasonable is to ignore growth rates in the definition of exurban areas and consider rates of growth as one variable in the analysis of those areas.

Minimum housing unit density seems to be an essential characteristic to consider in order to distinguish exurban tracts from rural areas. Maximum density, on the other hand, presents problems. The basis for including such a standard makes some sense if one is solely trying to define areas of very low-density settlement. The intention for the current work, however, is to define exurban areas as the contiguous set of census tracts extending out from the urban area that meet the exurban criteria. Some of the areas will inevitably have higher, urban densities. These will range from relatively small developments, to smaller towns and cities, to separate Urbanized Areas. A maximum density criterion would exclude those tracts, leaving holes in the exurban area. The choice is not use a maximum density criterion, to include such tracts with the intention of considering the amount of such imbedded urban area in the analysis of the exurban areas.

The final criterion to be considered is the level of commuting to the Urbanized Area. This is an indicator of the integration of the tract with the urban area that gets to the heart of what it means for an area to be exurban. Ideally, this would be a part of the definition of an exurban area.

The commuting data constitute the problem that distinguishes the ideal definition from the possible. Tract data on commuting to the Urbanized Area is

available for 2000 and 2010. The census has reported tract data on numbers commuting to central cities for a numbers of years. This is very different from commuting to the Urbanized Area and its use would have 2 problems. First, central cities vary greatly in terms of the proportion of the MSA and Urbanized Area included within them. And second, the commuting data reported by the census was commuting to the central city of the Primary Metropolitan Statistical Area (PMSA) for those large metropolitan areas that were subdivided. Numbers commuting to Newark or Gary are not as useful as numbers commuting to New York City or Chicago.

Furthermore, the Neighborhood Change Database only included data back to the 1970 census and data on the commuting question back to 1980. And the census did not collect any commuting data in the 1950 census and only county-level commuting in 1960. Data just are not available for employing a commuting criterion over the period from 1950 to 2010.

A minimum density standard will therefore be the primary criterion for defining exurban areas. However, two actions will be taken to increase the likelihood that tracts included in the exurban areas are integrated with the urban area. The first is to specify that the exurban areas cannot extend beyond the boundary of the CSA or MSA in which the urban area is located. For 2010, this provides reasonable assurance of some degree of integration. The CSAs and MSAs are themselves defined using commuting criteria. Therefore every county within the CSA or MSA is integrated with other portions of the area based on this standard. While this does not guarantee that every tract within a county would meet a commuting threshold, at least the county as a whole did in 2010. Of course, this is less reliable for very large counties that greatly overbound the metropolitan area. However, the second action will address this.

Restricting the exurban area to the area of the CSA or MSA provides the indication of integration for 2010. But we can expect that the extent of the metropolitan area and the area of integration was smaller in earlier years, very much smaller in 1950 and 1960 for many areas. The method for obtaining hoped-for integration for the exurban areas for the years before 2010 is to select a conservative, sufficiently high minimum density so that the 2010 contiguous areas of exurban density are largely contained within the CSA or MSA and would not have extended much beyond even in the absence of the rule stopping the exurban area at the boundary. The idea is that tracts meeting the density threshold are sufficiently non-rural that they most likely will generally be integrated with the urban area. There will necessarily be exceptions where contiguous exurban development in 2010 does extend beyond the CSA or MSA boundary. This could be development along a major transportation route that is indeed still integrated with the urban area. And when metropolitan areas are adjacent to one another, it is certainly possible for exurban areas (and sometimes even the urban areas) to be contiguous. The extent to which the 2010 exurban areas achieve this containment within the CSAs and MSAs is assessed in the following section.

So now comes the matter of selecting the minimum density for inclusion in an exurban area. The procedure was as follows: Examine the extent of contiguous exurban density tracts in 2010 inside and outside the CSA or MSA using various density thresholds and pick the one that looks the most reasonable. The objection to this would be that it is arbitrary. That is correct. But no more arbitrary than any of the other exurban definitions that have been reviewed. And for that matter, no more arbitrary than the Census Bureau choosing a minimum population density of 500 persons per square mile as the threshold for including blocks and other areas within Urbanized Areas. The decision to use the roughly equivalent housing unit density for defining the urban areas in this research was not arbitrary. Once the Census Bureau had selected that threshold and it was widely accepted as the definition of "urban," the choice to follow their example made sense and was no longer arbitrary.

As discussed above, minimum density thresholds that have been used for defining exurban areas have varied widely. The density minima stated in terms of acres per housing unit varied from a low of 40 acres per unit to a high of 10 acres per unit (and one population density minimum of 300 persons per square mile is roughly equivalent to 5 acres per unit). Values of 40, 30, 20, 15, and 10 acres per unit were considered as potential exurban thresholds. Maps were examined showing the tracts meeting these various density levels of housing units per acre in 2010 both within and outside of the CSAs and MSAs.

The lowest density cutoffs of 40 acres per unit and 30 acres per unit were far too inclusive. Large sections—in some cases the entire areas—of many CSAs and MSAs had tracts with at least these densities. And the areas of contiguous exurban density tracts extended well past the CSA or MSA boundaries, covering significant portions of some of the more densely populated states in the eastern United States. These density levels were obviously too low to meet the objectives sought.

At the other extreme, areas having densities as high as 10 acres per unit were very limited around many urban areas. These areas did not seem to encompass significant amounts of territory that should properly be considered exurban. This threshold was considered to be too high.

That left the density minima of 20 acres per unit and 15 acres per unit. Both produced contiguous exurban areas that looked quite reasonable (and produced results that were not that different for most of the areas). The areas of contiguous exurban density were largely well-contained within the CSAs and MSAs, at least for those areas not adjacent to other metropolitan areas.

The final decision to use the higher minimum density of 15 acres per unit was based on observations that the larger areas that would result from using 20 acres per unit produced some exurban areas that seemed to extend too far out from the urban areas. Portland and Indianapolis were two examples. For Portland, the area of contiguous 20 acre-per-unit development extended far south to encompass a major

portion of the Willamette Valley. The exurban area for Indianapolis reached about halfway to Louisville. Neither seemed reasonable. Hence the choice of 15 acres per unit as the minimum exurban density level.

The final definition of exurban areas was patterned on that used for defining the urban areas, which in turn generally followed the Urbanized Area definition. Exurban areas would consist of those census tracts contiguous to the urban area or to other exurban area census tracts that had a density of at least 15 acres per unit (42.67 units per square mile). Exurban areas could not extend beyond the boundary of the CSA or MSA in which the urban area was located. Census tracts separated by water were considered to be contiguous. (This was an issue for the exurban areas primarily in the Seattle-Tacoma area with islands in Puget Sound.) If an area of less than 5 square miles that did not meet the density minimum were surrounded by exurban area tracts, it would be considered to be exurban. Larger enclosed areas would not. This is the same as the standard used for the urban areas and the census Urbanized Areas. Finally, areas with multiple urban centers could have their urban areas noncontiguous in earlier years, such as Dallas and Fort Worth. In those cases, exurban areas would be delineated around each of those urban centers. These exurban areas could end up being contiguous with one another, but this was not required. This definition was used to delineate exurban areas around the urban areas within the 59 CSAs and MSAs for each census year from 1950 to 2010.

Assessment of Exurban Areas

The approach taken aimed at delineating exurban areas that could reasonably be considered to be integrated with the urban areas despite the lack of commuting data that would have allowed that to be considered explicitly. The objective was the selection of a sufficiently high, conservative minimum density for the exurban areas such that the area of contiguous exurban development in 2010 would be largely contained within the boundaries of the CSA or MSA. This section presents an assessment of the extent to which this was achieved.

It is important to emphasize that areas of contiguous exurban density extending past the CSA or MSA boundary are not necessarily not exurban. First, it is reasonable to expect that a string of tracts with higher densities could extend along major transportation arteries beyond the CSA or MSA boundary that would be integrated with the urban area. The CSAs and MSAs are delineated using counties as building blocks. They not only can include areas that are not integrated with the urban area (overbounding) but also can miss some areas that are integrated with the urban area (underbounding). The latter can occur with tracts in counties where the overall level of commuting does not meet the standard for the county being included in the MSA.

Areas of contiguous urban development can also extend beyond the CSA or MSA boundary in situations where the areas are adjacent to other metropolitan areas. The exurban areas for such areas can literally grow together, with the boundary serving to designate to which area the exurban tracts are to be assigned. Indeed, this can also happen with urban areas that become contiguous in regions with large, closely spaced metropolitan areas. This is the case among numbers of the urban areas in the Northeast Corridor.

This assessment considers the number of locations at which 2010 exurban areas were contiguous to tracts having exurban densities outside the CSA or MSA as well as the total numbers of tracts involved in such contiguity. Whether exurban tracts are adjacent to another CSA or MSA in the dataset or to another metropolitan area is critical to this assessment. Of the 59 areas in the dataset, 42 were adjacent to at least one other CSA or MSA in the dataset. Portions the boundaries were also adjacent to either other MSAs, to other counties not in MSAs, or both. All but one of the remaining areas were adjacent to at least one other MSA not in the dataset. Only El Paso was adjacent only to counties not in an MSA or a CSA within the dataset.

To distinguish exurban density contiguity with the different types of areas, the analysis begins with counts of the number of tracts in the CSA or MSA that lie on the border that are adjacent to the three different types of areas. These are other large CSAs or MSAs that are included within the dataset, other smaller MSAs that are not included in the dataset, and areas that are not within either of these two types of areas. Table 1 presents the counts of the total numbers of tracts on the CSA and MSA boundaries broken down by the type of area to which the tract is adjacent. About a quarter of the tracts were adjacent to another CSA or MSA in the dataset, with about the same percentage adjacent to an MSA not in the dataset. Over half of the tracts, about 60 percent, were adjacent to other areas. The counts and percentages add up to more than the totals because a tract can be adjacent to two types of areas.

Table 1. Numbers of Tracts on Boundaries of CSAs and MSAs by Type of Area Tracts Adjacent to. (Counts and percentages add up to more than total because tracts can be adjacent to multiple areas.)

Tracts on CSA/MSA Boundary	Number of Tracts	Percent of Tracts
Adjacent to CSA/MSA in Dataset	499	25
Adjacent to MSA Not in Dataset	523	26
Adjacent to Other Areas	1,232	61
All Tracts on Boundary	2,024	100

The assessment begins with the counts of the numbers of locations in each area where exurban tracts on the boundary in 2010 were contiguous to tracts having exurban densities across the boundary. These locations vary from a single exurban tract on the boundary being contiguous to one exurban-density tract outside to multiple adjacent tracts on either side of the boundary. For these counts to be meaningful, it is necessary to take into account the total numbers of tracts on the boundary, so the numbers of contiguous locations as a percentage of the number of tracts on the boundary is calculated. This is done for each of the 59 areas for all tracts on the boundary and then for the locations associated with the three different types of areas across the boundary.

The distributions of the numbers of areas by these counts as percentages of boundary tracts are presented in Table 2. For all boundary tracts, the majority of areas, 31 of the 59, had values less than 5 percent, very limited numbers of exurban density contiguity locations. The maximum was less than 30 percent. But the real story is in the breakdown by the type of area to which the tract is adjacent. For the sections of the

Table 2. Number of Areas by Number of Locations Where Exurban or Urban Area Tracts on Boundary Are Contiguous to Tracts Outside Area Having at Least Exurban Density as Percentage of Number of Tracts on Boundary.

Contiguous Locations as Percentage of Boundary Tracts	Areas Contiguous Tracts Within			All Areas
	CSA/MSA in Dataset	MSA Not in Dataset	Other Areas	
0-5	26	30	41	31
5-10	3	15	6	13
10-15	6	2	8	11
15-20	2	1	1	2
20-25	2	2	1	1
25-30	1	0	0	1
30-35	0	1	0	0
35-40	1	0	0	0
40-45	1	0	0	0
Number of Areas	42	51	57	59
Mean Number of Locations	7.3	4.7	3.8	5.8

boundaries adjacent to other CSAs or MSAs in the dataset, one area had over 40 percent and another was over 35 percent. Thirteen of the 42 areas were over 10 percent. For boundary locations adjacent to other MSAs not in the dataset, the area with the highest value had less than 35 percent and only 6 of the 51 exceeded 10 percent. And finally, for other areas, 41 of the 57 areas were at less than 5 percent, with the maximum under 25 percent.

Another way of looking at this is to consider just the counts of the number of exurban-density contiguous locations without consideration of the numbers of tracts on the boundaries. Of the 59 areas, 24 had no locations where exurban tracts were contiguous to tracts having the higher density across the boundary. In other words, the exurban areas would have been completely contained within the CSA or MSA. Another 22 areas had only 1, 2, or 3 such locations. Six a had as many as 7 to 12 locations, the maximum, and all of these areas were adjacent to other CSAs or MSAs in the dataset.

The conclusion is that there were limited numbers of locations where the exurban areas were contiguous to tracts having exurban density outside the area. The greatest number of such locations were concentrated in areas adjacent to other CSAs or MSAs in the dataset.

The analysis thus far considered just the number of separate locations at which the exurban area was contiguous with tracts having at least exurban density outside the CSA or MSA. It did not take into account the extent of those areas of contiguity. These could range from single tracts on either side of the boundary to many tracts on each side being contiguous to one another. The next step is to look at this aspect of the extent of contiguity.

The number of contiguous tracts at each location of contiguity is used as the measure of the extent of the contiguity. This raises the issue of how the tracts are counted. Obviously if there is one exurban tract at the boundary that is contiguous to a single exurban-density tract outside, the count would be one. Likewise, if 3 tracts inside are contiguous to 3 outside, the count would be 3. But what if the numbers of tracts on the 2 sides of the boundary differ? If a single exurban tract were contiguous to an area of 3 exurban-density tracts outside, it seems reasonable to count this as one tract being contiguous at this location. Alternatively, if a 3 exurban tracts on the boundary are contiguous to a single exurban-density tract outside, it also would be appropriate to consider there to be one tract of contiguity. So the rule in the counting of the tracts would be that for each location of contiguity, the smaller number of exurban density tracts on either side of the boundary would be the count of contiguous tracts.

For any area, the total number of tracts at locations of contiguity should be standardized by taking that value as a percentage of the total number of tracts on the boundary. The results are presented in Table 3. Considering the entire boundaries around the areas, 29 of the areas had the count of contiguous tracts as less than 5 percent of the total number of tracts on the boundary. This varied significantly for the

sections of the boundaries adjacent to different types of areas. For portions of the boundary adjacent to other CSAs or MSAs in the dataset, 25 areas were at less than 5 percent. For boundary sections not adjacent to those areas or to other MSAs, 38 areas were at less than 5 percent.

Table 3. Number of Areas by Number of Tracts at Locations of Contiguity as Percentage of Number of Tracts on Boundary.

Contiguous Tracts as Percentage of Boundary Tracts	Areas Contiguous Tracts Within			All Areas
	CSA/MSA in Dataset	MSA Not in Dataset	Other Areas	
0-5	25	29	38	29
5-10	0	7	6	6
10-15	0	1	5	5
15-20	1	1	5	2
20-30	4	2	2	8
30-40	5	4	1	3
40-50	1	3	0	2
50-60	3	2	0	0
60-70	0	1	0	3
70-80	2	1	0	0
80-90	1	0	0	1
Number of Areas	42	51	57	59
Mean Number of Tracts	18.0	13.0	5.6	14.2

Where the results for the different boundary sections differ greatly is in the number of areas having high percentages. For the boundaries adjacent other CSAs or MSAs in the dataset, the number of contiguous tracts as a percentage of tracts on the boundary was over 80 percent for one area and over 70 percent for 2 more. For the portions of the boundaries not adjacent to those areas or to other MSAs, on the other hand, the highest percentage was less than 40 percent, and only 3 areas exceeded 20 percent.

Another way of looking at this is consider the mean numbers of tracts across the areas at locations of contiguity for the different types of boundary adjacency. The effect of the type of area is striking. Boundaries adjacent to other CSAs or MSAs in the dataset had an average of 18 tracts at locations of contiguity. For the boundaries adjacent to other MSAs, the mean was 13 percent. And for the remaining boundary sections not adjacent to either, the mean was less than 6 percent.

What is driving the high levels of contiguous tracts in some areas? Table 4 breaks down the distribution of the number of areas by the number of tracts at locations of contiguity as a percentage of the number of tracts on the entire boundaries by areas within and outside the Northeast Corridor. For areas not in that region, the area that was highest was between 40 and 50 percent. For the areas in the Northeast Corridor, that was the interval for the area with the lowest percentage, with the highest over 80

Table 4. Number of Areas by Number of Tracts at Locations of Contiguity as Percentage of Number of Tracts on Boundary for Areas within and outside Northeast Corridor.

Contiguous Tracts as Percentage of Boundary Tracts	Area Not in Northeast Corridor	Area In Northeast Corridor	All Areas
0-5	29	0	29
5-10	6	0	6
10-15	5	0	5
15-20	2	0	2
20-30	7	1	8
30-40	3	0	3
40-50	1	1	2
50-60	0	0	0
60-70	0	3	3
70-80	0	0	0
80-90	0	1	1
Number of Areas	53	6	59
Mean Number of Tracts	9.3	57.7	14.2

percent. The mean number of tracts at the locations of contiguity was about 9 percent outside the Northeast Corridor areas, fully 58 percent for the 6 areas in that region.

Looking at counts without taking into consideration the total numbers of tracts on the boundaries, all of the areas not in the Northeast Corridor had 16 or fewer contiguous tracts. All of the Northeast Corridor areas had 16 or more. The maximum number of such tracts was 57 tracts for the New York area.

A higher, more conservative density threshold that increases the likelihood of integration of the exurban area with the urban area will cover a smaller proportion of the area of the CSA or MSA. The final assessment of the exurban areas examines the percentage of the CSA or MSA land area that is included in the urban and exurban areas. Some metropolitan areas are significantly overbounded due to the inclusion of very large counties, resulting in artificially low portions being included in the urban and exurban areas. Thus the focus here is on the areas with higher percentages urban and exurban. No attempt will be made to distinguish very low from low coverage.

Table 5 shows the distribution of the number of areas by the percentage of the CSA or MSA land area within the urban and exurban areas. Three areas have over 80 percent of the land urban or exurban. And these are areas in the Northeast Corridor: Hartford, New York, and Boston. A total of 15 areas had over half of the land in the urban and exurban areas. The remaining three-quarters of the areas had less. So only in

Table 5. Number of Areas by Percentage of CSA/MSA Land Area within Urban and Exurban Areas.

Percent CSA/MSA Land Area within Urban and Exurban Areas	Number of Areas	Cumulative Number of Areas
90-100	1	1
80-90	2	3
70-80	2	5
60-70	7	12
50-60	3	15
40-50	5	20
30-40	12	32
<30	27	59

a few cases does the exurban area come even close to filling up the remainder of the CSA or MSA. And in the overwhelming majority of areas, the exurban area is far from doing so.

The three approaches to assessment—numbers of locations of exurban density spillover, numbers of tracts at those locations, and the percentage of the metropolitan area in the urban and exurban areas—all support the conclusion that the areas of contiguous exurban density are confined largely to the CSAs and MSAs. And the situations with greater spillover tend to be into adjacent metropolitan areas, with the greatest contiguity in the densely urbanized Northeast Corridor.

Brief Description of 2010 Exurban Areas

With all this discussion of the exurban definition, it seems only appropriate to at least present a sense of the exurban areas that the definition produced for 2010. This is not intended to be an analysis of those exurban areas. That will be forthcoming in one or more additional papers. Rather, this is a brief picture providing some final context for understanding what that definition yielded.

Table 6 presents a few summary statistics for the land areas and numbers of housing units for the 59 exurban areas. Considering the absolute magnitudes, the exurban areas vary tremendously in terms of land area from under 200 square miles for the smallest area to nearly 8,000 square miles for the largest. The mean is slightly less than 1,800 square miles, with the median somewhat over 1,300. Numbers of housing units in the exurban areas likewise spanned a very broad range, from less than 20,000

Table 6. Summary Statistics for Land Area and Number of Housing Units in Exurban Areas.

	Mean	Median	Minimum	Maximum
Exurban area land area (square miles)	1,765	1,330	171	7,766
Exurban area housing units	239,911	177,754	18,851	1,258,298
Exurban area land area as percentage of urban area land area	248.2	195.4	33.6	784.9
Exurban area housing units as percentage of urban area housing units	33.9	22.5	2.7	139.4

units to over 1.2 million. The mean and median were respectively somewhat above and below 200,000 units.

The three smallest exurban areas in terms of both land area and housing units were Albuquerque, Fresno, and San Diego. The largest exurban areas in terms of land area were New York, Washington-Baltimore, Boston-Providence, and Atlanta, all at over 4,000 square miles. The next larger areas were a little over 3,000 square miles. Los Angeles joins New York, Washington-Baltimore, and Boston-Providence as the areas with the greatest number of housing units in the exurban areas. All had over 700,000 units, with the areas with the next larger counts at just over 500,000 units.

Of course it is not particularly surprising that the largest urban areas would also tend to have the largest exurban areas. Another way to look at the exurban areas is relative to the size of the urban areas. Table 6 also includes the summary statistics for exurban land area and housing units as a percentage of the corresponding urban area values. On average the land area of the exurban areas was about two (median) to two and one-half (mean) times the land area of the urban area. Again this varied widely from about a third to nearly 8 times the size of the urban area. Exurban housing units as a percentage of urban is naturally much lower because of the lower densities, ranging from under 3 percent to nearly 140 percent, with a mean of 34 percent and a median of about 23 percent.

Miami-Fort Lauderdale-West Palm Beach and San Diego had the smallest percentages of both urban area land area and housing units. The largest on both measures was Knoxville, with Grand Rapids next. Portland was the median area with respect to percentage land area, while Sacramento was the median area in terms of percentage of housing units.

So what do these exurban areas look like in relation to their urban areas? Figure 1 shows the urban and exurban areas for the areas with smallest percentage land area and housing units in the exurban area, the median percentage land area, and the largest percentage land area and housing units. The areas are shown at approximately the same scale.

The Miami area shows only very limited exurban areas. For the most part, the exurban area has extended westward to the barrier posed by the Everglades, leaving little area left at exurban densities. The Knoxville exurban area is very large in relation to the much smaller urban area. It extends to the east towards the Great Smokey Mountains, encompassing tourist-oriented development. To the northeast, the exurban area is adjacent to the Kingsport-Bristol MSA. Oak Ridge and the national laboratory lie to the west.

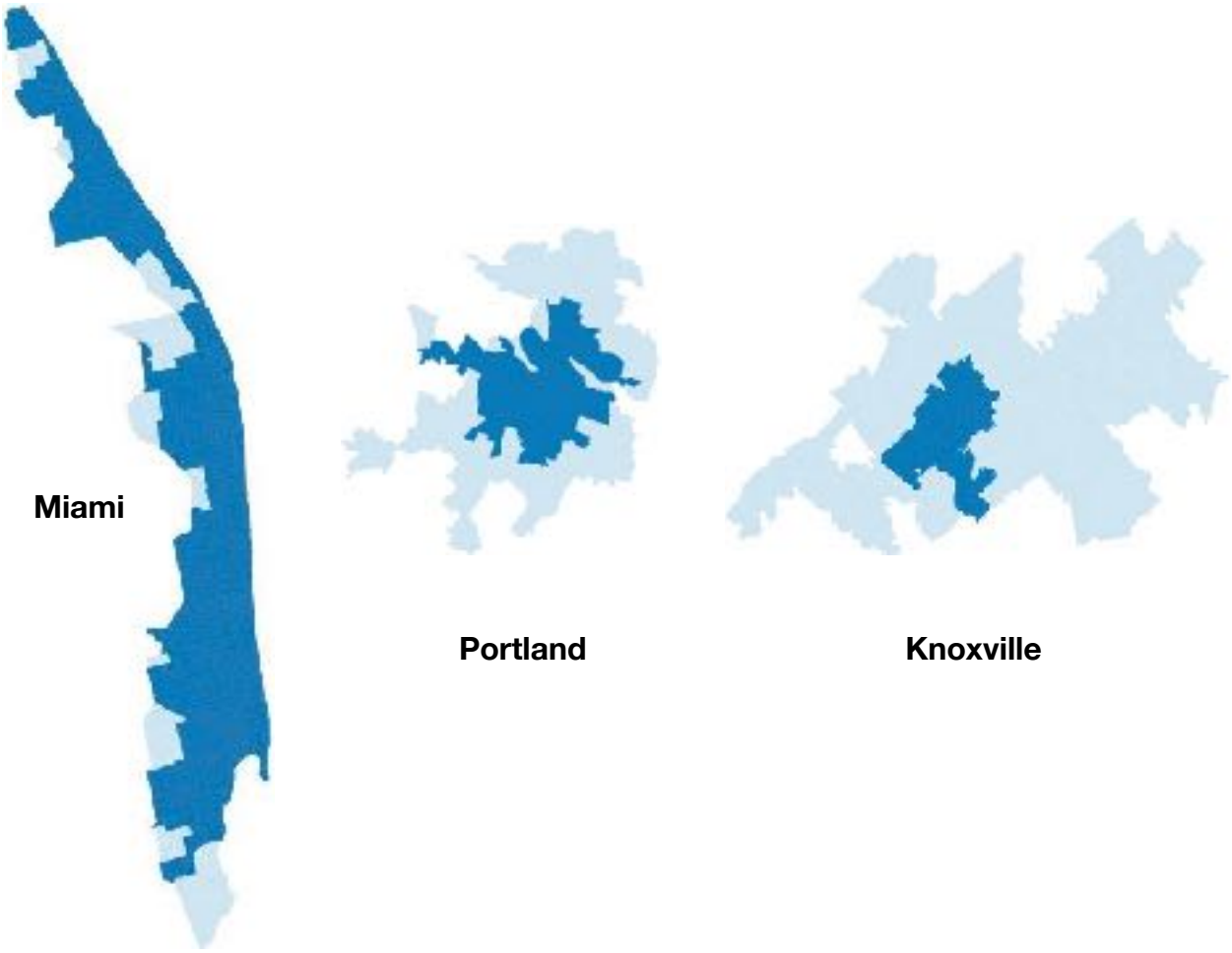

Figure 1. The Smallest (Miami-Fort Lauderdale-West Palm Beach), Median (Portland), and Largest (Knoxville) Exurban Areas in Terms of Exurban Land Area as a Percentage of the Urban Area (areas approximately to scale).

Conclusion

Whether considering the numbers of locations at which contiguous tracts having at least exurban density cross the boundary of the CSA or MSA, the numbers of tracts at those points of contiguity, or simply the proportion of the CSA or MSA area covered by the urban and exurban area, the conclusion is that these areas are largely contained within their CSA or MSA. Because the counties of the CSA or MSA are integrated with the remainder of the area in 2010 (by definition), it is reasonable to conclude that exurban areas for 2010 defined solely based on density without reference to the CSA or

MSA boundary would have been substantially integrated with their urban areas. And it is therefore not unreasonable to assume that exurban areas defined using the same density threshold for earlier years would also be integrated with the urban areas in those years.

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