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The majority of studies on the measurement of racial segregation have focused on the use of measures which do not consider the role of scale. These measures implicitly define the social environment as equivalent to some organizational or spatial unit such as a census tract, without regard for the patterning of these units in social space. Methodological issues arise when using these conventional "aspatial" measures including the checkerboard problem and the modifiable areal unit problem.

The purpose of this research is to analyze the role scale plays in the measurement of segregation. The spatial measures analyzed in this study address these issues by using individual level data and by defining the units of analysis independent from the areal unit boundaries the census provides (e.g. census tract, blockgroup, block). In some metropolitan areas, racial groups are segregated over large regions, with predominantly white regions and predominantly black regions, whereas in other areas, the separation of racial groups occurs over much shorter distances. This research analyzes an approach offering a scale sensitive alternative to the standard methodological practice for describing segregation. The Entropy Index along with the segregation profile and the macro/micro segregation ratio are implemented here as a spatial measure of segregation. Using this spatial measure, five of the most populous counties in North Carolina are examined to see at what scale segregation is occurring within them.

It is concluded that segregation is occurring over a large scale in all five N.C. counties. Visible differences in the spatial patterning of the pairwise Black/Other and

Hispanic/Other Entropy values are observed. The assumption of segregation as a non-increasing function of scale holds true and segregation values decrease as the scale of analysis is increased in all five counties. It is concluded that the spatial measure used here adequately addresses the methodological issues of the aspaial measures and that it also provides a more adequate measure of the scale at which segregation is occurring.

A GEOSPATIAL ANALYSIS OF RACIAL SEGREGATION

IN NORTH CAROLINA'S MAJOR

METROPOLITAN AREAS

by

David D. Morse

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Approved by

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Committee Chair

To Mom and Dad

APPROVAL PAGE

This thesis has been approved by the following committee of the Faculty of The Graduate School at The University of North Carolina at Greensboro.

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CHAPTER I

INTRODUCTION

Racial and ethnic residential segregation is a prominent feature of the U.S. metropolitan landscape (Fischer et al. 2004, Wilkes and Iceland 2004). Racial and ethnic segregation, most apparent in the metropolitan landscape, fosters disadvantages for some racial groups in terms of education, employment, exposure to higher crime, single parenthood, concentrated poverty, and even health and cognition outcomes. While segregation negatively affects these specific outcomes for certain groups, residential segregation speaks to the nature and quality of intergroup relations in U.S. society, where high levels of segregation are often indicative of the considerable social, economic and political distance between groups (Iceland 2006).

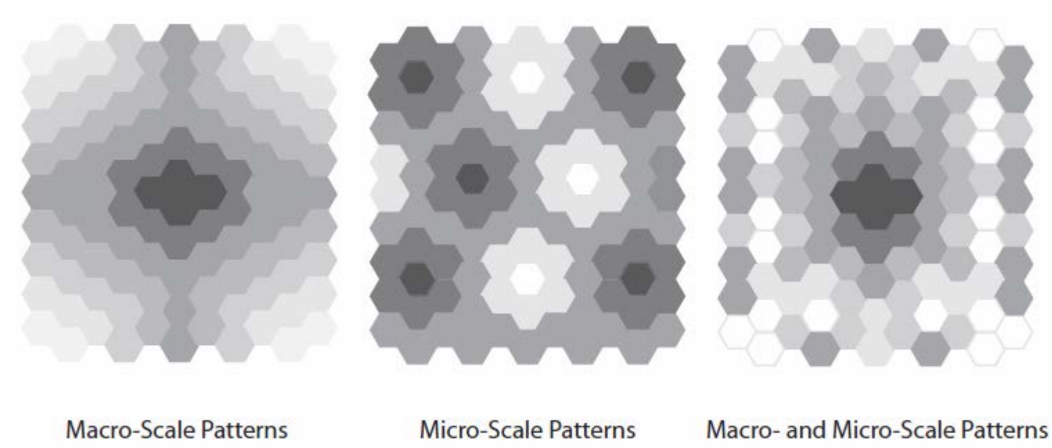
On the topic of segregation there seems to be an attempt to extend the usually aspatial methods of evenness and isolation measurement to account for the geographic scale of segregation (Fisher et al. 2004, Reardon and O'Sullivan 2004, Lichter et al. 2007, Jargowsky and Kim 2007, Fischer 2008, Reardon et al. 2008). One purpose of the inclusion of scale is to provide a more thorough analysis of the variable nature of segregation among metropolitan areas. Segregation can be thought of as the extent to which individuals of different groups occupy or experience different social environments. A measure of segregation requires that we (1) define the social environment of each individual and (2) quantify the extent to which these social environments differ across individuals (Reardon et al. 2004). Many measures are aspatial, in that they differ from one another only on the second of the above criteria, because they implicitly define the social environment as equivalent to some organizational or spatial unit (school district, census tract, etc.), without regard for the patterning of these units in geographic space. Much prior discussion of segregation indices has therefore focused only on the matter of the most appropriate mathematical formulation for quantifying differences across social environments (Collins and Margo 2000, Adelman et al. 2001, Reardon and Firebaugh 2002, Rusk 2003, Pendal and Caruthers 2003, Logan et al. 2004, Fischer and Tienda 2004, Iceland and Wilkes 2006, Yang and Jargowski 2006).

It has been proposed that by varying the size of the first criteria, the scale of the social environment, one can assess the scale over which segregation is occurring in a metropolitan area (Jargowsky 2003, Wong 2004, Jargowsky and Kim 2004, Reardon et al. 2008, Fischer 2008). It is this use of multiple scales of aggregation which differentiates the spatial measures from the aspatial measures. Here, four radii of lesser and greater extent independent of the arbitrary boundaries defined by the census are used. An aspatial measure would use only one unit of analysis (e.g. census tract) and only examine segregation at one scale.

Developing accurate measures of segregation is a necessary first step in assessing the causes of residential separation between groups and the social and economic consequences of these divisions (Boustan 2009). The spatial measures may very well provide a more accurate measure of segregation as it is more able to account for the difference in spatial patterns of segregation between and within metropolitan areas.

As the size of the sample area becomes larger, cities with scattered pockets of black residence (like Boston, San Francisco and Cincinnati) look increasingly integrated whereas cities with concentrated black belts (like Atlanta, Chicago and Los Angeles) do not (Reardon & O'Sullivan 2004). Stylized examples of such differences are shown in Figure 1. Each of the regions in Figure 1 contains relatively high levels of segregation – racial composition (represented by the grey shading) varies substantially across locations – but the geographic scale of segregation differs substantially among the regions. The left hand region is characterized by a macro-scale segregation pattern, in contrast to the center region, where micro-scale segregation accounts for the variation in racial composition across locations. The right-hand region illustrates the combination of macro- and micro- scale segregation, with some variation in racial composition over short distances evident in addition to the macro-scale pattern of concentration of one group in the center of the region. This difference is overlooked when aspatial measures are used as they do not consider the effect the size of the sample has on observed segregation levels.

Figure 1 Stylized Spatial Racial Population Distributions



(Based on Reardon et al. 2008)

Issues of scale are potentially important not merely in describing patterns of segregation, but in understanding both the causes and consequences of segregation. There is good reason to think that both the causes and consequences of macro-scale segregation may differ from those of micro-scale segregation. Geographic scale represents a distinct dimension of residential segregation (Reardon et al. 2008).

The purpose of this study is to attempt a comparison of the geographic scale of segregation in five of the most populous counties in North Carolina (Durham, Wake, Guilford, Forsyth, and Mecklenburg) to assess the benefits of using a spatial measure of segregation. In order to do this I will (1) analyze the role scale plays in the measurement of segregation, (2) address methodological issues of aspatial measures of segregation, (3) Choose a spatial measure which most adequately addresses these issues and (4) implement a spatial measure of segregation on major metropolitan areas within NC.

Several research questions will be addressed. The first of which will be, do the spatial measures adequately address the methodological issues of the aspatial measures? Does the assumption of segregation as a non-increasing function of scale hold when using a spatial measure of segregation? Are the segregation patterns within the five N.C. counties significantly different from one another? Do spatial measures provide a more adequate measure of the scale at which segregation is occurring?

Utilizing the capabilities of GIS software, segregation will not be measured at the block group, tract, or county level but at multiple scales of greater and lesser extent. Using four circular sampling units with radii varying from 500m to 4000m the segregation values observed at each scale will be displayed in a segregation profile. This, along with the macro/micro segregation ratio, will indicate to what extent large or small scale segregation patterns define the five N.C. counties. A mulitgroup White/Black/Asian/Other segregation measure will measure the overall segregation within each county. Pairwise Black/Other and Hispanic/Other segregation measures will indicate the segregation specific to the black and Hispanic populations within each county. The black and Hispanic minority groups are examined as they represent the largest minority groups within each N.C. county. A comparison of the geographic patterns produced by the Black/Other and Hispanic/Other segregation values should reveal if and how the spatial distributions vary within each county. It is hypothesized that the segregation patterns will be large in scale for all five N.C. counties. It is also hypothesized that there will be visible differences in the geographic location of high and low Black/Other and Hispanic/Other segregation values within each county.

CHAPTER II

LITERATURE REVIEW

All of the studies reviewed implement some sort of measure of segregation. The region which all of these papers focus on is the metropolitan statistical area. The first portion of the literature review contains articles which implement aspatial measures. Such measures include, but are not limited to, the Dissimilarity Index (evenness), Isolation Index (exposure), Metropolitan Segregation Index, Concentration of Poverty, and the Neighborhood Sorting Index. The second portion of the literature review contains articles which implement spatial measures which will be evaluated based on their suitability for measuring spatial segregation. These measures include but are not limited to the Spatial Segregation Profile, Spatial Information Theory Index, Spatial Entropy Index, Spatial Exposure/Isolation Index, Spatial Relative Diversity Index, Spatial Dissimilarity Index, and Generalized Neighborhood Sorting Index. Major findings of the articles will be noted and potential contributions and weaknesses of them will be discussed. A comparison of the methods used should make clear the advantages of some over others in their ability to measure patterns of segregation.

Aspatial Measures

Many measures are aspatial, in that they differ from one another only in the way they quantify the extent to which social environments differ across individuals. This is because they implicitly define the social environment as equivalent to some organizational or spatial unit (school district, census tract, etc.), without regard for the patterning of these units in social space. Prior discussion of segregation indices has therefore focused only on the matter of the most appropriate mathematical formulation for quantifying differences across social environments (Collins & Margo 2000, Adelman et al. 2001, Rusk 2003, Jargowsky 2003, Pendal & Caruthers 2003, Logan et al. 2004, Fischer & Tienda 2004, Iceland & Wilkes 2006, Yang & Jargowski 2006).

Concentration of Poverty

Jargowsky (2003) provides a measure of the concentration of poverty in the 1990s using sample data from the 1990 and 2000 decennial censuses. Census data at the tract level were used as it is assumed to be relatively homogenous with respect to social and economic characteristics and housing stock considerations. He calculated the percentage of poor in high poverty neighborhoods to create an indicator of the concentration of poverty. Jargowsky's findings highlight a welcome departure from past trends in concentrated inner-city poverty, but flag an area of growing concern in economically struggling suburbs which is also noted by Fischer (2008).

Jargowsky's use of the official U.S. poverty guidelines is not ideal as it does not accurately represent the minimum living standards of an area and therefore the data may not accurately represent the number of poor in a census tract. Jargowsky could have differentiated low-income and those that are not by households making less than half of their metropolitan area's median income, as was done by Pendall et al. (2003). The use of only census tract data misses any variation in segregation values when the sample size is increased or decreased. This is known as the Modifiable Areal Unit Boundary Problem (MAUP) and may be observed in any single scale analysis. MAUP will be discussed in more detail in the spatial measures section of this literature review.

Dissimilarity Index and Isolation Index

The Dissimilarity Index measures the evenness with which two mutually exclusive groups are distributed across the geographic units that make up a larger geographic entity; for example, the distribution of blacks and whites across the census tracts that make up a metropolis. Its minimum value is zero and its maximum value is 100. We would observe a value of zero it there was no segregation and a value of 100 if there was complete segregation. If a city's white-black dissimilarity index were sixty-five, that would mean that sixty-five percent of the white population would need to move to another neighborhood to make whites and blacks evenly distributed across all neighborhoods. The isolation index measures concentration or isolation of one group (e.g. blacks). It reports the percentage of one population group in the geographic unit (e.g. Census tract) for the typical person in that group. The maximum value is 100 and the minimum is asymptotically close to zero.

Adelman et al. (2001) use both the Dissimilarity Index and the Isolation Index. Public Use Microdata Samples (PUMS) for 1970 and 1980 linked neighborhood characteristics with individual households. The results indicate that the residential patterns prevailing in 1990, characterized by a sharp disadvantage for blacks, had already emerged in the 1970s. A residential disadvantage was observed for even high-status black households. They conclude that the persistence of the disadvantage experienced by blacks supports the general conclusion offered by Massey and Denton (1993) and John Yinger (1995), that discrimination, while possibly more subtle than in the past remains an important organizing principle in contemporary housing markets. On the other hand, newcomers to the United States who are not black are able to surpass relatively quickly native-born blacks in the quality of their neighborhoods.

The methods used are unique as there is a direct linkage between individual households and characteristics of neighborhoods due to the use of the 1970 neighborhood characteristics and the 1980 PUMS-F data. They therefore have more direct control over the number and form of the microlevel predictors used to analyze individual residential attainment processes across a large number of metropolitan areas (Adelman et al. 2001). However the direction of causal influence is uncertain when using individual-level data to predict neighborhood-level characteristics. For example, one cannot determine whether education level determines residential location or residential location determines education level. Despite its advantages, the individual level data used in this study makes no attempt to take scale into consideration. The observations are confined to the census tract. A multiscale analysis may have been revealing. A higher percentage rate of joblessness could possibly have been observed in larger areas characterized by higher percentages of minority population and lower levels of residential attainment.

Collins and Margo (2000) use the dissimilarity index to give a recent view of the effect of residential segregation on labor markets and social outcomes. They attempt to show that the adverse effects of such segregation are a recent phenomenon that began in the mid-1970s. They also use PUMS data but for a different time range, from 1940-1990, focusing on measures of idleness, annual income, and children born to never-married women. Their results suggest that segregation was not associated with idleness or single motherhood prior to 1970 when the 'bad' effects of ghettos appeared and that the 'ghettos-are-bad' conclusion is a recent historical phenomenon. This study would have benefited from an analysis of between city segregation levels as they could have examined the different causes related to individual cities. Also, the use of only the male idleness and income may have overlooked significant trends in female idleness and income characteristics. Finally, as in all single scale analysis, the MAUP issue is overlooked.

Fischer and Tienda (2004) focus on the burgeoning Hispanic population and its dispersal in U.S. metropolitan areas. They examine the effect a growing Hispanic population has had on segregation patterns, intergroup commingling, homeownership rates, and employment. Both the Dissimilarity index and the Isolation Index are used to measure the change in segregation experienced by Hispanics and blacks between 1980 and 2000. Also considered is the social significance of the new residential patterns based on changes in school segregation, home ownership, and employment outcomes. The 100 largest cities are divided up into three strata: Traditional Metros, New Hispanic Destinations, and Other Large Metros.

They conclude that the greatest ethno-racial diversification occurred during the 1990s in the New Hispanic Destinations and that overall segregation levels were uniformly lower in 2000 than in 1980. Also, the range of variation between racial groups, in their levels of segregation, contracted. Widespread declines in overall black segregation occurred, particularly in areas where the Hispanic presence rose dramatically. However, immigration has accentuated Hispanic re-segregation patterns. The 100 cities included in the study were examined as contiguous units so segregation trends within the city are overlooked.

This research would have benefited from the employment of a technique that accounts for the multiethnic character of the urban landscape, such as the entropy index could have been used to test the hypothesis of the causal connection between changing racial residential configuration and declines in racial segregation (Fischer 2008).

Iceland and Wilkes (2006) studied the interplay between race and class using one aspatial measure, the dissimilarity index. They examined the role of socioeconomic status and race in explaining the residential segregation of African Americans, Hispanics, and Asians from non-Hispanic whites throughout the 1990s. The authors' use of five indicators of socioeconomic status should be encouraged in other studies as a more accurate indicator as income can change dramatically from census to census. Census data, at the tract level were used as the tracts is an accepted indicator of the local neighborhood boundary in which characteristics are assumed to be uniform or influenced by one another. There is no variation in the scale of analysis from the established census tract boundaries assuming that the majority of the segregation is occurring at this scale in all of the cities analyzed (30 cities). The major fault in the aspatial measures used in this study is that they may overlook higher levels of segregation which may be occurring over shorter distances than the tract. Nor does it indicate the distance over which segregation levels begin to decline and therefore the degree to which the tract level measurement area explains the metropolitan wide segregation value.

Logan et al. (2004) use the dissimilarity index and the isolation index. They document metropolitan level segregation trends in the period between 1980 and 1990. Equal attention is given to blacks, Hispanics, and Asians. Logan et al. 2004 note that increasing importance in the latter two groups due to their recent growth and their greater presence in several Western metropolitan areas where blacks are now the smallest of the three minority groups. This analysis also addresses the hypothesis that “new” metropolises are less segregated than “old” metropolises.

Logan et al. 2004 conclude by giving reasons for the slow decline in black-white segregation and the continued stability or increase in the segregation of Hispanics and Asians. Logan et al. address the vanity of the hope for a breakthrough in the slow decrease in black-white segregation as the declines in segregation were not greater for metropolitan areas where the incomes of blacks were catching up with those of whites. The continued slow decline was thought to be possibly the result of the increasing multiethnicity of the metropolis however, it was found that neither the percentage of Hispanics nor the percentage of Asians nor the combined growth rate of these two groups compared to whites was associated with the segregation of blacks in 2000 or with changes in the segregation from 1980 to 2000. This is also observed by Reardon et al. (2008) who note that the segregation patterns of the Asian population are unrelated to those of blacks.

Pendal and Caruthers (2003) use the Dissimilarity Index and Isolation Index. Their paper proposes that the connection between development patterns and segregation may be more complex than is typically thought. Pendal and Caruthers analyze the relationship between development patterns and income segregation in a nationwide data set of metropolitan areas from 1980 to 2000. During his empirical analysis he examines how density affects income segregation.

Pendal and Caruthers (2003) findings suggest that sprawl in its low-density manifestation is not directly associated with nor does it cause income segregation. Regions in which density fell dramatically between 1980 and 2000 had less income segregation than regions whose medium to high densities remained the same from 1980 to 2000. The findings do not however endorse sprawl as, overall, less dense areas were found to have more income-based segregation than more dense metropolitan areas and older regions are more integrated by income than newer ones.

The authors were wise to differentiate between low-income and those that are not by households making less than half of their metropolitan area's median income. This classification of very low income households more accurately represents minimum living standards than does the national poverty line which is well below the reasonable base living standard. This single scale analysis employed here and also by Logan et al. (2004) are also subject to the MAUP problem.

Metropolitan Segregation Index

The Metropolitan Segregation Index is based on the Dissimilarity Index and also has a range of zero to 100 however it is based solely on Census tract data. Using the Metropolitan Segregation Index, David Rusk (2003) analyzed what he believes to be America's real urban problem, which is racial and economic segregation that has created an underclass in many of America's major urban areas. Rusk examines in detail 119 urban areas with populations of 250,000 or more. He focuses on entire metropolitan areas, cities and suburbs, in order to measure what he has coined the elasticity of a metro area. The elasticity of a city refers to its ability to expand geographically. The three sections of the text discuss how racial prejudice shapes growth patterns and how a city's elasticity affects demographic, social, and economic patterns within it. He concludes that inelastic cities are more segregated than elastic cities and that there needs to be a reinvestment in the city center to reverse severe racial and economic segregation.

Rusk's evaluation of a city's elasticity would have benefited from a comparison of the scale of segregation occurring within the elastic v. inelastic cities. More elastic cities may have had larger scale segregation than cities with little to no elasticity. In addressing issues such as a jobs housing imbalance and concentrated poverty, knowing the scale at which these equity issues are occurring within the metropolitan area would aid the creation of policy which adequately addressed them. The reader is however left with metropolitan level segregation values which overlook any within metro variation.

Neighborhood Sorting Index

The Neighborhood Sorting Index (NSI) is defined as the square root of the ratio of the between-unit (e.g. Census tract) income variance to the total (e.g. metropolitan area) income variance. While the NSI does not examine racial segregation here the methods used could be applied to create a spatial measure of racial segregation. Yang and Jargowsky (2006) use the NSI to document the recent trends in economic segregation as they relate to suburbanization. Based on 1990 and 2000 U.S. Census tract data, they examine these empirical questions by conducting a nationwide metropolitan-level analysis. Findings support that economic segregation, as measured by the NSI, declined during the 1990s, reversing the earlier trend. However, results from cross-sectional and fixed-effects regression models at the metropolitan level suggest that suburbanization had a countervailing influence during the decade. Metropolitan areas that were suburbanizing more rapidly had smaller declines in economic segregation than comparable metropolitan areas.

The results of Yang and Jargowsky (2006) support the development of regional planning strategies which would resist suburban development and support investment in the already developed or center city areas. Gale (1992) and Bolens (1992) give several examples of state growth management programs supporting intergovernmental frameworks to resist trends of increasing economic segregation. Rusk (2003) also calls for the reinvestment in our city centers as critical to the overall health of the entire metro area. Since this work focused on a particular type of development pattern, low density suburban development, it would have benefited greatly from the inclusion of a scalar measure which would have been able to identify to what degree the observed segregation values were due to large scale segregation patterns and at what scale segregation began to decline.

Spatial Measures

Many existing spatial segregation measures are not scale-sensitive, at least not in any easily interpreted way, because they rely on tract boundaries and contiguity patterns to measure spatial proximity (Reardon & O'Sullivan 2004). While such measures can be employed using areal units of different levels of aggregation (block, block group, tract, city, county, and so on) – yielding segregation levels at multiple scales (Jargowsky 2003, Jargowsky and Kim 2004, Wong 2004, Fisher 2008) – the scales are not readily interpretable because they depend on areal units of widely varying shapes and sizes. Nor is the scale of such measures comparable, since the average size of census tracts and blocks are not uniform across space or time.

A measure of spatial segregation should satisfactorily address the problems identified with existing measures of segregation. The most commonly used measures of segregation – such as the dissimilarity index and the isolation index – are aspatial, meaning that they do not adequately account for the spatial relationships among residential locations (Massey and Denton 1988, Morrill 1991, Wong 1993, Grannis 2002, Reardon and Firebaugh 2002b, Wong 2002). A satisfactory spatial segregation measure would allow "researchers to specify theoretically appropriate definitions of how spatial features constrain or enhance the possibility of social interaction" (Reardon & O'Sullivan 2004).

Reardon and O’Sullivan (2004) pose alternative dimensions of residential segregation in order to erase the distinction between the dimensions of aspatial measures of evenness and isolation and the spatial measure of clustering (level of spatial evenness). A segregation measure from information about the exact locations, spatial environments of individuals and their proximities to one another in residential space would provide such a dimension. Based on this insight, two primary conceptual dimensions to spatial residential segregation are proposed: (1) spatial exposure and (2) spatial evenness. Exposure refers to the extent to which members of one group encounter members of another group in their local environments. Evenness refers to the extent to which groups are similarly distributed in residential space.

Methodological issues in the measurement of spatial segregation include the checkerboard problem (White 1983, Morrill 1991) and the MAUP (Openshaw & Taylor 1979, Wong 1997). The checkerboard problem occurs when measures ignore the spatial proximity of neighborhoods and focus instead only on the racial composition of them. To visualize the problem it helps to imagine a checkerboard where each square represents an exclusively black or white neighborhood. If all of the black squares were moved to one side of the board, and all the whites to the other, we would expect a measure of segregation to register this change as an increase in segregation, since the neighborhoods are both homogeneous and surrounded by similarly homogenous neighborhoods. Aspatial measures do not distinguish between the first and second patterns, since in each case the racial compositions of individual neighborhoods are the same (White 1983).

The MAUP arises in residential segregation measurement because residential population data are typically collected, aggregated, and reported for spatial units such as census tracts that have no necessary correspondence with meaningful social/spatial divisions. This data collection scheme implicitly assumes that individuals living near one another but in separate spatial units are more distant from one another than are two individuals living relatively far from one another but within the same spatial unit. Even if these subarea boundaries do not correspond to meaningful social boundaries all measures of spatial and aspatial segregation that rely on population count aggregation within subareas are sensitive to the definitions of the boundaries of these spatial subareas. If the spatial units in a particular study were specified differently, there might be an observed difference in patterns and relationships. Also, regression equations are usually strengthened by data aggregation. This is caused by two main things. First, the aggregation effect - combining any pair of observations will produce an outcome that is closer to the mean of the overall data so that aggregated data are more likely to be more tightly clustered around a regression line and have a stronger coefficient of determination. Second, the zoning effect - substantial differences may be observed under different aggregation schemes (O'Sullivan & Unwin 2010).

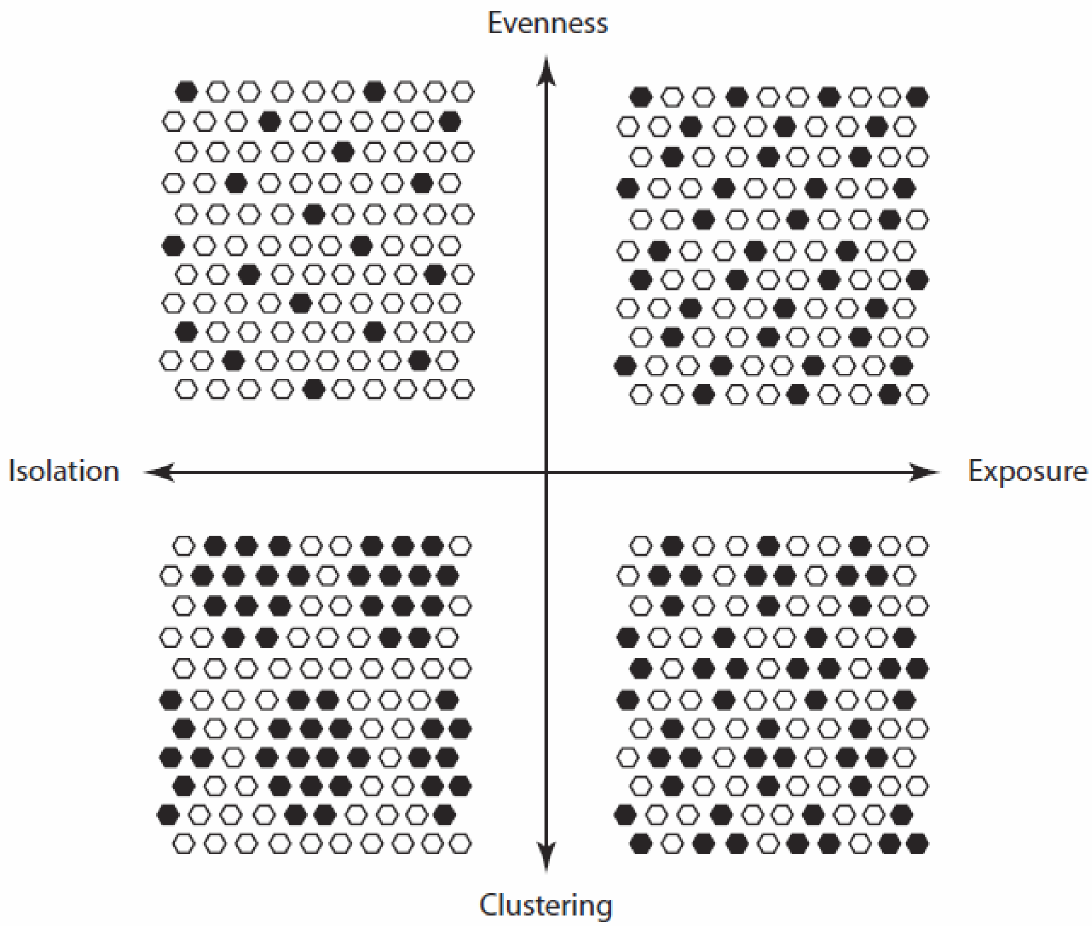
Essentially then, the definition of spatial segregation measures requires a redefinition of the social environment implicit in the traditional aspatial segregation measures. In fact, the checkerboard problem and the MAUP are both artifacts of a reliance on subarea (e.g. census tract) boundaries in the computation of segregation measurement. In principle, a segregation measure that used information on the exact locations of individuals and their proximities to one another in residential space could eliminate the checkerboard problem and MAUP issues entirely (Reardon et al. 2008). This type of measure would also eliminate the conceptual distinction between the aspatial and spatial dimensions of segregation.

Massey and Denton (1988) describe five conceptually distinct "dimensions" of residential segregation: (1) evenness, (2) exposure, (3) clustering, (4) centralization, and (5) concentration. Evenness and exposure are aspatial dimensions, however, implicitly spatial because they depend on census tract boundaries. Clustering, concentration, and centralization are explicitly spatial dimensions of segregation, and they require information on the location and size of census tracts to compute. As stated above however, the distinction between aspatial evenness and spatial clustering is an artifact of the reliance on spatial subareas at some chosen geographical scale of aggregation. Evenness at one level of aggregation (census tracts), is clearly strongly related to clustering at a lower level of aggregation (block groups), since tracts where a minority group is overrepresented will tend to be clusters of block groups where the minority population is overrepresented. The distinction between evenness and clustering is thus arbitrary unless the subarea boundaries correspond to meaningful social boundaries.

As a result of this insight, Reardon and O'Sullivan (2004) suggest an alternative to the Massey and Denton (1988) dimensions. Two primary conceptual dimensions to spatial segregation: (1) spatial exposure (or spatial isolation) and (2) spatial evenness or (spatial clustering). Spatial exposure, like aspatial exposure, is a measure of the typical environment experienced by individuals and depends on the overall racial composition of the population in the region under investigation. Spatial evenness, is independent of the population composition however, as it refers to the extent to which groups are similarly distributed in residential space.

Consider the four patterns of individual residential locations (not subarea proportions) shown in Figure 2. Black and white households are evenly distributed throughout space in the upper two patterns and therefore have low levels of clustering. The pattern in the upper right exhibits higher levels of exposure than the pattern in the upper left due to more black households in the local environment of each white household in the upper right pattern. The bottom two patterns exhibit higher levels of clustering but the same levels of exposure as the corresponding patterns above.

Figure 2 Dimensions of Spatial Segregation.



(Based on Reardon and O'Sullivan 2004)

In this framework of individual level observations Massey and Denton's evenness and clustering are collapsed into a single dimension. Their exposure dimension remains intact, but it is now conceptualized as explicitly spatial. Their centralization and concentration dimensions can be seen as specific subcategories of spatial unevenness. The following articles implement segregation measures in an attempt to avoid the above stated problems associated with aspatial measures.

Spatial Dissimilarity

Wong (2004) uses three types of spatial segregation measures, Morril's Dissimilarity, the Boundary-Adjusted Dissimilarity, and Dissimilarity which has incorporated a shape-compactness calculation for the block and tract level. Morrill's Dissimilarity incorporates a comparison of the ethnic mixes of neighboring sample areas. Boundary-Adjusted dissimilarity incorporates the length of shared boundaries. Using this set of spatially explicit segregation measures Wong (2004) determines whether the set of measures are as sensitive to scale changes as the traditional aspatial measures. Census data at the block groups and tract level for 1990 were used to compute both traditional and aspatial measures for two-group and multigroup comparisons. These measures are then compared over the two scales (block group and tract).

The effect the MAUP has on sociological and population studies is discussed. As most segregation measures have a direct relationship to the internal homogeneity of population within areal units, a smaller enumeration unit will likely produce a higher level of segregation. It is however considered unclear whether this relationship will hold when spatial measures are employed. It is concluded that the assumption of a non-increasing function of scale does hold and the performance of multiple-scale spatial segregation analysis, because of the increased sensitivity of spatial segregation measures to scale, is valuable when considering the scale of segregation within a metropolitan area.

Wong (2004), while an informative evaluation of the effects of scale on a measure, is still dependent on arbitrarily defined administrative units such as census blocks and would have been even more informative if measurements of isolation had been taken at more numerous and variable scales as was done in Reardon et al. (2008). The units of analysis, the census tract and block, are used and as a result this study is easily compared to the many aspatial studies which employ these boundaries as their unit of measure.

Entropy Index

Thiel's (1972) entropy index of segregation is used to measure residential segregation because of several advantages it holds over more commonly used measures of segregation such as indices of dissimilarity and exposure. Like dissimilarity, it is a measure of evenness that compares the distribution of groups in each tract to the representation of those groups in the metropolitan area as a whole. Unlike the dissimilarity index, however, the entropy index can measure segregation among more than two groups simultaneously. The entropy index is based on comparisons of diversity at one level (e.g. Census tract) to diversity at some higher level (e.g. metropolitan area). The lower bound of the index is zero, which would occur if each census tract had the same diversity as the metropolitan area as a whole. If all of the census tracts contained only one group (no diversity) relative to a diverse metropolitan area, this would be a state of complete segregation with an entropy index value of one.

Fischer (2008) use one measure of spatial segregation, the spatial entropy index. Fischer's purpose is to assess the effect increased suburbanization of blacks has had on decreases in residential segregation. Using the entropy index's decompositional properties she partitions the segregation of blacks from others into within-city, within-suburb, and between-city-and-suburb elements over the past 30 years. By doing this it is possible to see the extent to which each of these elements has changed in its relative importance in explaining metropolitan levels of segregation. The analysis is based on 1980, 1990, and 2000 tract-level data standardized to 2000 tract boundaries, with tract-level central-city indicators appended to the dataset.

It is concluded that suburban declines in segregation were less rapid than those in central cities. Crediting the population shift of minorities to the suburbs, a growing proportion of segregation is now observed within the suburban tract. This is by far the most important in the west and south, but in the south within-city sorting is equally as important. These findings confirm the importance of the population shifts to the suburbs in explaining patterns of segregation as suburban growth is positively correlated with suburban segregation.

Fischer (2008) treats the suburbs as a single entity when in fact the suburbs are usually an accumulation of several separately incorporated communities with multiple centers. One within-suburb spatial pattern identified by Jargowsky (2006) is the clustering of Blacks in the suburban areas closest to the city and therefore closer to low-income neighborhoods inside the city limits. Fisher (2008) therefore overlooks within-suburb and within-city segregation variation. The comparison of west, midwest, northeast and south regions would have been more informative if it had divided the regions into mega-regions - physically and economically connected metropolitan areas. This way variation within the regions could have been examined. Tract level Census data were used, limiting the analysis to between track level values of entropy. Variation within the tract itself is however overlooked which may lead to misrepresentation of the level of segregation within the tract and possibly have a significant effect on the metropolitan segregation level. It is observed by Wong (2008) and Reardon et al. (2008) that the observed segregation level tends to decrease as sample size increases. Block level data could have been used however to most effectively avoid the MAUP, the analysis could have been performed using proximity measures based on individual level data as done in Reardon et al. (2008). This would have provided a more satisfactory analysis of the scale of segregation, as the sample sizes could be aggregated to sample sizes both smaller than and greater than the tract boundary. The difference in these segregation values could then be compared to see if spatial aggregation misses any significant smaller scale segregation patterns.

Generalized Neighborhood Sorting Index

The Generalized Neighborhood Sorting Index (GNSI) is a modification of the NSI discussed in the above aspatial measures. The main difference between the two is that the GNSI incorporates a flexible moving window for the calculation of a neighborhood's economic level which is larger than the neighborhood itself. GNSI can measure segregation at various spatial levels from a small scale to a large scale, by changing the size of the moving window, reducing the dependence on arbitrarily defined administrative units such as census tracts. It is considered to be sensitive to the spatial relationships of the unit of analysis (e.g. Census tract) and reflect the heterogeneity of the parcels and the spatial patterning of neighborhoods.

Jargowsky and Kim (2004) use one spatial segregation measure, the GNSI. The purpose of this paper is to address the major deficiencies in common measures of economic segregation, in particular, their blind spot when it comes to spatial data. Jargowsky et al. criticize the NSI for its sensitivity to the population size of the parcels (tract, block), the MAUP and its insensitivity to the physical location of census tracts vis-à-vis one another, also known as the “checkerboard problem”. “The NSI and the Dissimilarity Index are based on dichotomous groups and are not well suited for studying income segregation.” As a solution to these problems the GNSI is proposed.

In order to test whether or not the conceptual superiority of the GNSI has any practical significance the change in GNSI between ten large metropolitan statistical areas from 1990 and 2000 is measured. Census tracts are used as proxies for neighborhoods. A decline in segregation is observed between 1990 and 2000. It is concluded that the level of segregation observed is dependent on the scale employed in the analysis, the segregation of income occurring at different scales and the relative importance of these scales differing among metropolitan areas. This is also noted by Wong (2008), Reardon et al. (2008) and Fischer (2008).

Using the individual, rather than the neighborhood as the basic unit of observation the GNSI effectively avoids the MAUP problem inherent in NSI. However MAUP manifests itself in the individual level data as a decline in the level of segregation as a consequence of expanding the area over which community mean incomes are calculated. Also, the orders of expansion are based on the census tract boundaries and therefore they miss any variation within each tract.

Spatial Information Theory Index

The Spatial Information Theory Index $(\widetilde{H})$ is a measure of how much less diverse individuals' local environments are, on average, than is the total population of a region. It is equal to one when maximum segregation is observed and an individual's environment is monoracial. If the individual's environment has the same racial composition as the total population then the value will be zero, indicating complete integration.

Reardon et al. (2008) use one spatial measure of segregation, the Information Theory Index and displayed it in a Spatial Segregation Profile. These authors were interested in investigating the geographic scale of racial residential patterns and the extent to which the spatial concentration of racial groups in U.S. metropolitan areas occurs at larger and smaller scales. They propose that "distinctive racial and residential patterns are evident at a range of scales." The authors extend Reardon and O'Sullivan's (2004) method of measuring spatial segregation to develop an approach for addressing questions about the scale of segregation. Reardon et al (2008) computes a "spatial segregation profile"– a curve that depicts the level of segregation at a range of spatial scales (radial distances) – for forty of the largest metropolitan areas in the United States. Rather than pick a particular definition of local, their approach entails computing segregation levels at a range of definitions of local – specifically at a range of radii. Scale sensitivity is achieved by varying the radius parameter of the proximity function used to compute the local spatially weighted average population composition.

Reardon et al. (2008) conclude that there may be some common factors shaping the geographic scale of segregation patterns among white, black, and Hispanic populations but a different set of mechanisms shapes the scale of Asian residential patterns. The highest levels of segregation were observed for the black population at all scales of analysis. Reardon et al. (2008) conclude that macro/micro segregation ratio measures a distinct dimension of segregation patterns than that measured by a single measure of segregation alone and could therefore provide new insight into the causes and consequences of segregation.

The methodology of this thesis will most closely reflect the methods used in Reardon (2008). Out of all the literature covered in this review the methods in this paper are considered to provide the most adequate measure of spatial segregation patterns. Of the spatial measures examined in this literature review $\widetilde{H}$ most adequately meets the eight criteria used by Reardon and O'Sullivan (2004) to evaluate spatial segregation measures. These criteria include scale interpretability, arbitrary boundary independence, location equivalence, population density invariance, composition invariance, transfers and exchanges, additive spatial decomposability, and additive grouping decomposability. See Reardon and O'Sullivan (2004) for a detailed explanation of these criteria.

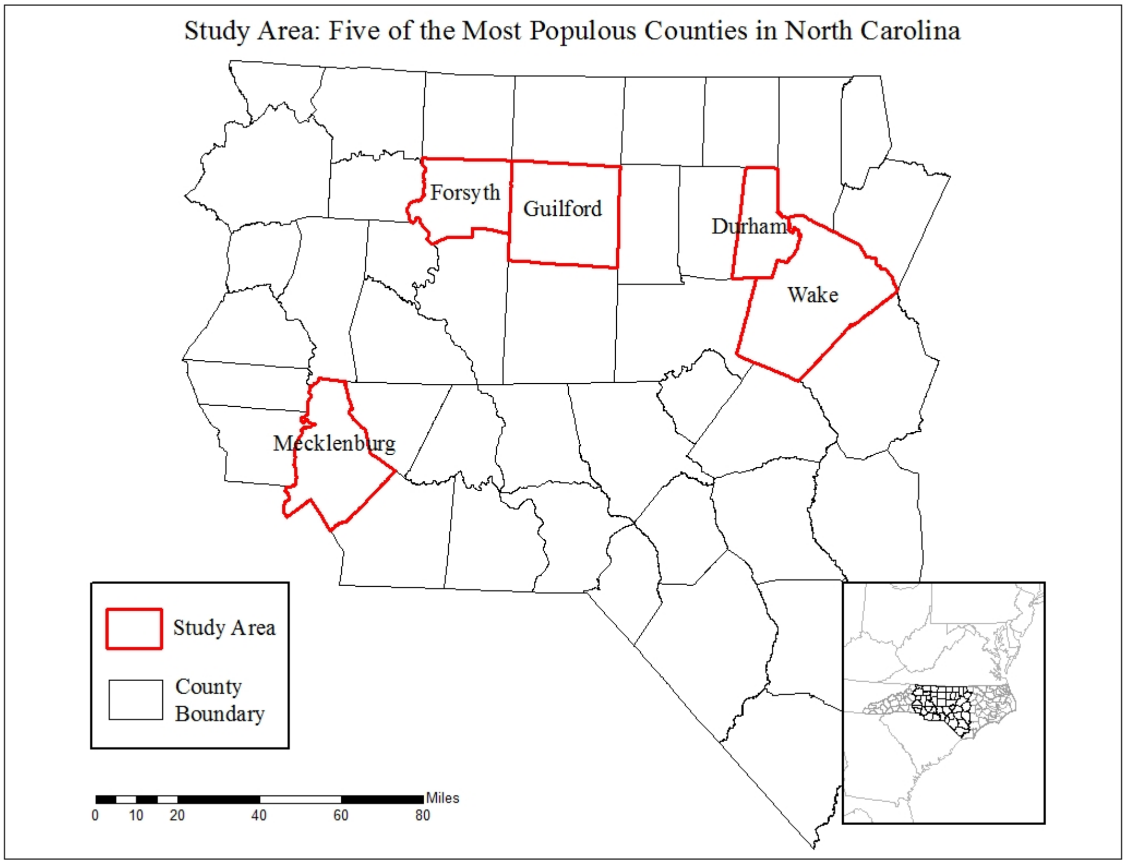
CHAPTER III

METHODOLOGY

Study Area

The study area includes five of the most populous counties in N.C.: Guilford, Forsyth, Mecklenburg, Wake, and Durham. These counties contain some of the largest metropolitan areas in the state: Raleigh, Durham, Greensboro, Winston-Salem and Charlotte. Segregation is considered to be most prominent in metropolitan areas and this is why some of the largest metropolitan areas in N.C. are included in this research. Also, in order to derive accurate segregation measures the minority groups studied need to be present in large enough numbers to avoid misrepresentation of the true level of segregation (Fischer 2008). In order to ensure accurate calculation of segregation statistics the study areas must be large enough to warrant analysis. Their starting point population must be at least 50,000 and their black population must be at least 2,500 (Fischer 2008). The value of 2,500 is considered the cutoff for considering a metropolitan area "racially diverse" (Lichter et al. 2007). All the county populations within this study meet these criteria and should therefore produce accurate segregation values. A map of the study region is given in Figure 3.

Figure 3 Study Area



To give an impression of the demographic composition within these five counties the total population and population percentage for black, Hispanic and combined black-Hispanic-Asian minority groups are listed in Table 1 along with several other characteristics which have been associated with residential segregation in the above literature review. These include percent poverty, density, and single mother households. Percentage of minorities, rates of single motherhood, and percent poverty are all positively correlated with segregation (Collins and Margo 2000, Rusk 2003, Jargowsky

2003, Pendal and Caruthers 2003, Iceland and Wilkes 2006, Yang and Jargowsky 2006, Fischer 2008). Durham County contains the highest percentages of minority population accounting for a little over half of its population (55.6 %). The lowest minority percentages are observed in Wake County which is majority white (62.2%). The difference between these two neighboring counties is great, their group black-Hispanic-Asian population percentages differing by approximately twenty percent.

Table 1 2010 Population Characteristics by N.C. County

County	Wake	Durham	Guilford	Forsyth	Mecklenburg
Population					
Total	900,993	267,587	488,406	350,670	919,628
black	182,793	100,260	156,982	89,533	278,042
	(20.3)	(37.5)	(32.1)	(25.5)	(30.2)
Hispanic	87,922	36,077	34,826	41,775	111,944
	(9.8)	(13.5)	(7.1)	(11.9)	(12.2)
b-H-A	319,022	148,517	191,808	137,735	431,977
	(35.5)	(55.6)	(43.1)	(39.2)	(47.0)
White	560,536	112,697	265,228	205,934	465,372
	(62.2)	(42.1)	(54.3)	(58.7)	(50.6)
Density/ Square Mile	1,708.8	935.7	756.4	859.2	1,755.5
Poverty	80,717	39,573	73,375	50,942	108,296
	(9.7)	(16.1)	(15.9)	(15.3)	(12.5)
Single Mother Household	24,909 (7.2)	9,466 (8.7)	17,558 (8.9)	12,433 (8.8)	32,017 (8.8)

Note: Population percentages are shown in parenthesis bellow each population number. b-H-A denotes the group black-Hispanic-Asian population. Non-Hispanic Black, non-Hispanic white and non-Hispanic Asian populations are displayed. Poverty is based on 2010 American Community Survey 12 month estimates. Single mother, density and race/ethnic populations based on 2010 Census Summary File 1.

The highest densities are observed in Wake and Mecklenburg counties which also have the largest populations. However, Durham County, with the smallest population, is denser than both Guilford and Forsyth. The highest observed density in Mecklenburg County (1755.5 persons / sq. mile) is over twice as dense as the lowest density which is observed in Guilford County (756.4 persons / sq. mile). The highest rates of poverty are observed in Durham and the lowest are observed in Wake. Higher rates of poverty seem to be positively correlated with the percent minority in these five N.C. counties. This trend has been well documented in previous research (Cutler et al. 1997, Cutler et al. 1999, Collins & Margo 2000, Rusk 2003, Fischer 2008). Wake has the lowest percentage minority and the lowest poverty rates and Durham has the highest percentage minority population and the highest rate of poverty. An exception here is Mecklenburg which has the second highest minority population percentage but less poverty than both Guilford and Forsyth which have lower percentage minority populations. Single motherhood is most prevalent in Guilford County (8.9%) and least prevalent in Wake (7.2%). The observed single mother household percentages for Mecklenburg (8.8%), Forsyth (8.8%), and Durham (8.7%).

Sprawl has also been positively associated with increases in segregation (Rusk 2003, Pendal & Caruthers 2003, Yang &Jargowski 2006, Ficsher 2008). Ewing et al. (2002) rank the nations Metropolitan Statistical Areas (MSA) by a sprawl index they created based on four criteria; (1) residential density, (2) neighborhood mix of homes, jobs, and services, (3) strength of activity centers and downtowns, and (4) accessibility of the street network. In the overall national ranking the Raleigh-Durham MSA ranks third in the nation and the Greensboro-Winston-Salem-High Point MSA is second only to Riverside-San Bernardino, CA. These MSA's are contained by four of the counties included in this study. Greensboro and High Point are within Guilford County, Winston-Salem is the largest city in Forsyth, the city of Durham is in Durham County and Raleigh is in neighboring Wake County. However, the Charlotte-Gastonia-Concord MSA which is partially contained by Mecklenburg County does not rank in the top eighty three most sprawling MSA's listed by Ewing et al. (2002), differing greatly in the degree to which it meets the above sprawl criteria.

Data

Population data was gathered from ESRI's ArcData website (http://arcdata.esri.com/data/tiger2000). The website has been produced for informational purposes as a service to Esri, end users and the geographic information system (GIS) community. Esri has compiled Census 2000 data so that it can be imported and manipulated in ArcMap, their proprietary software used to create and manipulate geographic datasets and maps. The U.S. Census Summary File 1 (SF1) for North Carolina was downloaded from this site. The SF1 file contained data at the Census block level. Reardon et al. (2008) also used block level data to minimize the area of data aggregation. The Census block is the smallest enumeration unit for which the Census provides 100 percent population data. This means that data were collected from all houses, rather than a sample of houses. Several blocks make up block groups, which again make up census tracts. As the SF1 included data for the entire state of N.C., subsets of the table needed to be extracted before it was manipulated in Excel. The data for each county were selected using ArcMaps join by attribute tool so that a separate dataset was created for each county. TIGER line data, separate files downloaded for each county from the online ArcData website, were used to select the block data specific to each county. The SF1 table and the TIGER line data attribute table have a common key, STFID, indicating the census enumeration unit. Data tables specific to each county were then exported as Excel files where the entropy was calculated.

The TIGER line shape files needed to be projected in ArcMap so that accurate distance measurements could be made when creating the sampling radii. The projection used is the NAD 1983 StatePlane North Carolina FIPS 3200 Feet, Lambert Conformal Conic. This is a conformal projection and preserves the shape and angles of the map features. Distortion of areas and direction occur at the edges of the map. However the small scale at which this analysis is performed means that the study areas are not subject large amounts of distortion. For studies at the national scale including larger metropolitan areas an equal area projection like North American Albers Equal Area Conic may be considered to limit the effects of area distortion on the spatial measure. Equal area projections preserve the areal relationships so that surface ratios are identical across the map.

The maps presented in the results section were created using ArcMap. A choropleth representation of the observed H values and the population percentages for blacks and Hispanics was mapped. Each block was assigned a value based on their 500m or 4000m environment. The color assigned to each block therefore represents the aggregated population data of all the blocks contained within a 500m or 4000m radius of the center block. Only the largest metropolitan areas are listed on the maps as they contain the majority of the population within each county. The municipal boundary file was downloaded from the NCOneMap web site (http://data.nconemap.com/geoportal/catalog/search/browse/browse.page). The N.C. Department of Transportation GIS Unit developed the digital GIS Municipal Boundaries file which provides the boundaries of all major municipalities within N.C. Its projection needed to be set to match that of the above TIGER line files so that the municipal boundaries accurately overlaid the block shapefile.

The Entropy Index

The segregation values will be calculated using the Entropy Index (H). Out of all the spatial measures reviewed here the Spatial Entropy Based Information Theory Index ($\widetilde{H}$) most satisfactorily meets the spatial measure criteria used to evaluate spatial measures of segregation (Reardon & O'Sullivan 2004). $\widetilde{H}$ is based on a measure of H and this is why H is used as the measure of segregation here. Theil's (1972) entropy index of segregation (H) has several advantages over more commonly used measures of segregation such as indices of dissimilarity and exposure. Similar to the dissimilarity index, it is a measure of evenness that compares the distribution of groups in each sample area to the representation of those groups in the metropolitan area as a whole. Unlike the dissimilarity index, however, the entropy index can measure segregation among more than two groups simultaneously. A quick review of the index's components and interpretation should be informative.

H compares diversity at one level (census block) to diversity at some higher level (metropolitan area). The lower bound of the index is 0, which would occur if each census block had the same diversity as the metropolitan area as a whole. If all of the census blocks contained only one group (no diversity) relative to a diverse metropolitan area, this would be a state of complete segregation with a value of 1. The equation, below, shows the measure of diversity (E) used by the entropy index, where p_r is the proportion of the population composed of group r, indexed over all groups. E reaches its minimum value of 0 when there is only one group present and its maximum value of $ln(n)$ when each group is represented equally. The value of E will be low when any racial group represents a large proportion of the census block in question. This causes the other racial groups to have low proportions and also low values of E.

$$E = \sum_{r=1}^{n} p_r \ln\left(\frac{1}{p_r}\right) \tag{1}$$

H compares diversity at the block level (E_b) to diversity at a higher level of aggregation, such as the metropolitan area as a whole (E_m), weighted by the proportion of the aggregated population living in that block (w_b/W) and summed over all blocks. w_b is the block population and W is the population of the entire metropolitan area. W is the sum of w_b. When all $E_b = 0$ then $H = 1$. When all $E_b = E_m$ then $H = 0$.

$$H = \sum_{t=1}^{n} \frac{w_b(E_m - E_b)}{WE_m} \tag{2}$$

In order to measure the Entropy here a different form of the above equation was used.

$$H = 1 - \left(\frac{1}{WE}\right) \times \sum W_b E_b \tag{3}$$

W and E represent the total population and diversity within a specified radius (500m, 1000m, 2000m, 4000m). The values of $W_b E_b$ for each census block within the specified radius are summed and that value is assigned to the block at the center of that circle before calculating$H$. Each block is given a value of $\sum W_b E_b$ based the census blocks within their 500m, 1000m, 2000m, and 4000m radius environment.

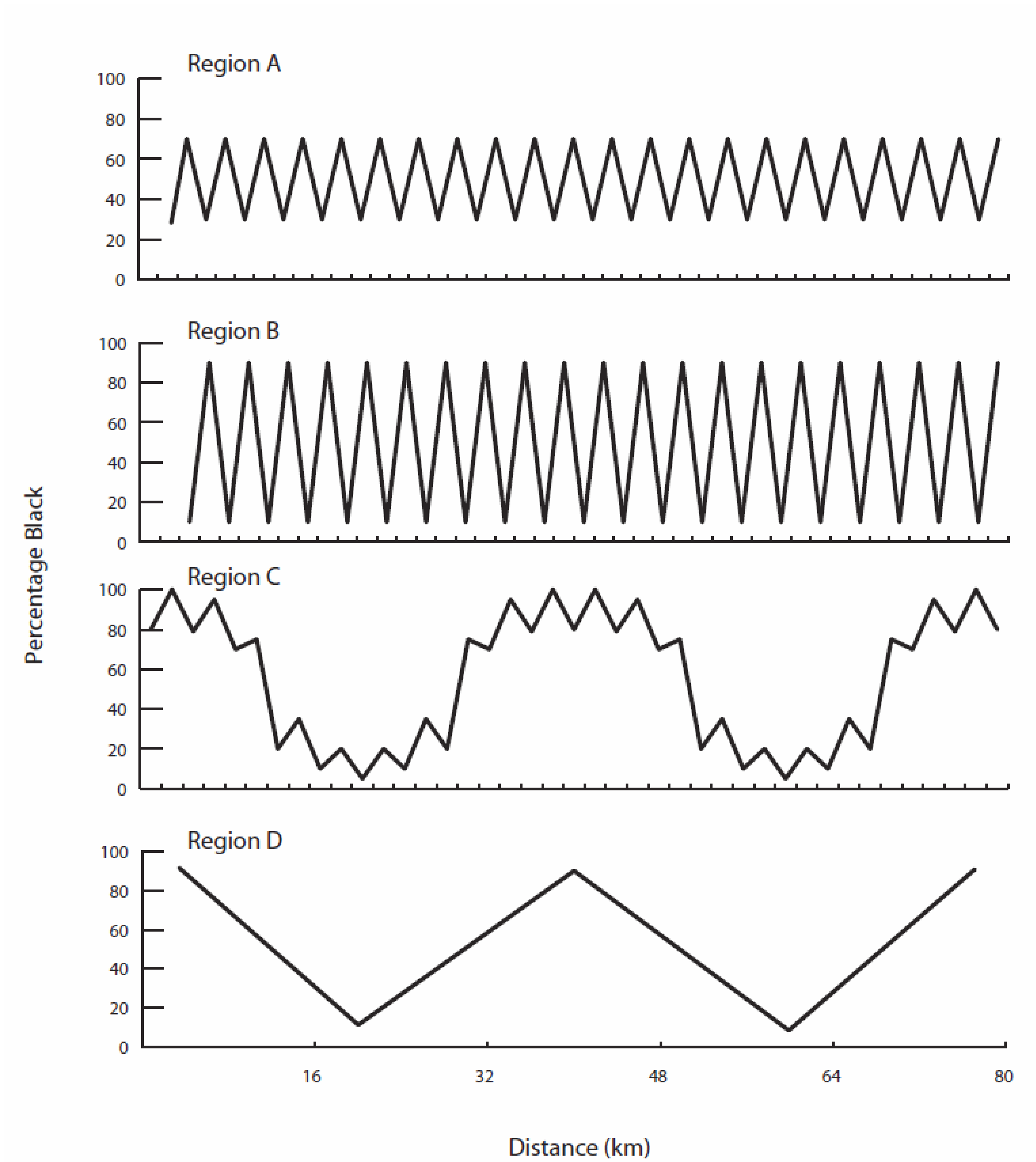
The Segregation Profile

In an attempt to address the limitations inherent in existing approaches to characterizing the spatial scale of segregation, Reardon (2008) developed an approach to compare and contrast multiscale segregation values both within and between regions. By using a proximity measure and a range of sample radii H indicate what percentage of the observed micro-scale segregation is due to larger macro-scale segregation patterns within a metropolitan area. Segregation patterns among small-radius local environments will be referred to as micro-segregation. Macro-segregation will refer to segregation patterns among large-radius local environments.

To illustrate the difference the scale of segregation may cause on observed segregation levels when using a single aspatial measure Figure 4 shows hypothetical racial distribution patterns. Each pattern is unique in the combination of their segregation levels and the scale at which segregation is occurring within each region. In Region A, locations vary from thirty percent to seventy percent in their proportion black, and the spatial patterns change over one to two kilometers. Region B is like region a in the scale at which segregation is occurring but the level of segregation varies to a greater degree over that same distance from ten percent to ninety percent. Two spatial patterns exist in Region C, a micro-scale and a macro-scale pattern. The macro-scale variation in percent black is much greater than the variation for the micro-scale segregation pattern. Racial composition is therefore due to a greater degree to the macro-scale pattern in Region C. Region D has only a macro-scale segregation pattern without the micro-scale variation observed in Region C.

If we consider segregation as the variation across each region in the racial composition of local environments then, as is evident from the comparison of regions A, B, C, and D, the description of segregation will depend on how local environment is defined. In Figure 4, the local environment of a 4km radius will describe regions A and B as not segregated while a 100m radius will describe all regions as segregated. The information theory index accounts for this variation by computing segregation values for a range of definitions of local.

Figure 4 Hypothetical Racial Distribution Patterns

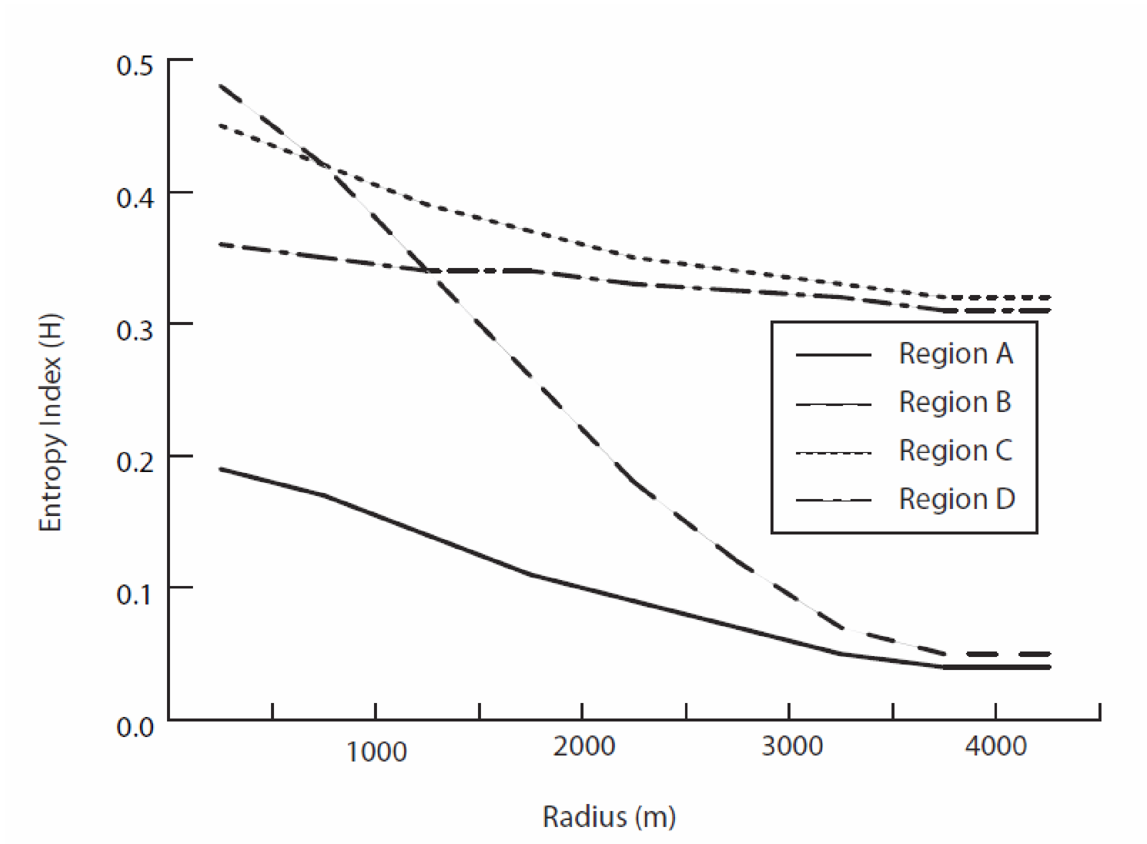


(Based on Reardon et al. 2008)

Figure 5 is a stylized segregation profile for the four hypothetical regions in Figure 4. Note that the slopes of each profile are unique and represent a unique pattern of spatial segregation. The profiles of A and B differ in their segregation level at scales less than 3,000m. However beyond 3,000m their segregation values both reach a value of zero or no segregation. Almost all of the segregation occurring in these two regions is therefore occurring over a small scale. Because Region D does not exhibit a small scale segregation pattern like that in Region C it is less segregated at a small scale. As the sample area grows however the segregation values of Regions C and D converge. At a small scale Regions B and C are similar but as the sample area grows the regions diverge and Region C is much more segregated than Region B at a large scale. Macro-scale segregation patterns play a more important role in defining micro-scale segregation patterns in Region C than in Region B. This translates into a steeper segregation profile for region B than for region C.

The lesson which should be drawn from these stylized regions is that we can characterize the segregation patterns in a region using a segregation profile and that this profile contains information not just on the level of segregation using a particular definition of local environment but also on the extent to which segregation among small local environments is due to racial patterns at larger geographic scales. It should be noted that this is a result of the MAUP.

Figure 5 Stylized Segregation Profile



(Based on Reardon et al. 2008)

In defining a local environment by a given radius, we effectively ignore variation in racial composition occurring over distances smaller than the given radius. It is therefore assumed that segregation values are always a nonincreasing function of scale; as the sample radii grow larger the observed segregation will always decrease (Wong 2008, Reardon et al. 2008). Consider the case of a sample set made up of single-family homes. If the segregation value were to be measured using each home as a single sample the segregation value would be its maximum value of one, assuming that each household was monoracial. On the other hand you could measure the segregation using the entire metro area, within which many local environments are located, and observe segregation values approaching zero (no segregation). A result of this is that the segregation profile typically declines with increasing radii. The steepness of this decline is informative concerning the geographic scale of segregation patterns. Indicating the slope of the line - the ratio of macro- to micro-segregation, termed the macro/micro segregation ratio, is the measure of the proportion of micro-segregation that is due to residential patterns at the macro-scale or larger and is calculated by dividing the observed macro-level segregation by the observed micro-level segregation (Reardon et al. 2008).

In order to produce a segregation profile for a given region, we must have a scalable segregation measure, that is, a measure that can be tuned to measure segregation at a range of scales (Reardon et al. 2008). This requires that we have a method of computing segregation levels at a range of scales and that the notion of scale used is well defined and comparable across place and time. This means that instead of relying on predefined areal unit boundaries (Census tract, block group, block) and contiguity patterns we rely on a measure of spatial proximity.

The distances of the radii used in this study are based on those used by Reardon et al. (2008) and include 500m, 1000m, 2000m, and 4000m radii. These radii correspond roughly to local environments ranging from "pedestrian" in size to those that are considerably larger – perhaps the size of a large high school attendance zone. After the segregation profile has been constructed the macro/micro segregation ratio will be calculated. The micro level and macro level segregation values correspond to the 500m and 4,000m sample radii.

In order to calculate individual H values for each block within all five counties and for all four sample radii ArcMap 9.1 was used in collaboration with Microsoft Excel. First, the population data needed to be grouped so that the racial categories being examined contained the total population of each block. Three separate groupings were considered. The first contained four racial groups, white, black, Asian and Other which included all other racial groups. The second contained two racial groups, blacks and Other. The third contained two groups, Hispanics and Other. The blocks with no population had to be removed so that they did not skew the Entropy data and make the counties seem more segregated than they actually were. Population values of zero result in low values of diversity and therefore high values of entropy. This was done using the Select by Attribute function in ArcMap which would select only those bocks with a total population of zero and then delete any selected blocks. Next the block diversity (E_b) and block population (W_b) was calculated for each block within the county. These two values were then multiplied to produce a value of $W_b E_b$ for each block. A point file was then created using ArcMap's Feature to Point function with the Census block TIGER files for each county as the input feature class. The values of $W_b E_b$were then attached to each point (census block centroid) using ArcMap's Join Attributes to Table procedure. Circles of 500m, 1000m, 2000m and 4000m radii were then drawn around the points using the Evaluate Site tool using multiple sites in ArcMap. To sum the values within these circles the Analysis tool within the Business Analyst toolbar was used. Here the racial groups being investigated and $W_b E_b$ within the circles radius were summed and assigned to the point at the center of the circle. Fallowing this procedure E was calculated for each block in Excel using the output from the Analysis tool which was exported as a DBF. Finally, a value of H for each sample radii was calculated for each block within the county in Excel. The countywide H values were calculated by averaging the individual block H values.

These block specific values of H where used in an ANOVA procedure to test against the hypothesis of no significant difference between the segregation observed in the five N.C. counties and at the four sample radii. The multiple group $H_{W\backslash B\backslash A\backslash O}$ values for White, Black, Asian and Other (W/B/A/O) along with the pairwise $H_{B\backslash Other}$ between Blacks and the combined White, Asian and Other population (B/Other), as well as the pairwise $H_{H\backslash Other}$ values between Hispanics and Others (H/Other) will be tested against the hypothesis of no significant difference.

CHAPTER IV

RESULTS

Table 2 gives a general impression of the segregation levels observed in the five N.C. counties. It reports the mean and standard deviation of H observed in the five counties. In addition, Table 2 reports the macro/micro segregation ratio. The segregation ratio indicates to what extent micro-scale segregation patterns are due to macro-scale segregation patterns and is calculated by dividing the macro-scale segregation value by the micro scale segregation value. The five county H values are averaged for each sample radii.

Table 2 Average Segregation Levels and Average Macro/Micro Segregation Ratio for Five of the Largest N.C. Counties

Racial/Ethnic Groups	H_{500m}	H_{1000m}	H_{2000m}	H_{4000m}	Macro/Micro Ratio H_{4000m}/H_{500m}
Black/Other	.86 (.027)	.84 (.030)	.83 (.033)	.82 (.038)	.95 (.016)
Hispanic/Other	.96 (.006)	.96 (.008)	.96 (.009)	.96 (.009)	.99 (.003)
W/B/A/O	.67 (.053)	.64 (.065)	.61 (.078)	.58 (.087)	.85 (.069)

Note: Standard deviations are shown in parentheses. Macro/micro ratio is the ratio of the Spatial Entropy Index computed at a 4km radius to the index computed at a 500m radius. W/B/A/O is the multigroup white, black, Asian and other segregation.

Hispanic/Other (H/Other) segregation levels are higher and less variable than the multigroup W/B/A/O and pairwise Black/Other (B/Other) *H* levels at any scale between 500m and 4000m. This is not consistent with prior research measuring aspatial segregation levels in which the black population exhibits the highest segregation levels (Massey & Denton 1987, Iceland, Weinberg, & Steinmetz 2002). The multigroup W/B/A/O segregation levels are lower and more variable than both black and Hispanic segregation levels at all scales.

While there is some variation in the segregation values for each racial group depending on the scale of local environment used as the areal boundary, the differences are not great. This means that the conclusions drawn here using the spatial measure of segregation would not differ greatly from those drawn from the use of an aspatial measure such as the dissimilarity index at the tract level. However we can do more than simply describe the level of segregation across the county areas using the spatial measure. We can investigate the geographic scale of segregation using the macro/micro segregation ratios. The segregation ratio measures the relative extent to which segregation levels observed at the micro-scale (500m) are due to macro-scale (4000m) racial residential patterns.

The B/Other segregation ratio is .95, indicating, on average, that more than ninety percent of black micro-scale segregation is due to macro-scale segregation patterns. The H/Other segregation ratio is even larger at .99. The mulitgroup W/B/A/O segregation ratio is lower at .85 but it still represents a high level of macro-scale influence.

Table 3 Significant Difference between County *H* Values

B/Other		H/Other		W/B/A/O	
Forsyth	A (.863)	Guilford	A (.977)	Forsyth	A (.710)
Wake	B (.859)	Wake	B (.965)	Guilford	B (.657)
Guilford	C (.848)	Forsyth	C (.960)	Wake	C (.631)
Mecklenburg	D (.839)	Mecklenburg	C (.960)	Mecklenburg	D (.608)
Durham	E (.784)	Durham	D (.947)	Durham	E (.518)

Note: Means with the same letter are not significantly different. Mean segregation values are in parenthesis.

A significant difference is observed in the levels of B/Other *H* between all five counties (Table 3). For the H/Other *H* values there is a significant difference among all counties except Mecklenburg and Forsyth (Table 3). Significant differences in the W/B/A/O *H* values, like the black *H* values, are observed among all five counties (Table 3). The significant difference among the counties suggests a different set of mechanisms may operate to shape the scale of residential patterns within these counties.

Complementing Table 2 and Table 3, Figure 6 shows the segregation profiles for each race group combination. Table 4 lists the values of *H* and the macro/micro segregation ratios for each county and radii by race group combination. There is some variation in the slope of the profiles. This variation in the slope means that the ranking of segregation levels depends on the scale at which segregation is measured.

Figure 6 Segregation Profiles for Five of the Largest N.C. Counties

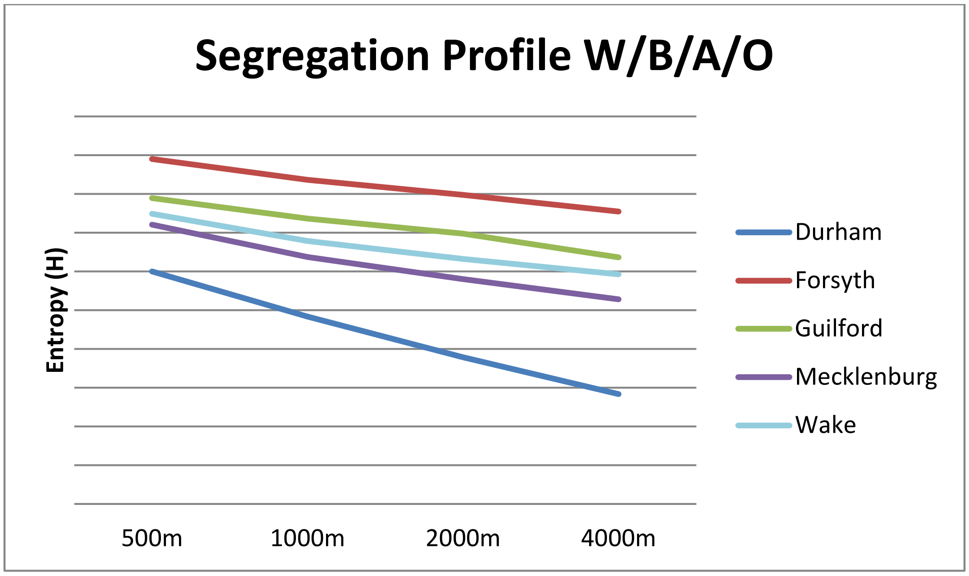


Figure 6 (Continued)

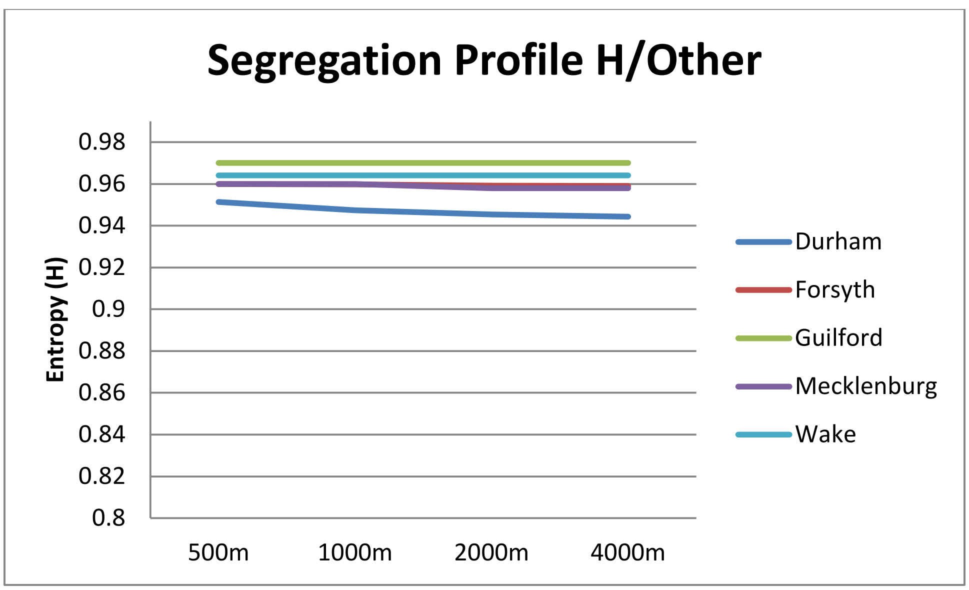
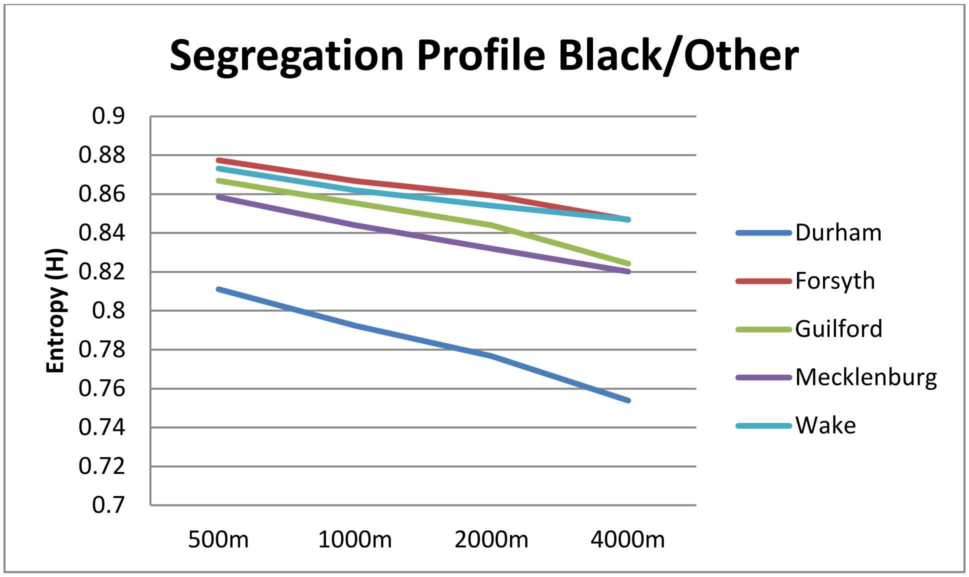


Figure 6 (Continued)



Note: Segregation values on y axis are values of Entropy. W/B/A/O represents the group white, black, Asian and Other Entropy values.

Table 4 Values of H for each Radii and Macro/Micro Segregation Ratios by Race Combination and County

County	Race	H_{500m}	H_{1000m}	H_{2000m}	H_{4000m}	Macro/Micro Ratio H_{4000m}/H_{500m}
Durham	B/Other	.81	.79	.78	.75	.93
	H/Other	.95	.95	.95	.94	.99
	W/B/A/O	.60	.54	.49	.44	.74
Wake	B/Other	.87	.86	.85	.85	.97
	H/Other	.96	.96	.96	.96	1
	W/B/A/O	.67	.64	.62	.60	.88
Forsyth	B/Other	.88	.87	.86	.85	.97
	H/Other	.96	.96	.96	.96	1
	W/B/A/O	.75	.72	.70	.68	.91
Guilford	B/Other	.87	.86	.84	.82	.95
	H/Other	.97	.97	.97	.97	1
	W/B/A/O	.69	.67	.65	.62	.89
Mecklenburg	B/Other	.86	.84	.83	.82	.96
	H/Other	.96	.96	.96	.96	1
	W/B/A/O	.66	.62	.59	.56	.85

The highest macro/micro segregation ratios (the flattest segregation profiles) are observed in Forsyth, Guilford and Wake. The segregation patterns in these areas are largely due to variation in racial composition over larger distances. Lower macro/micro segregation ratios (steeper segregation profiles) are exhibited by Mecklenburg and Durham. The segregation patterns in these areas are, to a greater degree, due to variation in racial composition over smaller distances. There seems to be a correlation between the population density and the macro/micro segregation ratio. The lowest population densities are observed in Guilford and Forsyth. Higher densities are observed in Mecklenburg and Durham (Table 1). Density therefore seems to be negatively correlated with the macro/micro segregation ratios. In other words, the higher the density the smaller the role macro-scale segregation patterns play in defining micro-scale segregation patterns. There also seems to be a negative correlation between percentage minority population and the macro/micro segregation ratios. The largest percentage minority populations are observed in Mecklenburg and Durham and the lowest percentage minority groups are observed in Guilford, Forsyth and Wake (Table 1).

Of the five counties, the two with the highest levels of B/Other H values at a 500m scale (Forsyth and Wake) are also the two with the highest levels of black segregation at the 4000m scale (Figure 6). The lowest levels of B/Other H are observed in Durham. It should be noted that Durham also has the highest percentage black population (Table 1). The highest levels of micro-scale and macro-scale H/Other H are observed in Guilford however all five counties have very high H/Other H values. This is likely due to the small proportion of the population which is Hispanic in these counties causing most radii to have very low Hispanic proportions and diversities and therefore very high *H* values. The lowest levels of Hispanic segregation are observed in Durham which also has the highest percentage Hispanic population (Table 1 and Figure 6). It should be noted that the level of Hispanic segregation is significantly higher than the black segregation in all counties. Higher levels of Hispanic segregation were observed by Ficsher (2004) for metropolitan areas that have large and growing Hispanic populations. She attributed this high level of isolation to the tendency for new Hispanic migrants to settle in areas where there was already a large population of Hispanic immigrant populations.

Forsyth and Guilford exhibit the highest W/B/A/O *H* values at all scales. Durham exhibits the lowest segregation levels. The division of the Other category in the H/Other and B/Other *H* values into white and Asian and Other in the mulitgroup W/B/A/O measure is likely the cause of the observed lower W/B/A/O *H* values. This also supports the conclusion that the white and Asian populations are more integrated than blacks. This makes sense as the white population makes up a much larger proportion of the total population and is therefore more likely to share an environment with other racial groups and produce higher average diversity values. Iceland (2006) also found that the Asian minority population, while usually smaller than both the Hispanic and black populations, is more integrated. He attributes this to differences in social/cultural practices and higher average education levels.

No shift in the rank order of the N.C. counties segregation levels is observed. Each county can therefore be clearly differentiated from the others. If two of the counties segregation profiles had crossed one another we would not be able to unambiguously say which is more segregated, since the relative segregation levels at different scales would differ. This is a disadvantage of using segregation profiles rather than single indices for describing segregation patterns between metropolitan areas (Reardon et al. 2008).

The different slopes exhibited by the segregation profile should be investigated as well. A flat profile would have equal segregation values at the 500m level and the 4000m level indicating that there is no variation in average diversity of an individuals' environment regardless of its definition. The geographic scale of segregation is large in areas like this where a large proportion of micro-segregation is attributable to macro-segregation patterns. On the other hand a steep slope results from significant variation in segregation levels or racial composition over distances of 500m – 4000m.

Guilford and Durham's segregation profiles provide a good illustration of this difference in slope. The maps of Guilford (Figure 7) and Durham (Figure 8) show the W/B/A/O H_{500m} and H_{4000m} as well as the percentage black of populations taken within a 500m and 4000m radius of each block centroid. A graduated color scheme was applied to the census blocks based on these values. The shades of brown indicate the level of W/B/A/O H assigned to each block after sampling the 500m and the 4000m radius environments around each block. The Census blocks were therefore assigned colors based on the populations contained within 500m and 4000m of each block and do not solely represent the populations contained within one block but an aggregation of the populations in that block and the surrounding blocks. The maps containing shades of blue represent black population percentages based on the surrounding 500m and 4000m environments. The black population percentages are represented here as the black population represents the largest minority group within both counties and should therefore provide the most insight into the minority population distributions which are causing the overall trends in segregation within each county.

The focus here will be on the metropolitan portions of the county as they contribute the most to the computation of the segregation levels which are weighted by population density. The levels of multigroup W/B/A/O segregation at 500m are similar, H = .69 for Guilford and H = .60 for Durham (Table 4). However, their W/B/A/O H levels diverge as the sampling environment grows, at 4000m the segregation levels are H = .62 for Guilford and H = .44 for Mecklenburg (Table 4).

Greensboro is dominated by a pattern of high H in the north-west and south-east while much lower levels of H are located in the south-west and north-east portions of the city. In other words, north-west and south-east Greensboro is much less diverse than south-west and north-east Greensboro (Figure 7). High Point exhibits high levels of segregation in its northern portion gradually declining as you move south. Pockets of the highest segregation are outside the two main cities of High Point and Greensboro in and around Oak Ridge and Summerfield and to the south-west of Greensboro. The population densities in these outlying areas are however less than that observed within the cities of High Point and Greensboro so they do not contribute as much to the overall segregation values.

These trends are reflected in the 500m and 4000m proportion black maps also in Figure 7. South-east Greensboro has high proportions of black and the north-west Greensboro has low proportions black. This supports the low diversity and high Entropy values in these areas. The city is clearly divided even in the 4000m percentage black map indicating that segregation is occurring over a large scale. If segregation was occurring over a smaller scale the clear difference in the proportion black population at the 500m scale would be much less clear at the 4000m scale. If segregation were occurring only at a small scale the 500m radii containing a high proportion black population would become much more diverse when the population within a 4000m radius was sampled as the surrounding population would be more diverse than that included in the 500m environment. Medium shades of blue would be present throughout the study area. This is however not the case in Greensboro or High Point as clear separation persists even at the 4000m scale.

Greensboro clearly illustrates residential patterns dominated by macro-scale segregation. This corresponds to a relatively flat segregation profile with a W/B/A/O macro/micro segregation ratio of .89 (Table 4), meaning that eighty nine percent of segregation among 500m-radius environments is due to variation in racial composition over distances of 4000m or more. Given the large difference in radius between the macro and micro-level segregation, a 4000m-radius is sixty-four times the area of a 500m-radius neighborhood, a difference in segregation of approximately ten percent is very small. Therefore, in Guilford County an individual's 4000m environment is only modestly more diverse than their 500m-radius environment.

Figure 7 Maps of Guilford County W/B/A/O *H* and Percentage Black for Radii 500m and 4000m by Census Block

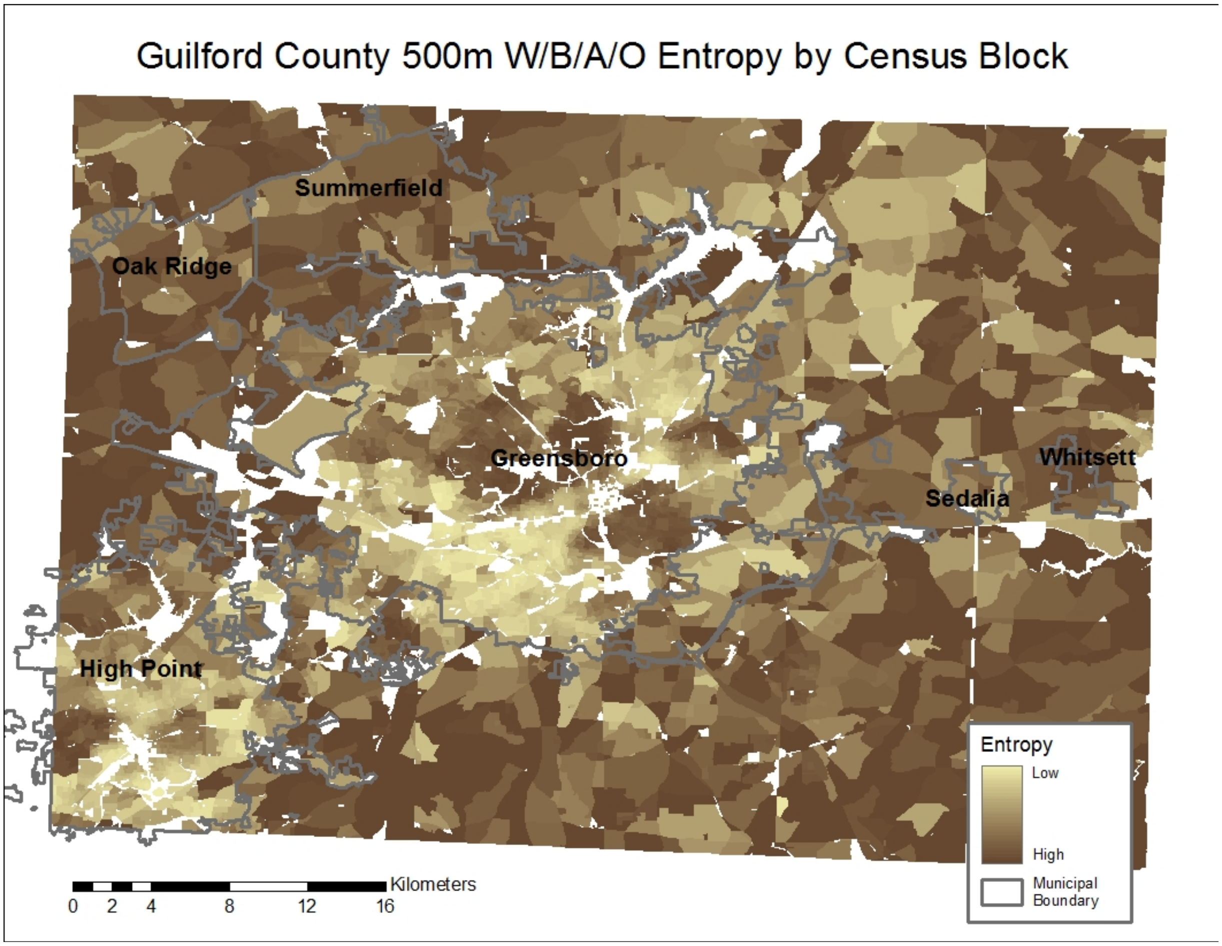


Figure 7 (Continued)

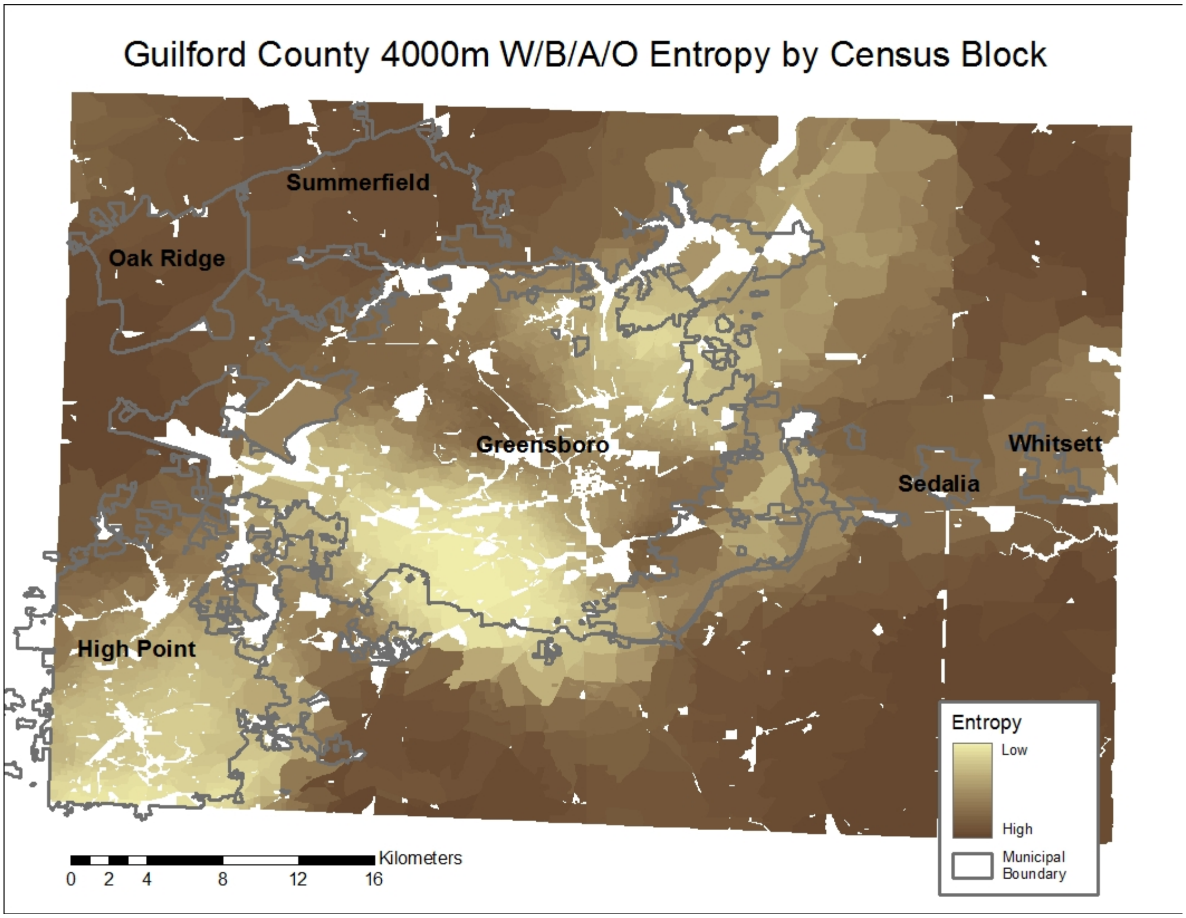


Figure 7 (Continued)

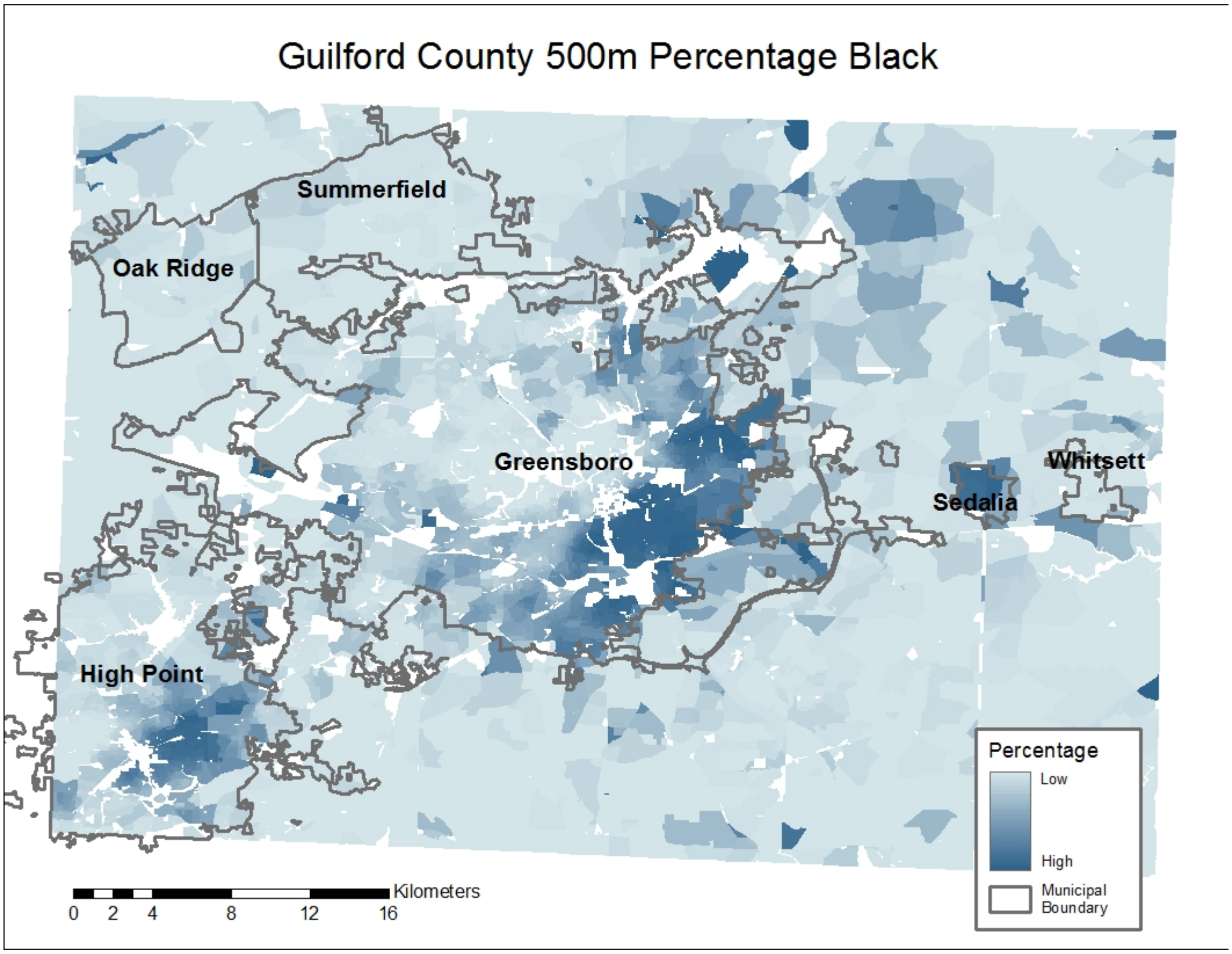
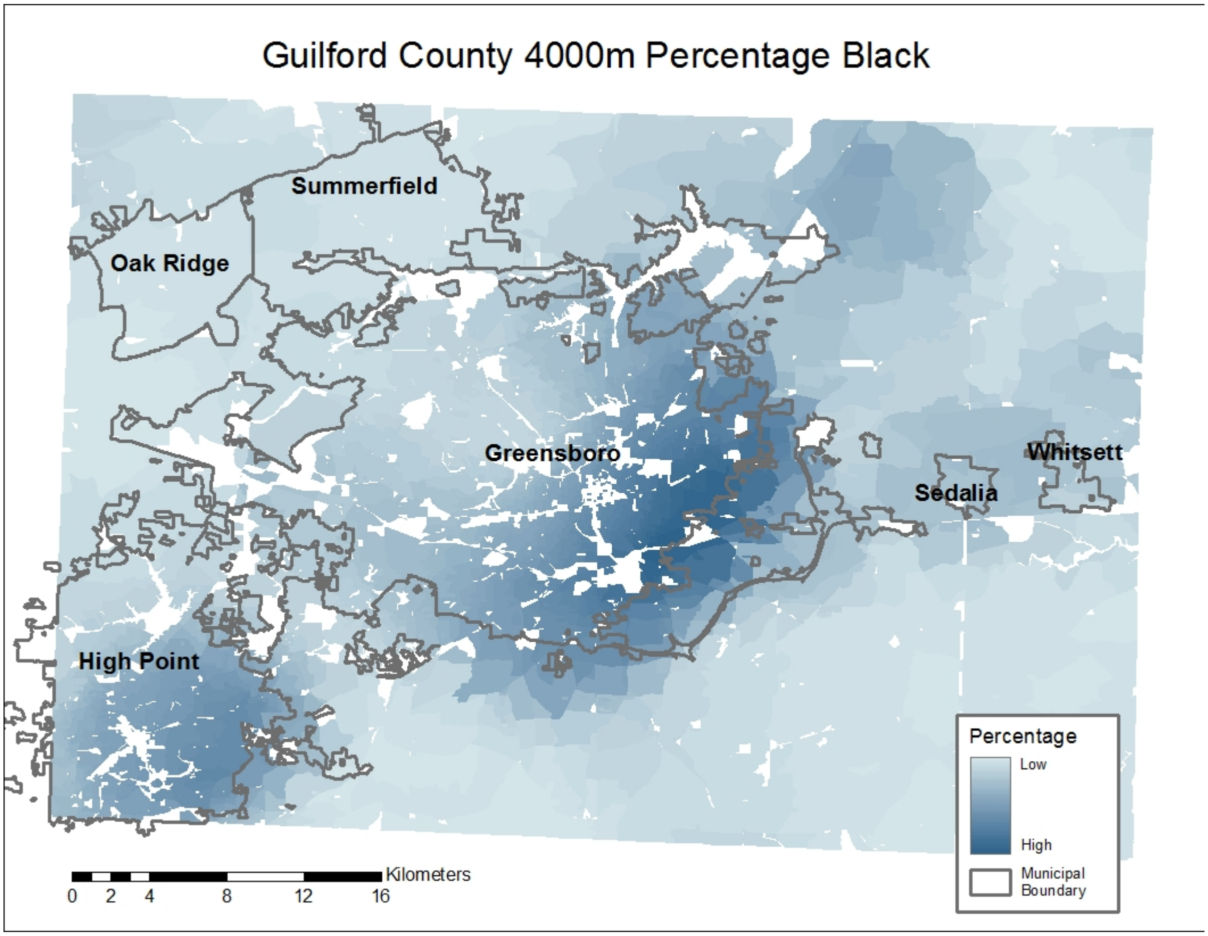


Figure 7 (Continued)



Note: The white Census Blocks in the Map have populations of zero and were not included in the measurement of Entropy or proportion.

In the city of Durham there is one large area of high W/B/A/O *H* in the south-east portion of the city (Figure 8). There were two areas like this in Greensboro. This supports the observed lower levels of *H* for Durham County as the rest of the city of Durham is relatively diverse. The percentage black population for the 500m and 4000m radii supports this conclusion. The 500m percentage black map shows high percentages of blacks in the south-east portion of the city of Durham and lower percentages in the western portion of the city however the contrast is much less dramatic than that observed in Greensboro. When the population data is aggregated to the 4000m scale however Durham is no longer a two sided city, one side with a high percentage black and the other with low percentage black populations. Instead, the proportion black population in the western portion of the city of Durham increase to moderate levels and we observe medium shades of blue throughout the western portion of the city. This reflects the higher diversity and lower H_{4000m} values observed in Durham County as the densely populated city is much less segregated at a 4000m scale than it is at a 500m scale. Durham County's higher percentage black population and also its relatively high density may contribute to the lower levels of H_{4000m}.

This small-scale segregation patterning results in a relatively steep segregation profile with a macro/micro segregation ratio of .74 (Table 4), meaning that segregation levels are approximately twenty six percent less among 4000m-radius environments than they are among 500m environments. It should be noted however that this segregation ratio is still high compared to cities like Pittsburgh which exhibited a ratio of .508 (Reardon et al. 2008). None the less, these two counties provide a good illustration of the geographic scale of segregation.

Figure 8 Maps of Durham County W/B/A/O H and Percentage Black for Radii 500m and 4000m by Census Block

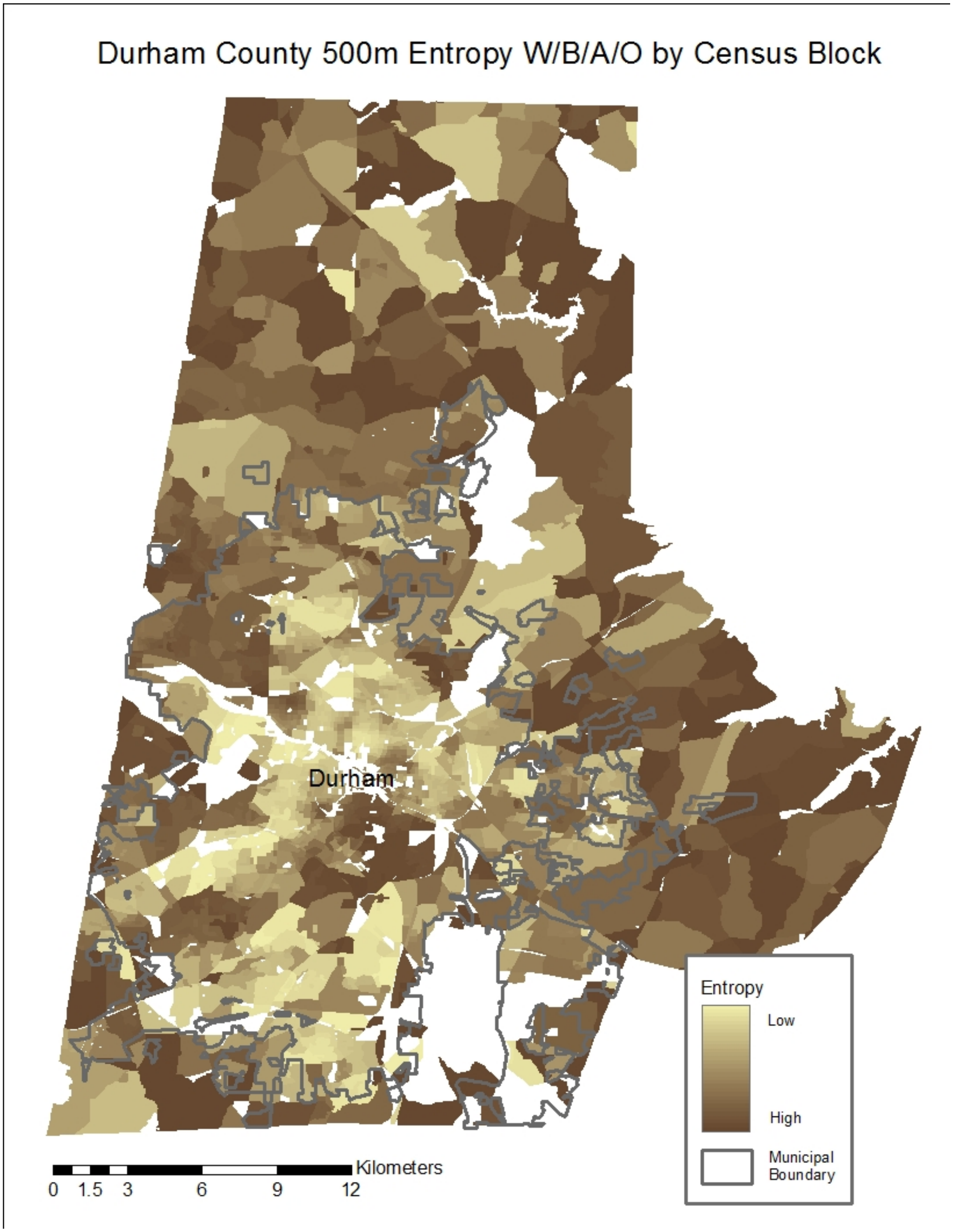


Figure 8 (Continued)

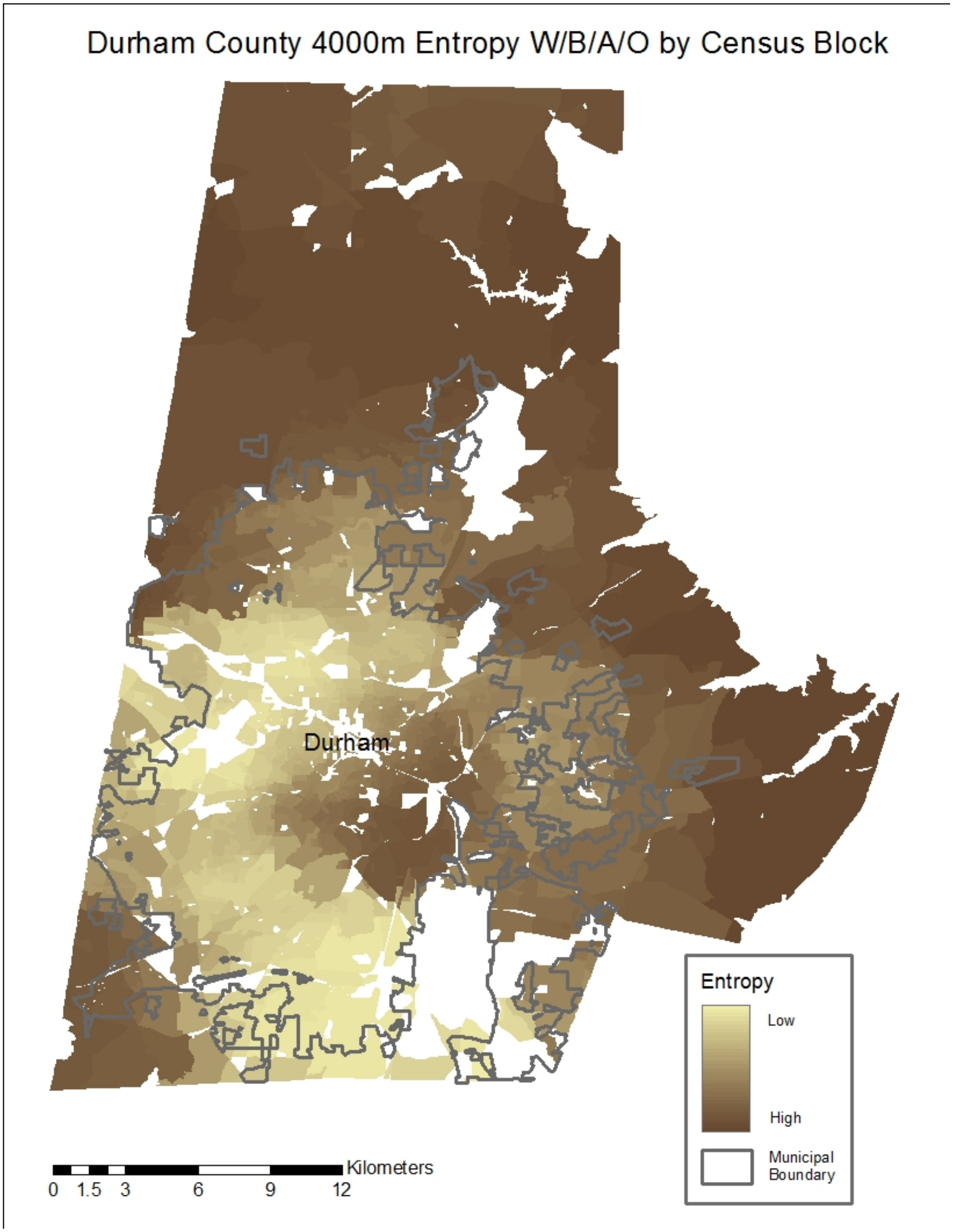
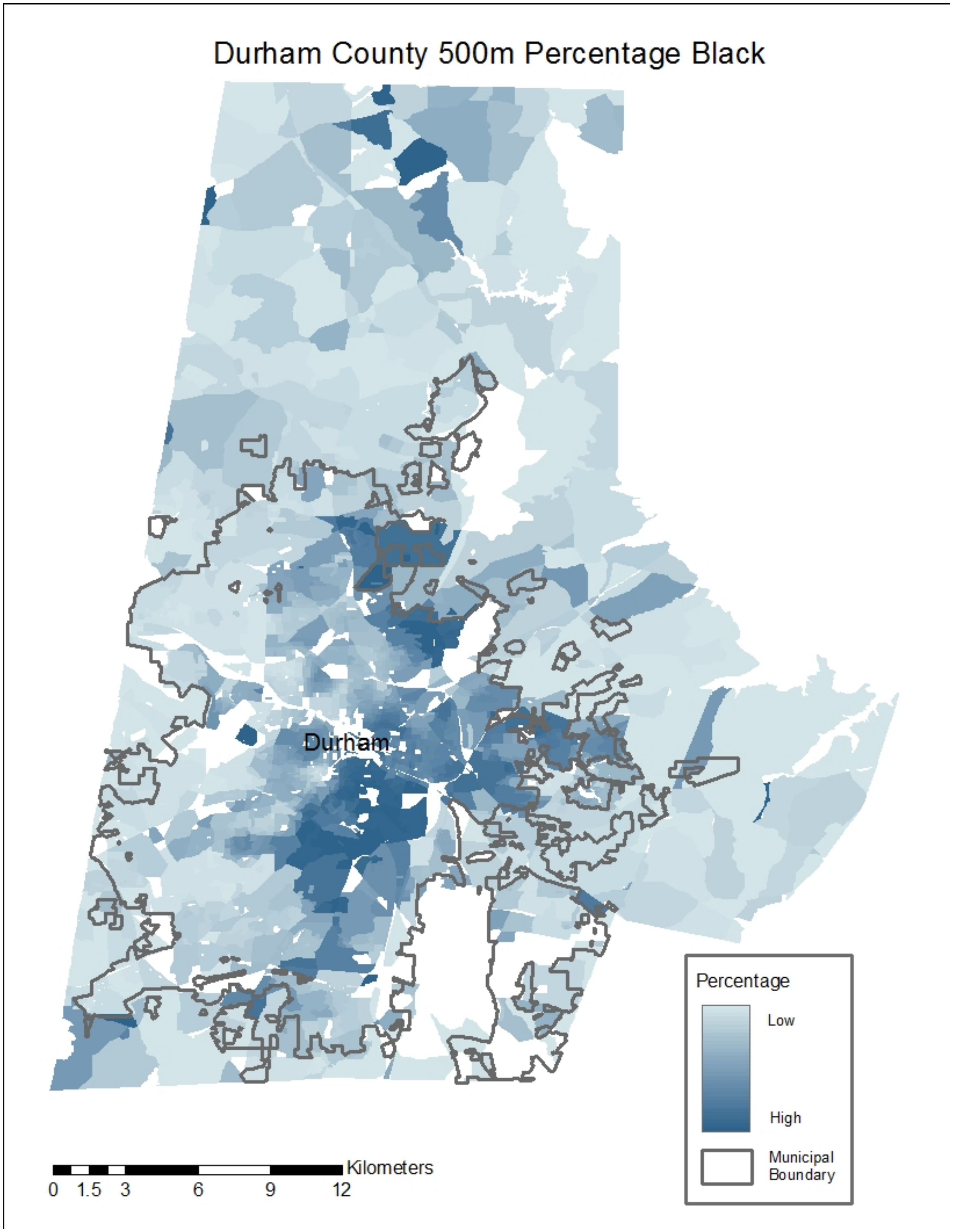


Figure 8 (Continued)



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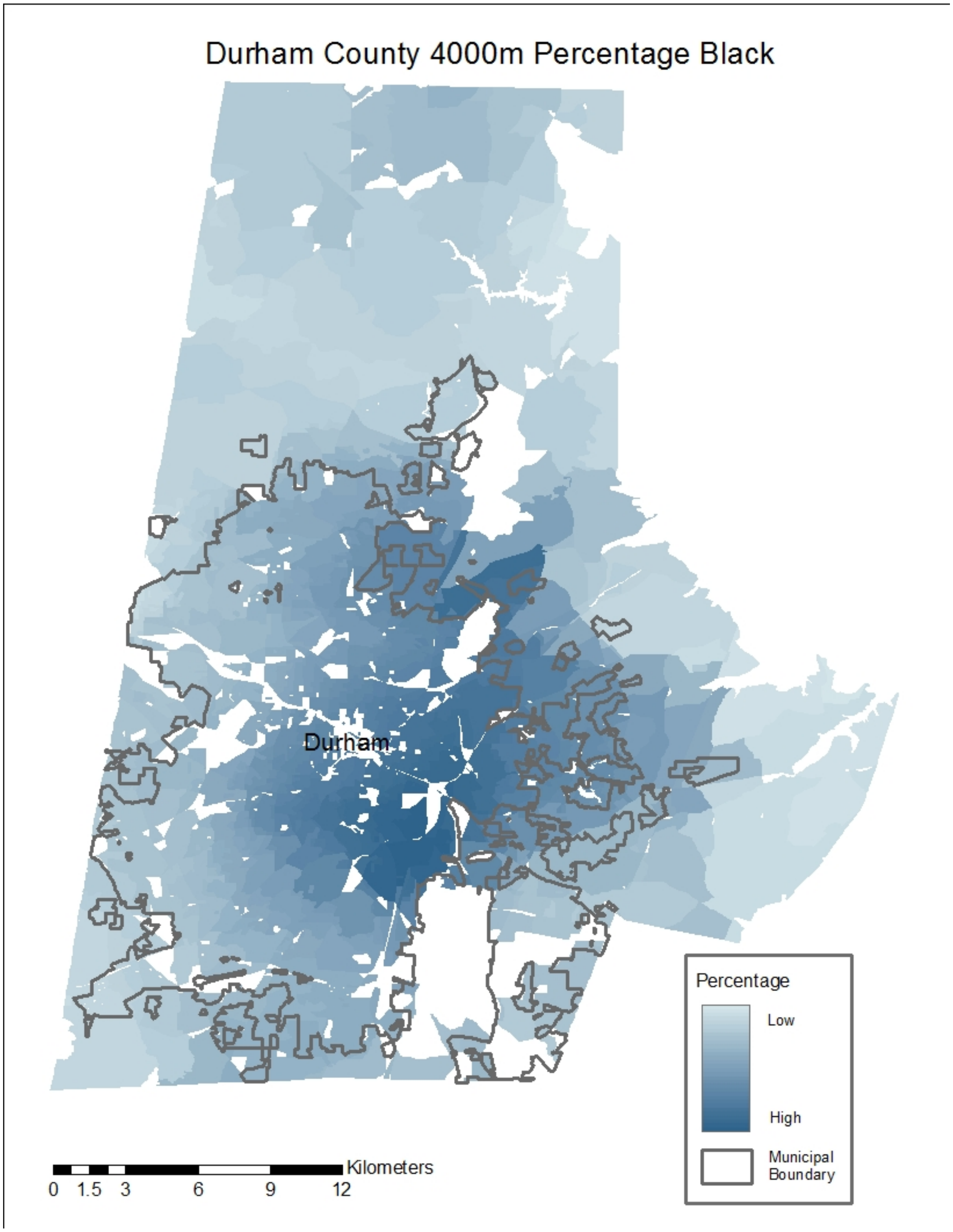


Note: The white Census Blocks have populations of zero and were not included in the measurement of Entropy or proportion.

In this case, using a conventional aspatial measure such as tract-based Entropy (H), we would conclude that Guilford (H = .69) and Durham (H = .60) are similarly segregated. A single spatial measure such as the H_{500m}would provide the same conclusion. Neither approach would convey the significant difference in the geographic scale of segregation between the two metropolitan areas. The segregation profile however, through its slope, and the corresponding macro/micro segregation ratio indicates this difference.

By mapping the H values for each county difference in the spatial distribution of segregation for the observed B/Other and H/Other pairwise segregation measures can be observed. Figure 9 displays maps of Guilford County 4000m B/Other H, H/Other H and percentage Hispanic. These maps were produced in the same manner as the maps in Figure 7 and Figure 8. There is little if any difference in the observed B/Other segregation pattern from the W/B/A/O segregation pattern in Figure 7. In Greensboro high levels of B/Other H are observed in the north-west and south-east portions of the city. High B/Other H values are also observed in north High Point, Oak Ridge and Summerfield. Low levels of B/Other H are observed in south-west and north-east Greensboro, south High-Point and to the north-east of Greensboro. The black percentage map corroborates the spatial trends shown in the 4000m B/Other H map (Figure 7). The highest percentage black populations are located in south-east Greensboro where they are in large enough numbers to produce low diversity levels and high H values. The lowest percentages black are observed in north-west and to the south-west of Greensboro, in north High Point, Oak Ridge and Summerfield producing low diversity levels and high H

values in these areas. Moderate percentages black are located where H is lowest in south-west and north-east Greensboro, to the north-east of Greensboro and in southern High Point.

The H/Other H values exhibit the same spatial pattern in Greensboro, High Point, Oak Ridge and Summerfield. However, while relatively low levels of B/Other H are located to the north-east of Greensboro, relatively high levels of H/Other H are observed in this area. Where there are relatively high levels of B/Other H to the south-west of Greensboro there are relatively low levels of H/Other H. Also, the census blocks in and around Sedalia have relatively high and Whitsett relatively low H/Other H values compared to the H/Other H values throughout Guilford County. In contrast, the B/Other H values are relatively moderate in this area compared to the B/Other H values observed throughout Guilford County. The Hispanic population percentage map supports the spatial patterns of high and low H/Other H. Higher percentages of Hispanics are observed in south-west and north-east Greensboro as well as in southern High Point, to the south-west of Greensboro and around Whitsett. It should be noted that the percentage Hispanic map has a maximum percentage of fifteen percent so that the darkest blue represents blocks with a 4000m environment containing fifteen percent Hispanic.

Figure 9 Maps of Guilford County 4000m B/Other H, H/Other H and Percentage Hispanic

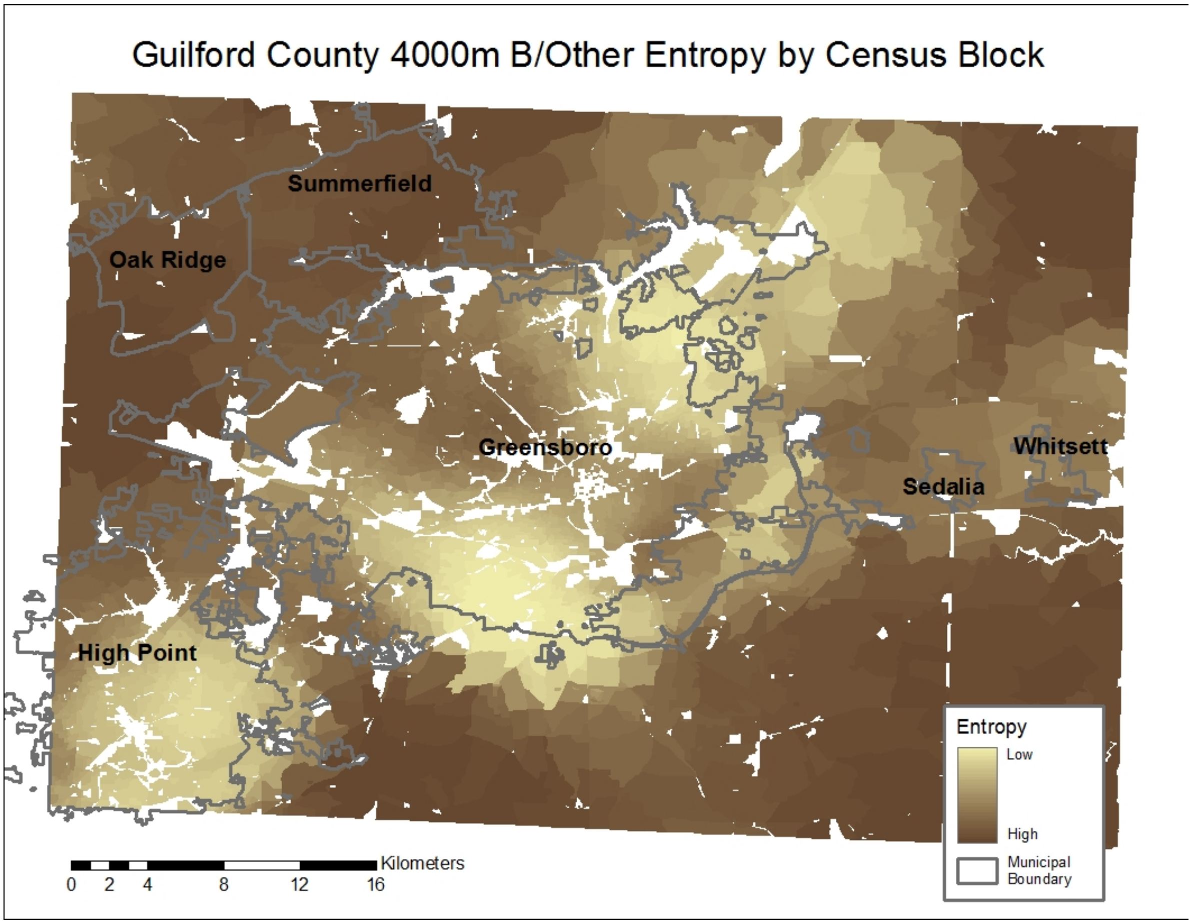


Figure 9 (Continued)

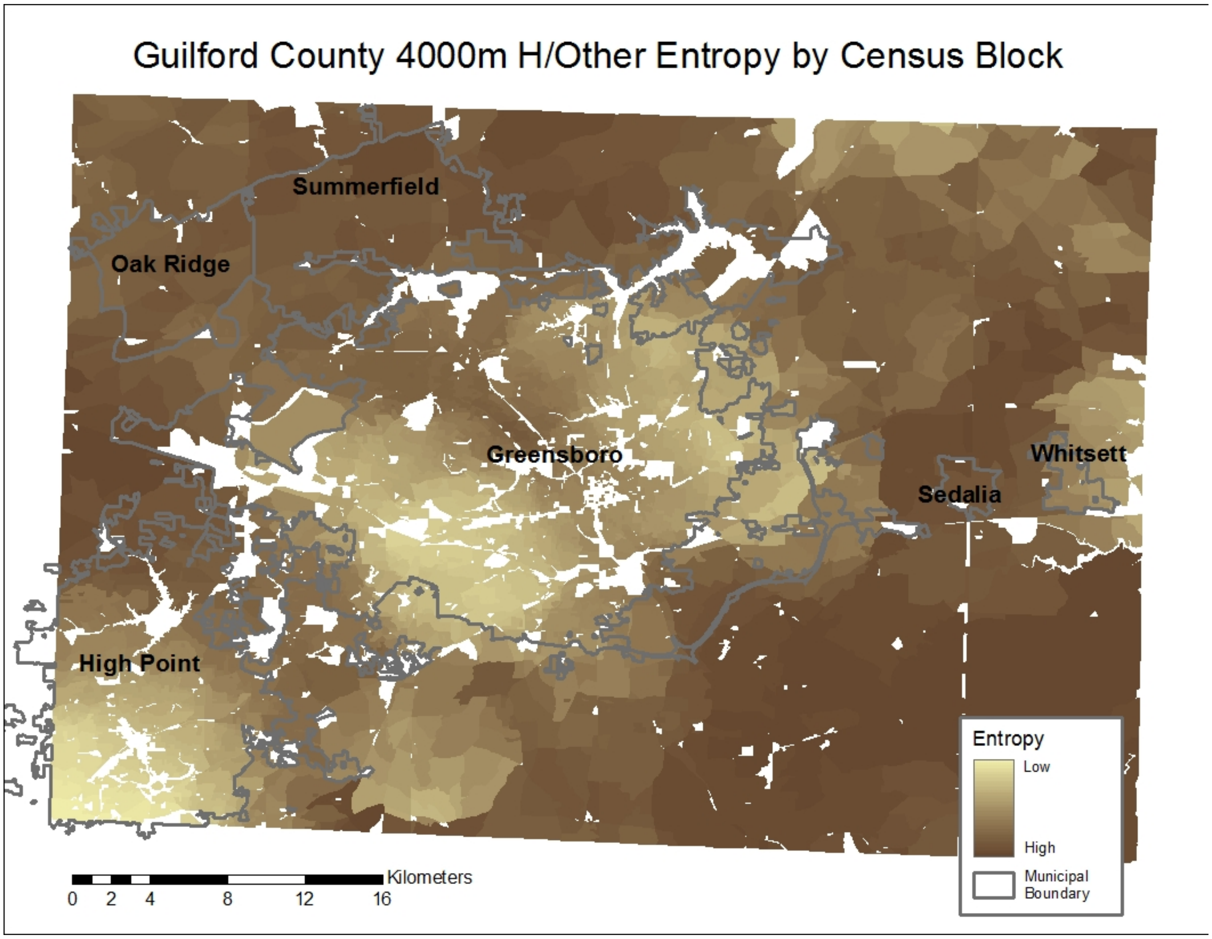
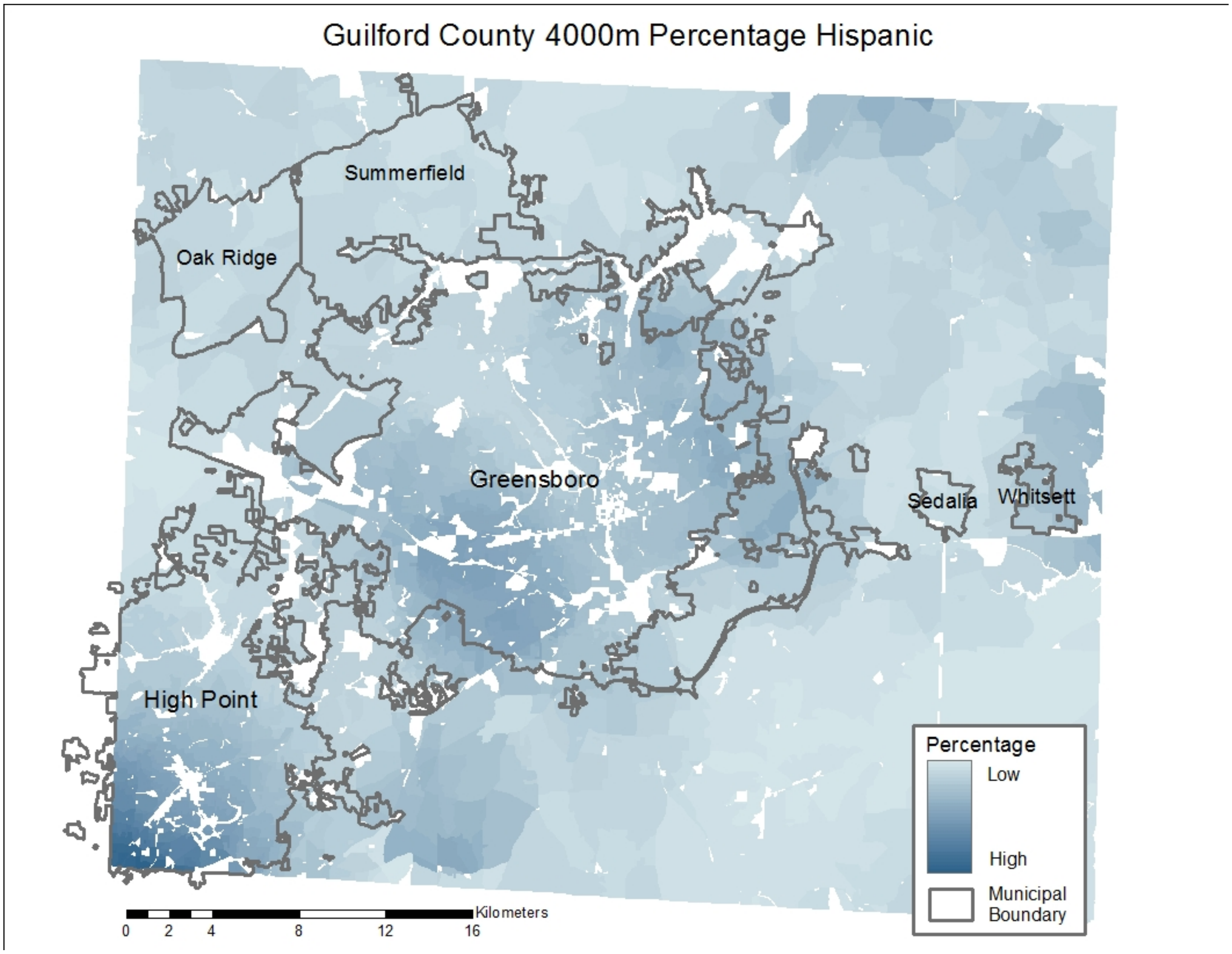


Figure 9 (Continued)



Note: The white Census Blocks have populations of zero and were not included in the measurement of Entropy or proportion.

Figure 10 contains maps for the 4000m B/Other H, H/Other H, and percentage Hispanic in Durham County. The spatial pattern of B/Other H values within Durham County are similar to those of the W/B/A/O H values. Two notable exceptions are present however. The levels of B/Other H observed in the south-eastern portion of the city of Durham are matched by H values on the western border of the city. The W/B/A/O

H values were lower by comparison along the western boarder to the W/B/A/O H values observed in the south-eastern portion of the city. Also there is a greater contrast between the high B/Other H in the south-eastern portion of the city and the lower B/Other H values in the eastern and northern portions of the city of Durham. These spatial patterns are supported by the black population percentage map which shows high percentage black population in the south-eastern portion of the city of Durham, low percentages along the western border and moderate black percentages in eastern, northern and southern portions of the city of Durham (Figure 8).

The spatial distribution of H/Other H is noticeably different from that of the B/Other H. The concentration of high B/Other H in the south-eastern portion of the city of Durham is not present. The highest levels of H/Other H are observed in the southern and northern portions of the city along the municipal boundary (Figure 10). The lowest H/Other H values are concentrated in the north-central, eastern and western portions of the city of Durham and are not present in the northern or southern portions of the city where the lowest B/Other H values were observed. The spatial pattern of H/Other H is supported by the percentage Hispanic map which shows relatively high proportions Hispanic in the areas of low H/Other H and low percentages where the H/Other H values are high. It should be noted that the Hispanic population percentage map has a maximum percentage of fifteen percent which means that the darkest blue has a Hispanic percentage of fifteen percent.

Figure 10 Maps of Durham County 4000m B/Other H, H/Other H and Percentage Hispanic

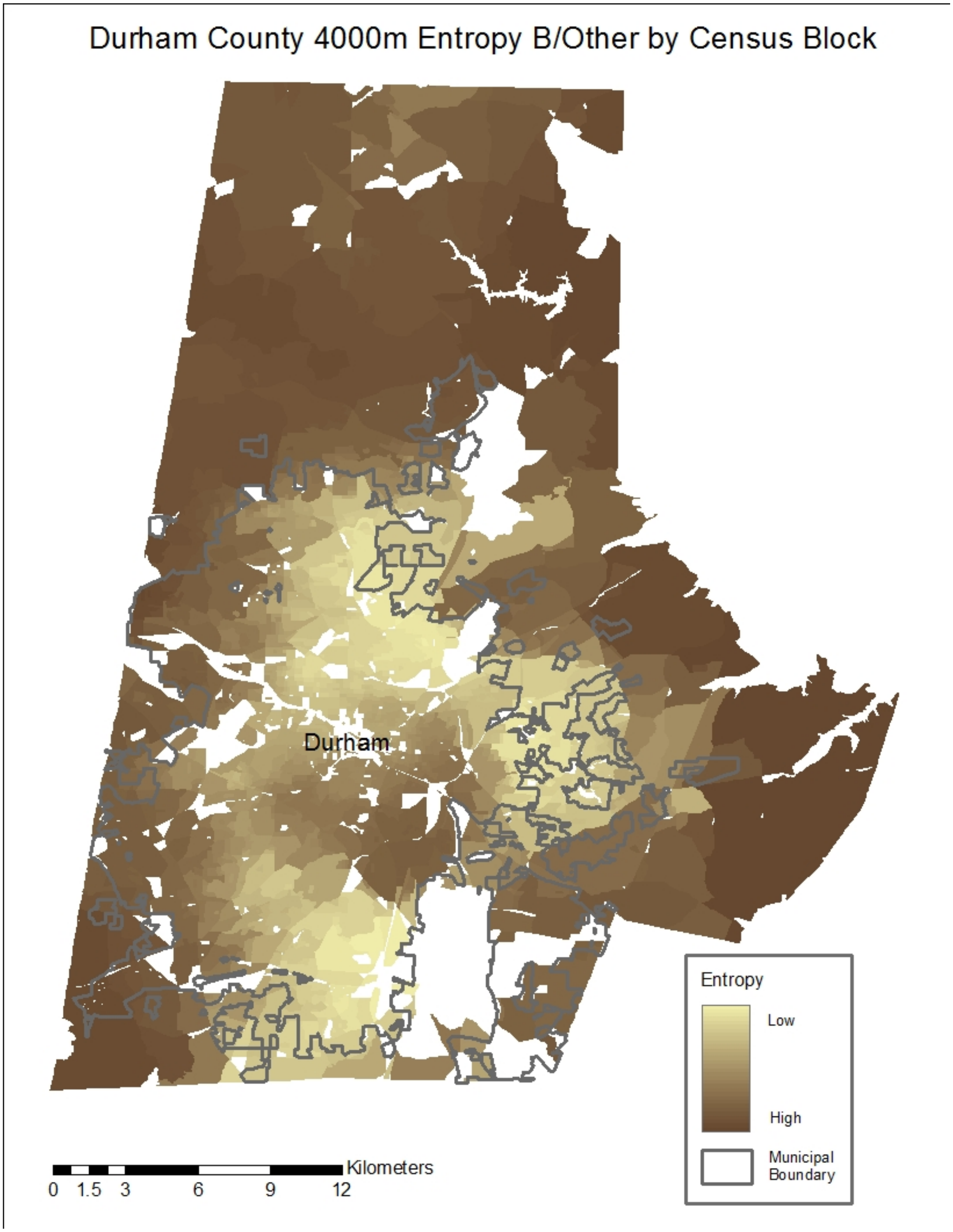


Figure 10 (Continued)

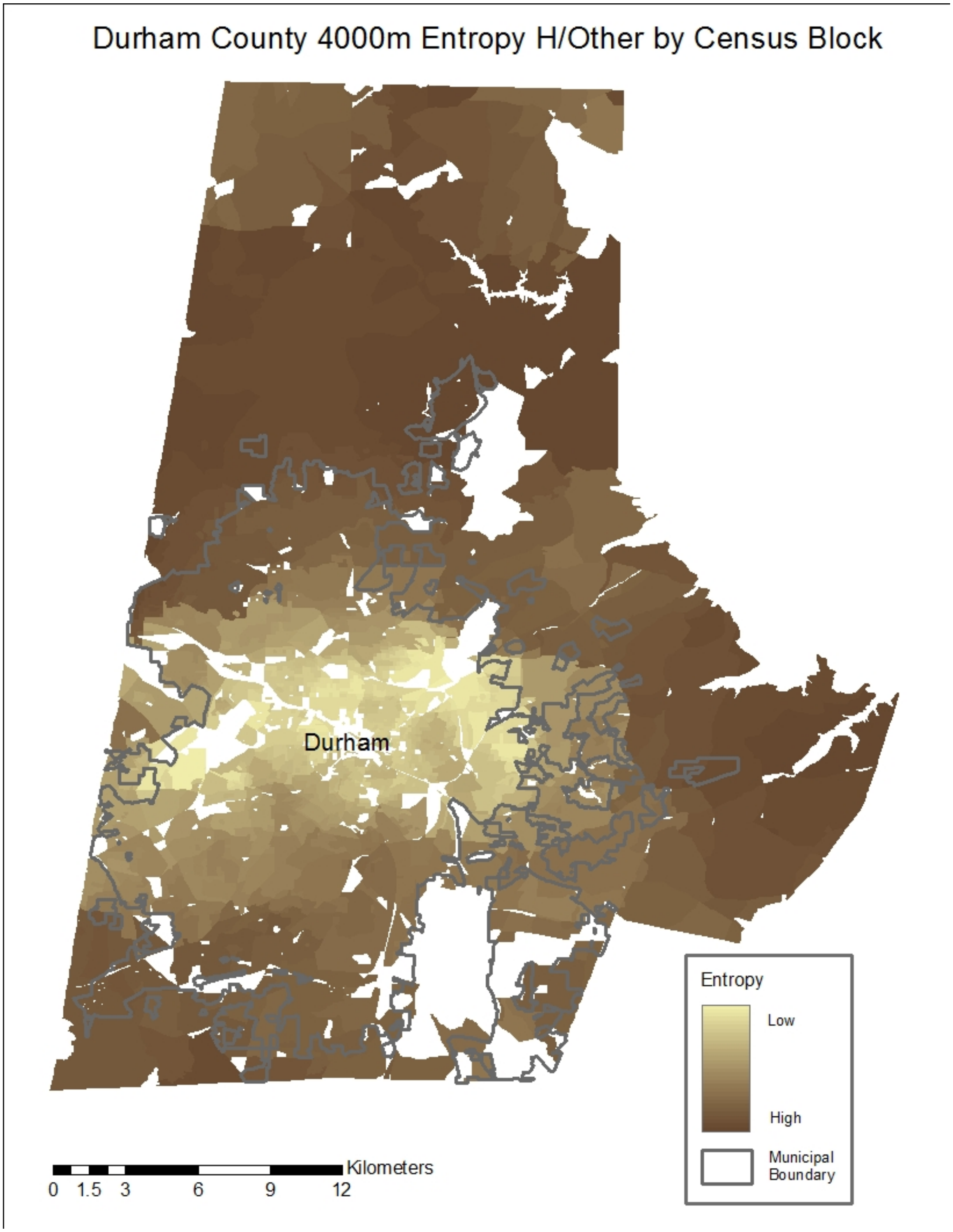
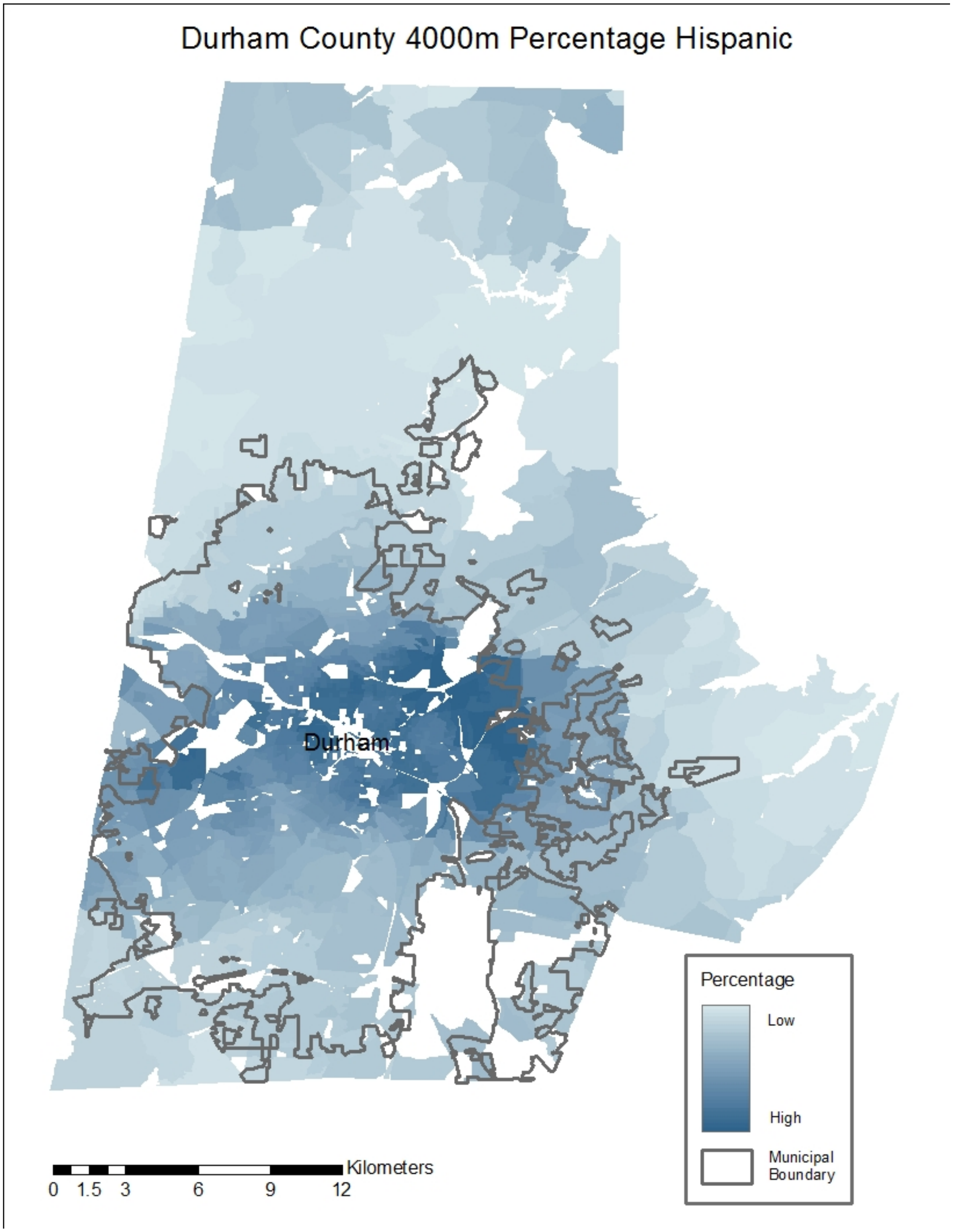


Figure 10 (Continued)



Note: The white Census Blocks have populations of zero and were not included in the measurement of Entropy or proportion.

Figure 11 contains maps for the 4000m multigroup W/B/A/O H, B/Other H, percentage black, H/Other H and percentage Hispanic for Forsyth County. Within Forsyth County the highest B/Other H values are observed in eastern and western Winston Salem, southern Clemmons and throughout Lewisville and Kernersville. These spatial patterns are supported by the black population percentage map which shows a concentration of high percentage black in east Winston-Salem causing the high H values there. Moderate black population percentages are observed in north, and south-east Winston-Salem supporting the low H values and high diversities located there. Low percentages of blacks are observed in western Winston-Salem, Kernersville, Clemmons and Lewisville, corroborating the high H values in these areas.

The highest Hispanic H values are observed in west Winston-Salem, Tobaccoville and Walkerton. Clemmons and Kernersville do not exhibit the same level of Hispanic segregation as that observed in western Winston-Salem. Also, there is no pocket of high Hispanic H in east Winston-Salem. The lowest levels of H/Other H are located in north and south-east Winston-Salem as well as in east Kernersville. These trends are supported by the Hispanic population percentage map which shows concentrations of Hispanics in these areas of high diversity and low H/Other H. It should be noted that the Hispanic population percentage has a maximum of eighteen percent. Therefore the darkest blue on the map represents blocks whose 4000m radius environment is eighteen percent Hispanic.

Figure 11 Maps of Forsyth County 4000m W/B/A/O H, B/Other H, Percentage Black, H/Other H and Percentage Hispanic

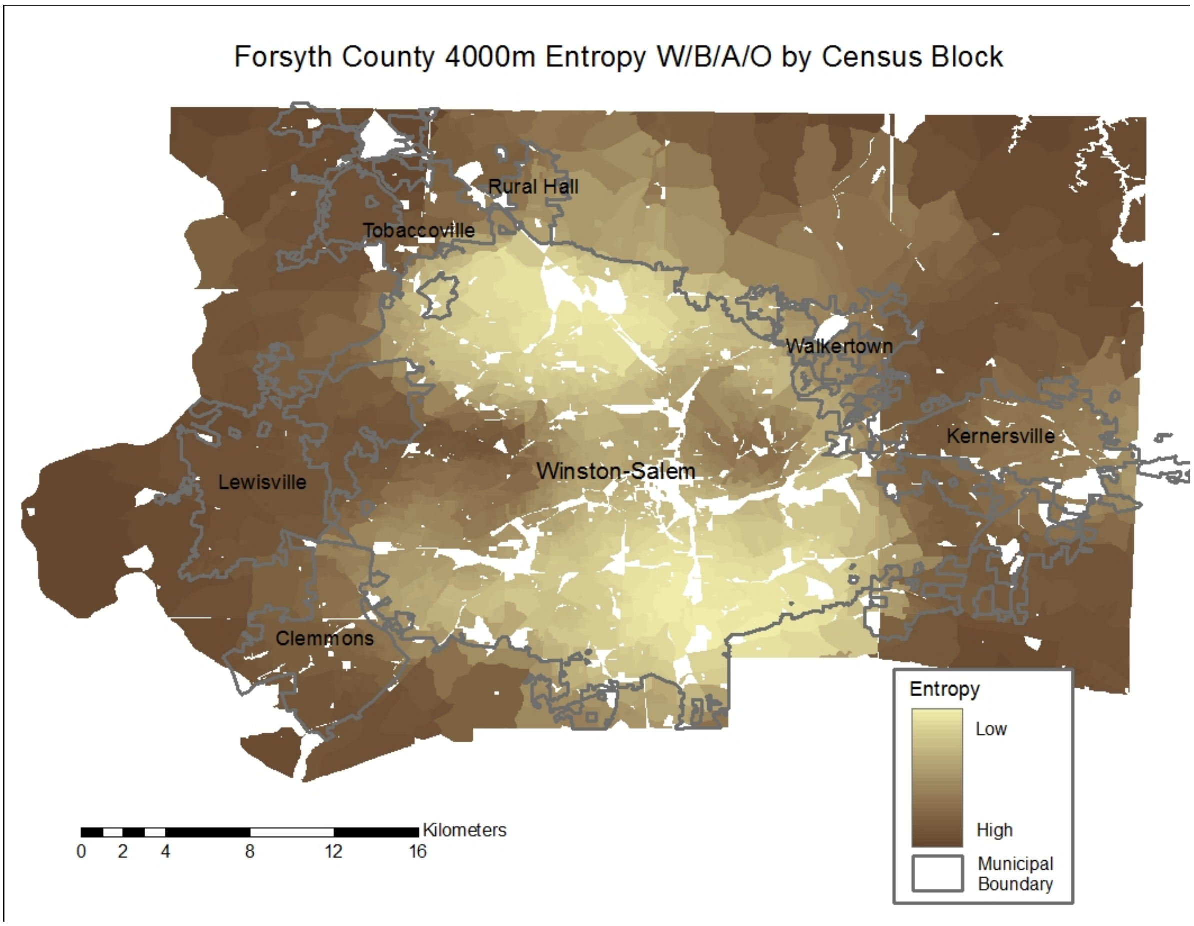
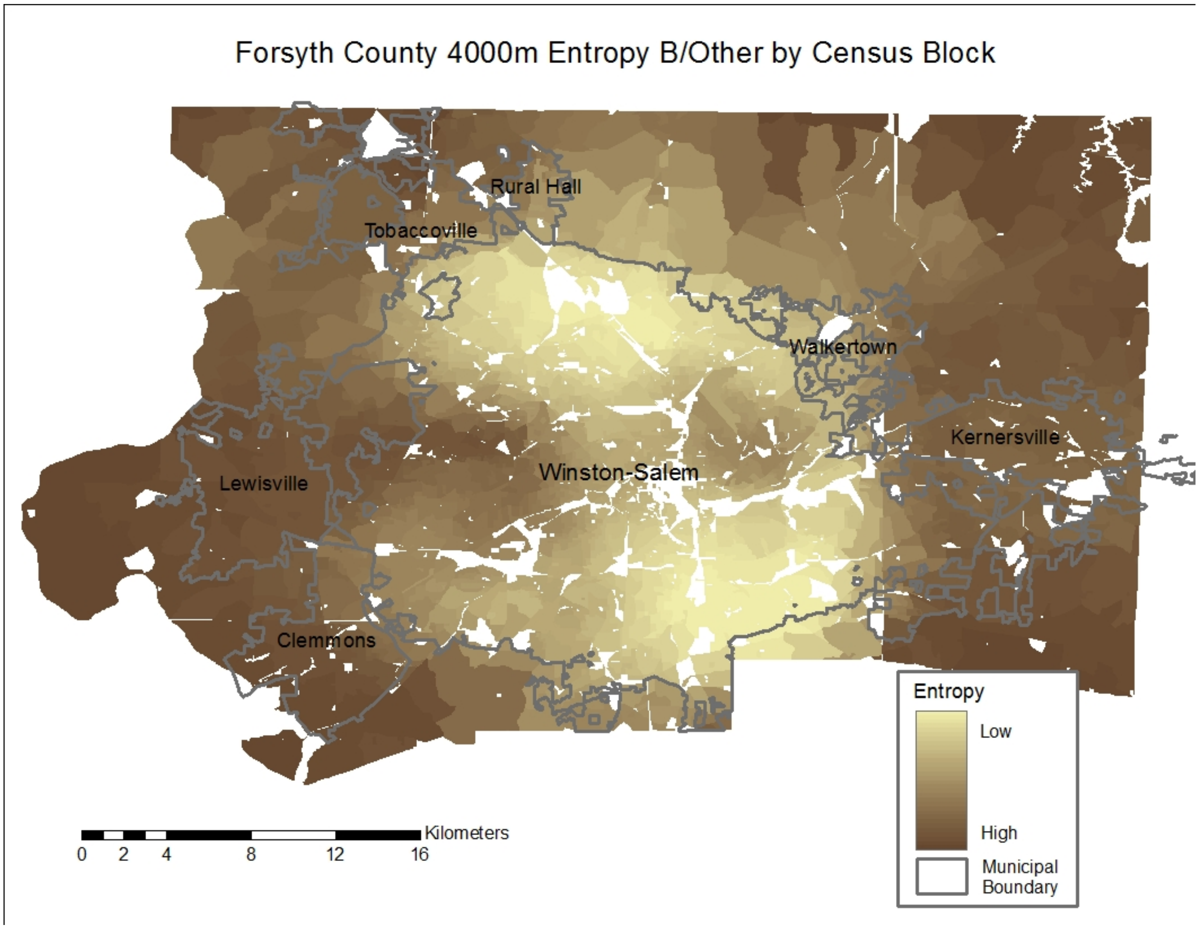


Figure 11 (Continued)



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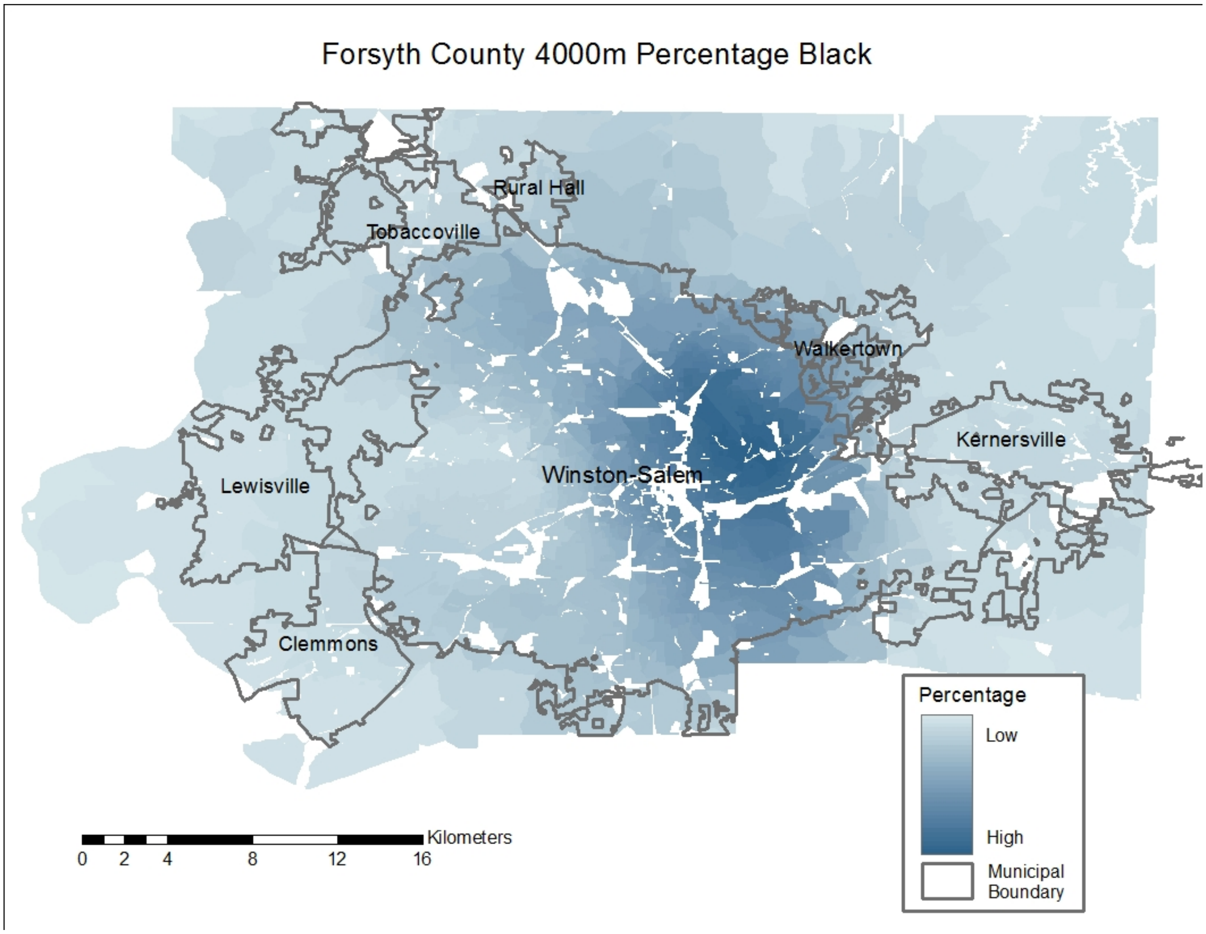

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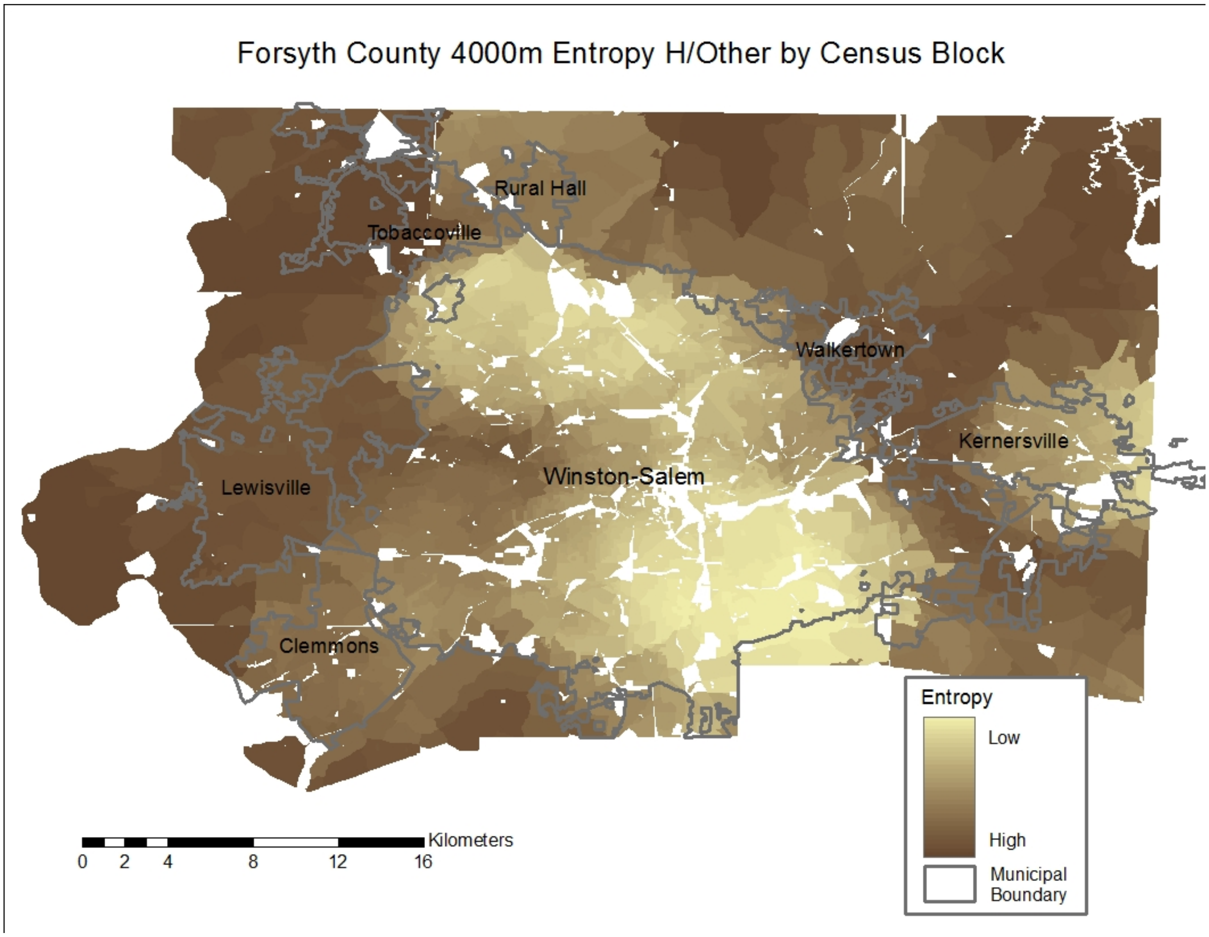

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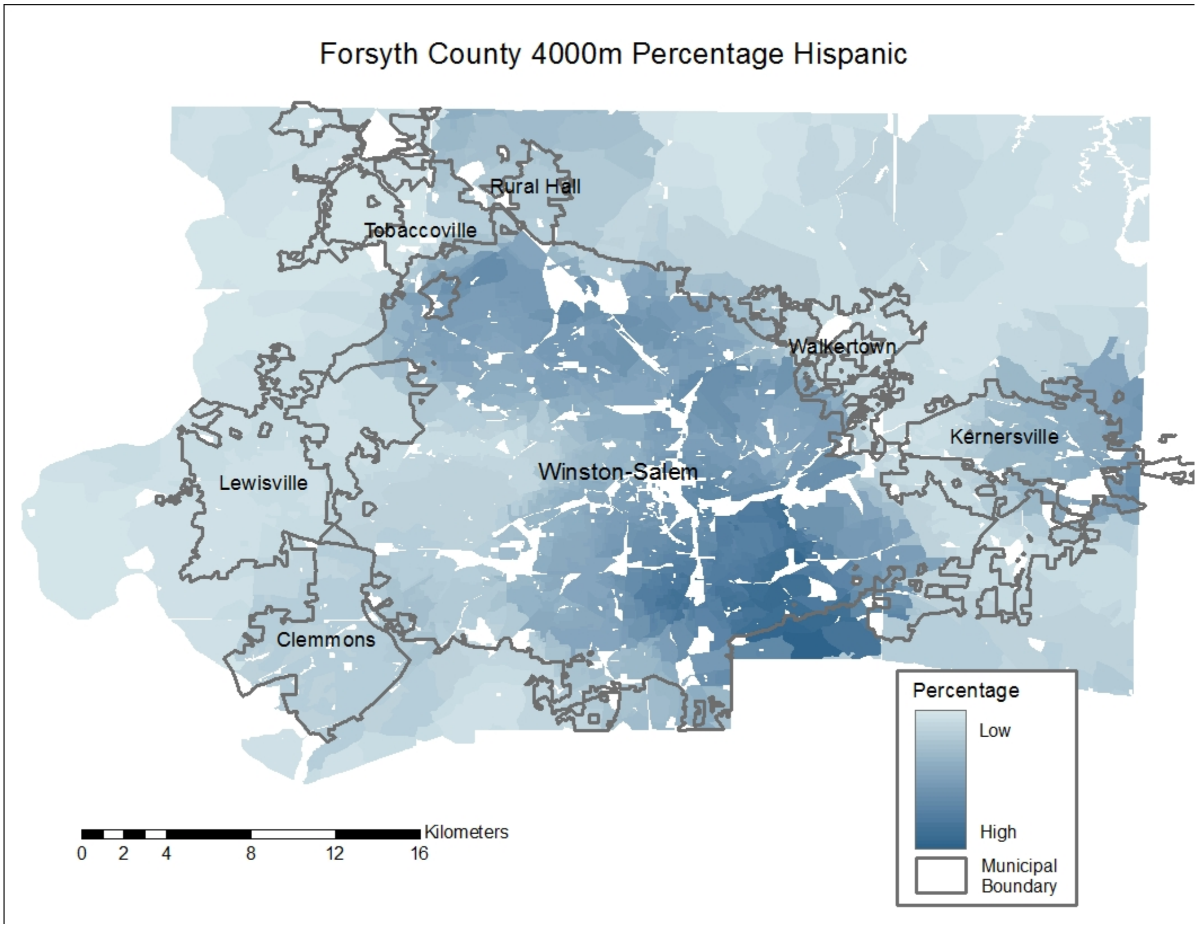
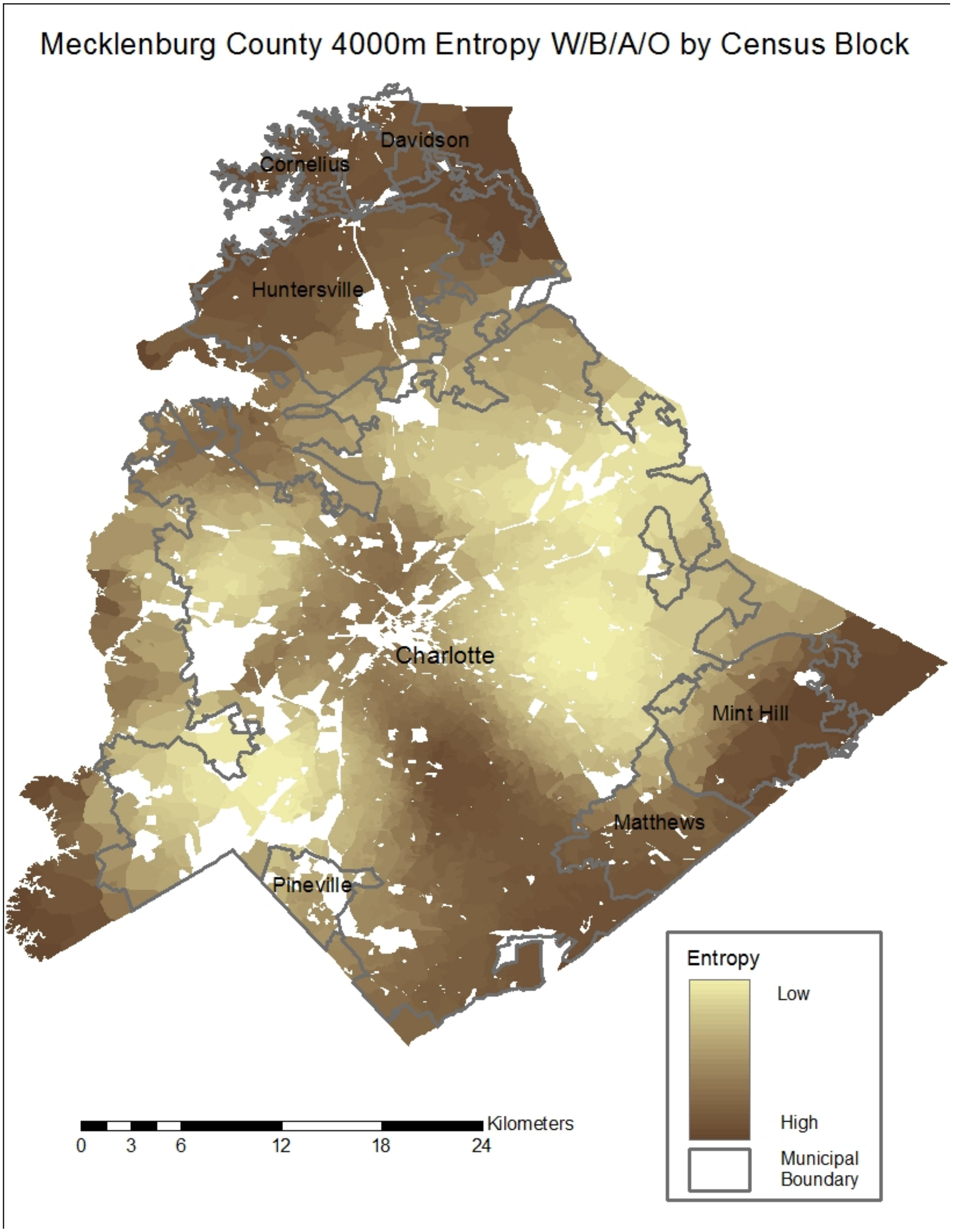


Note: The white Census Blocks have populations of zero and were not included in the measurement of Entropy or proportion.

Figure 12 contains maps of Mecklenburg 4000m W/B/A/O H, B/Other H, black population percentage, H/Other H, and Hispanic population percentage. The largest concentrations of high B/Other H are in south-central Charlotte, central and southern Matthews, south-east Mint Hill, north-west Huntersville, throughout Cornelius and in south-east Davidson. These spatial trends are supported by the black population percentage map which shows the highest percentages of black population in north-western Charlotte making this area slightly more diverse than south-central charlotte where the lowest values of black percentage are observed. Moderate percentages are observed in west and east Charlotte where B/Other H is lowest and diversity is highest. The Hispanic H value map exhibits a similar pattern but there are notable differences. The Hispanic segregation is more prominent in north-east, north-west and western Charlotte. These trends are corroborated by the Hispanic population percentage map which exhibits highest Hispanic percentages in east and south-west Charlotte. It should be noted that the Hispanic percentage ranges from zero to twenty percent, so the darkest blue represents a maximum of twenty percent Hispanic.

Figure 12 Maps of Mecklenburg County 4000m W/B/A/O H, B/Other H, Percentage Black, H/Other H and Percentage Hispanic.



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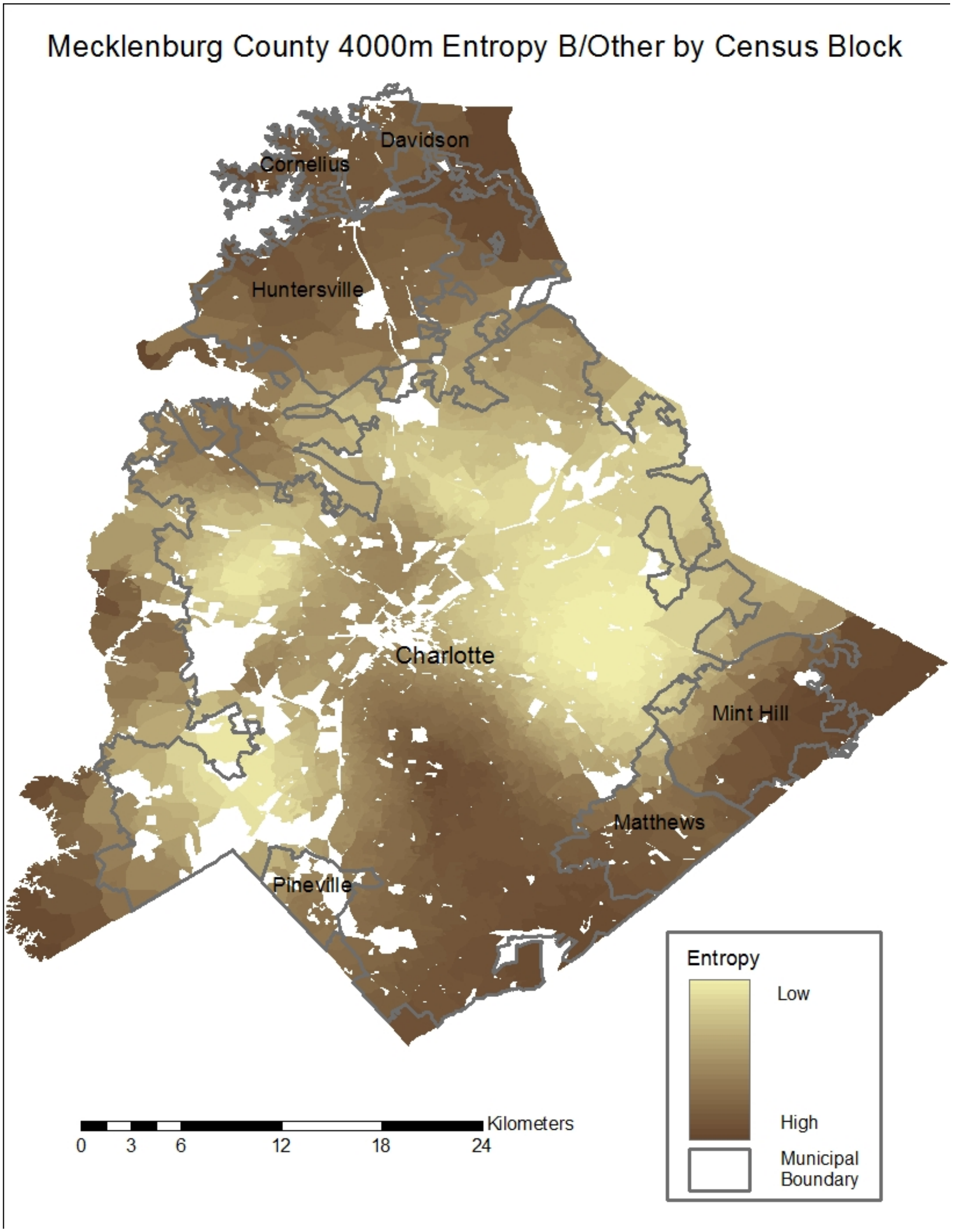

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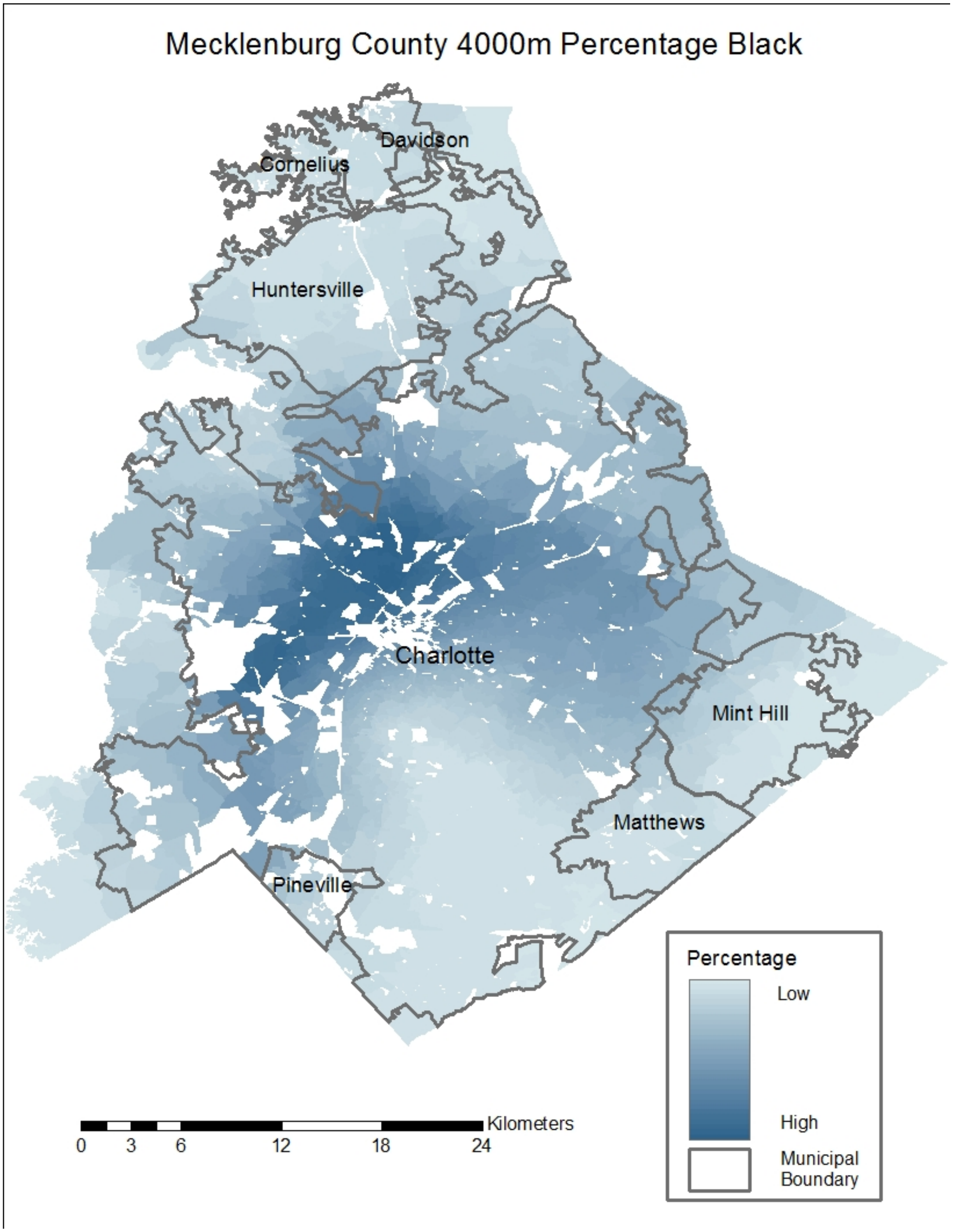

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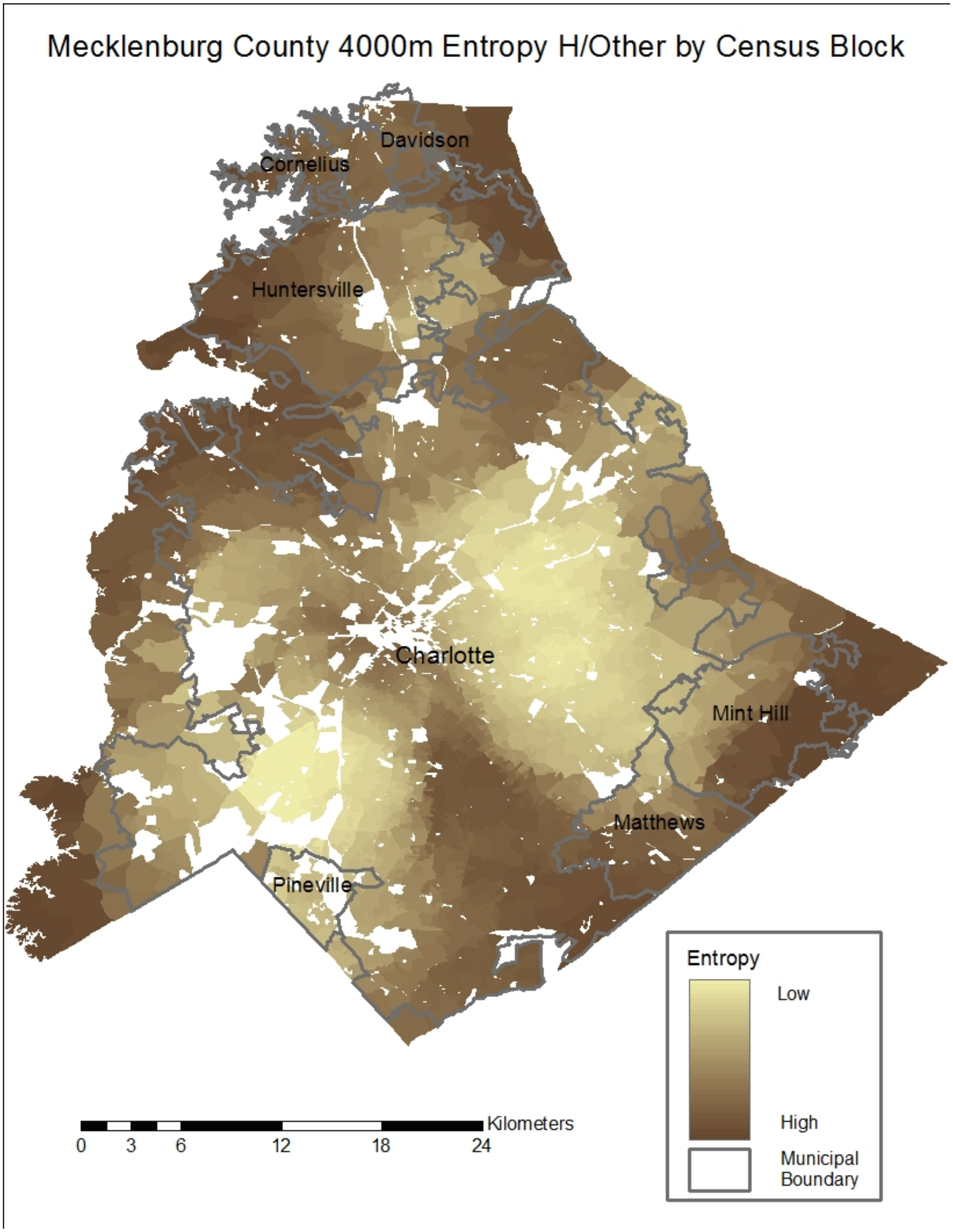

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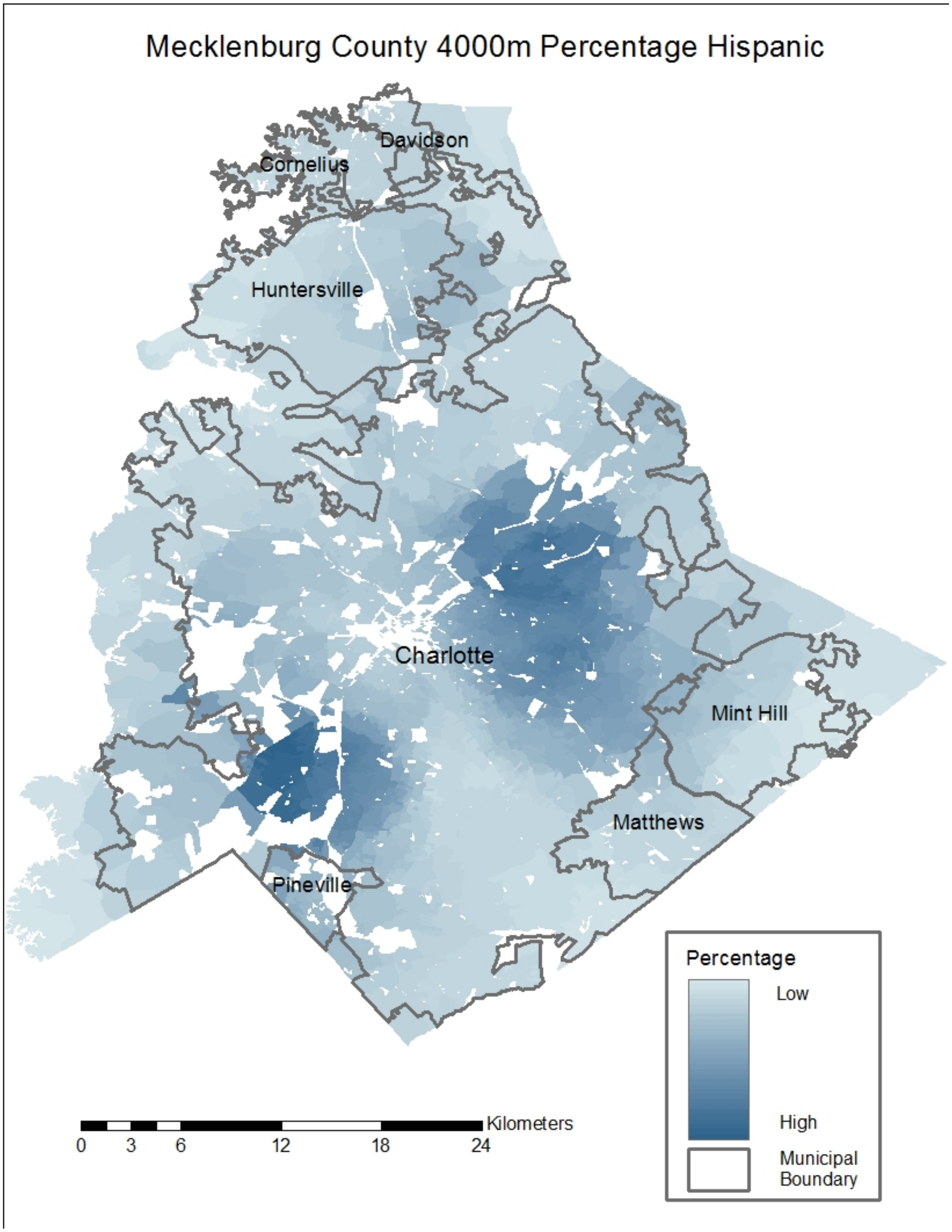


Note: The white Census Blocks have populations of zero and were not included in the measurement of Entropy or proportion.

Figure 13 contains maps of Wake County 4000m W/B/A/O H, B/Other H, black population percentage, H/Other H and Hispanic population percentage. The largest concentrations of high B/Other H in Wake County are in central-western and to the north of Raleigh, in south and to the south of Cary (Figure 13). Within Raleigh, the largest city in the county, there are low B/Other H values in the south-eastern portion of the city. This is supported by the percentage black population map which shows higher percentages of blacks in this area of the city making it more diverse. The high H values in central-western and to the north of Raleigh, in and south of Cary are also corroborated by the black population percentage map which shows low percentages of blacks in these areas. The Hispanic map shows slightly different patterns with a larger concentration of highest H/Other H values in Wake Forest than in Raleigh or Cary. There are however concentrations of high H/Other H south of Cary, in central-western and to the north of Raleigh. These patterns are reflected in the proportion Hispanic map which shows relatively high Hispanic percentages in south-east Raleigh and eastern Cary and low percentages south of Cary, in western and north of Raleigh and in Wake Forest. It should also be noted that there seems to be a concentration of Hispanics in north-east Wake. This sort of rural area concentration is not as prevalent in the black population percentage map. It should be noted that the Hispanic percentage map ranges from zero to twenty percent Hispanic, so the darkest blue represents a maximum of twenty percent Hispanic.

Figure 13 Maps of Wake County 4000m W/B/A/O H, B/Other H, Percentage Black, H/Other H and Percentage Hispanic

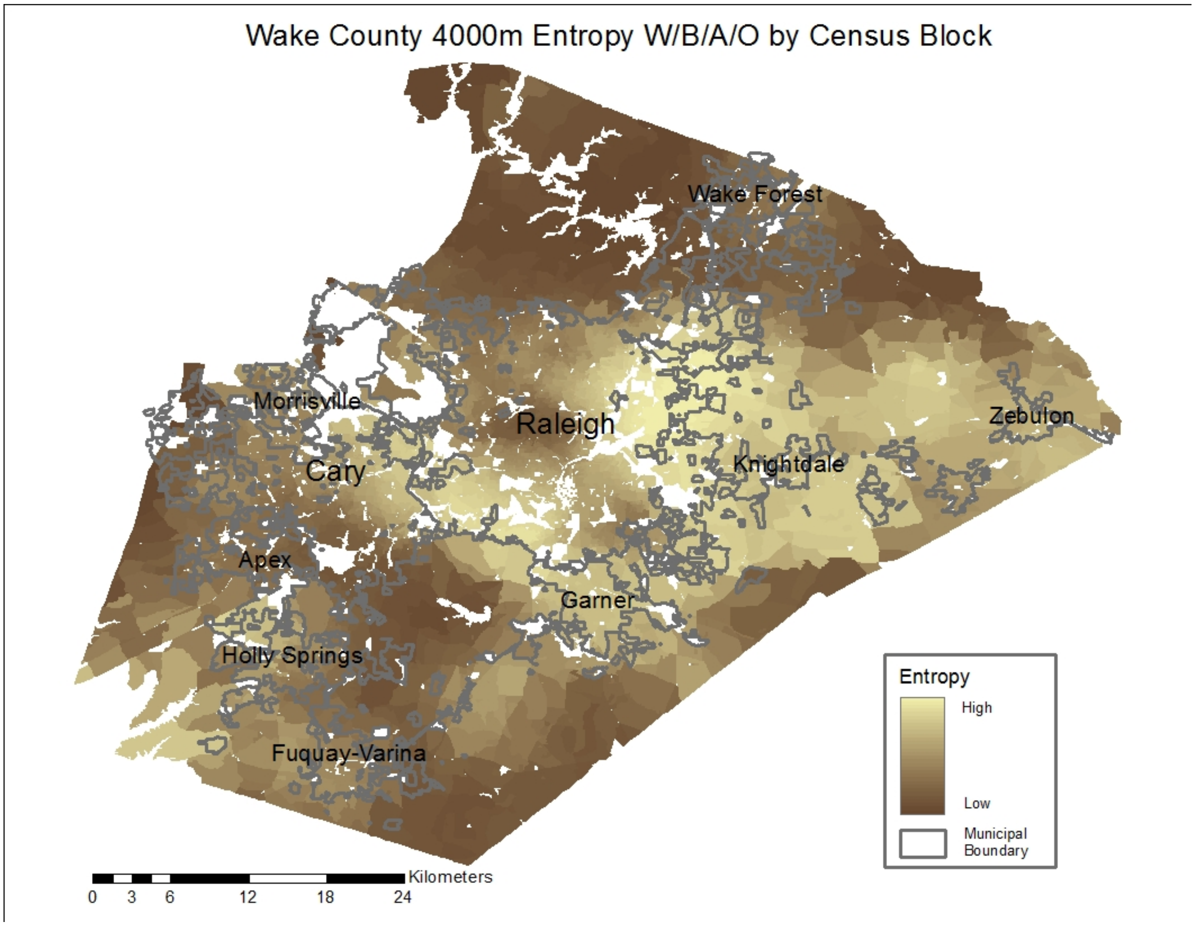
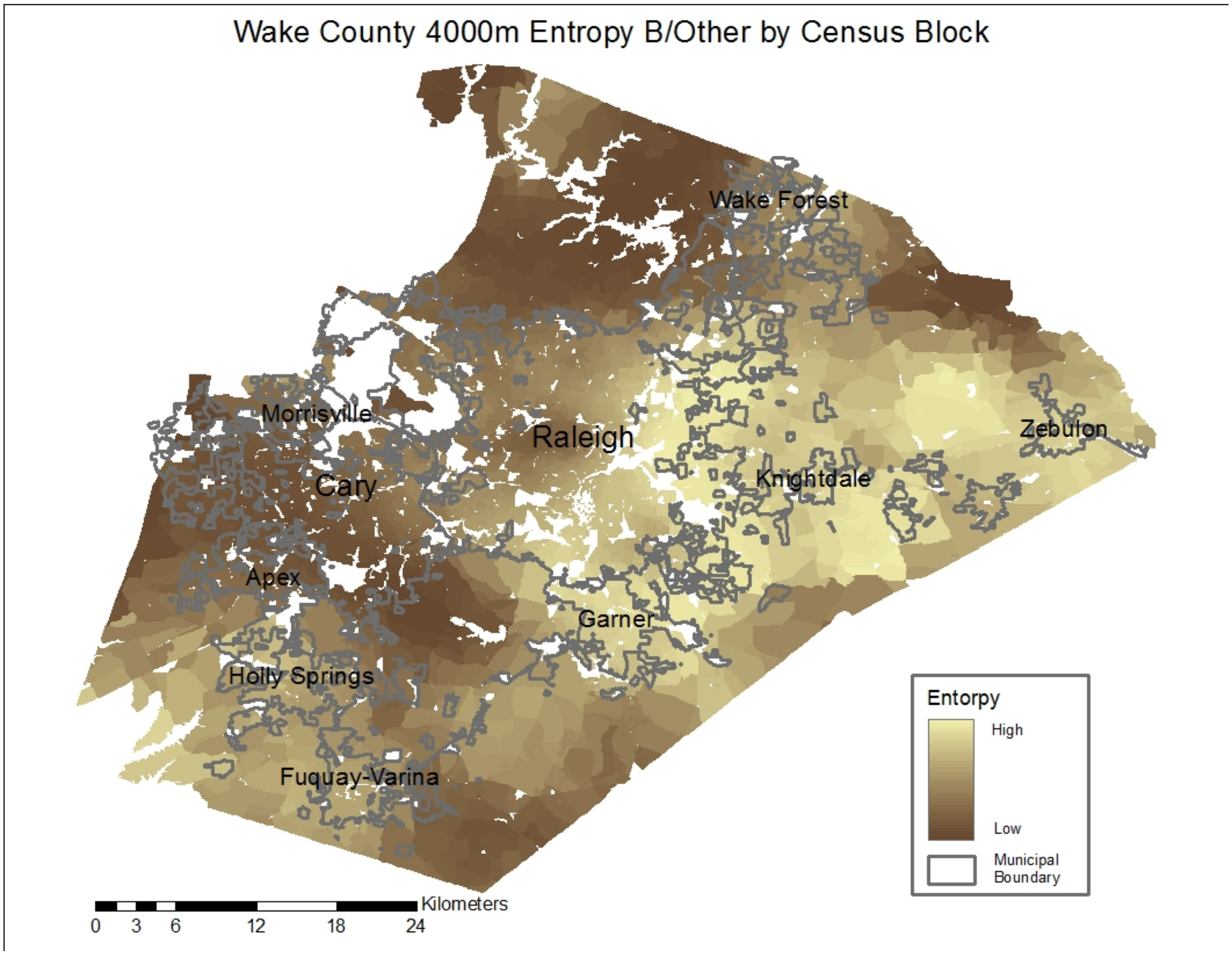


Figure 13 (Continued)



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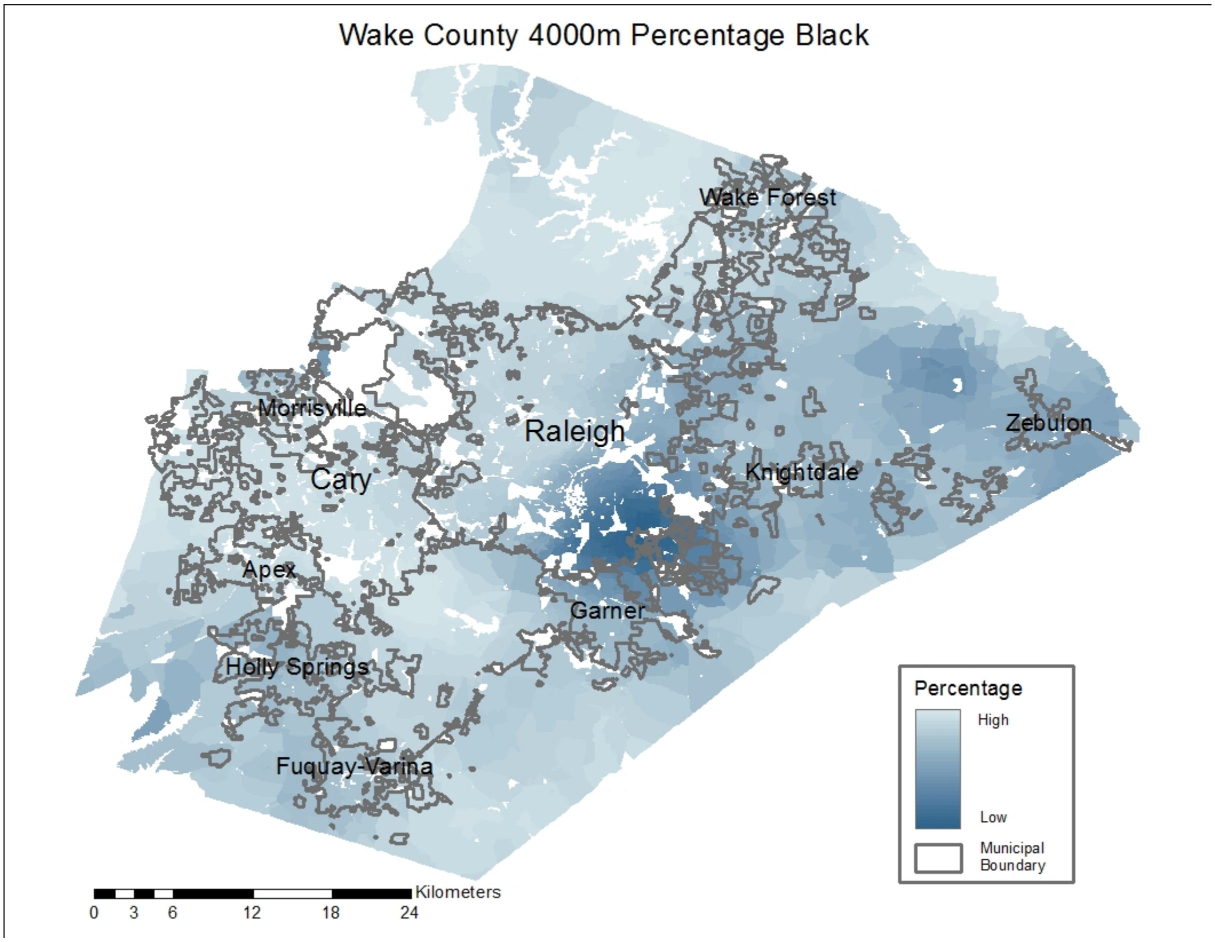


Figure 13 (Continued)

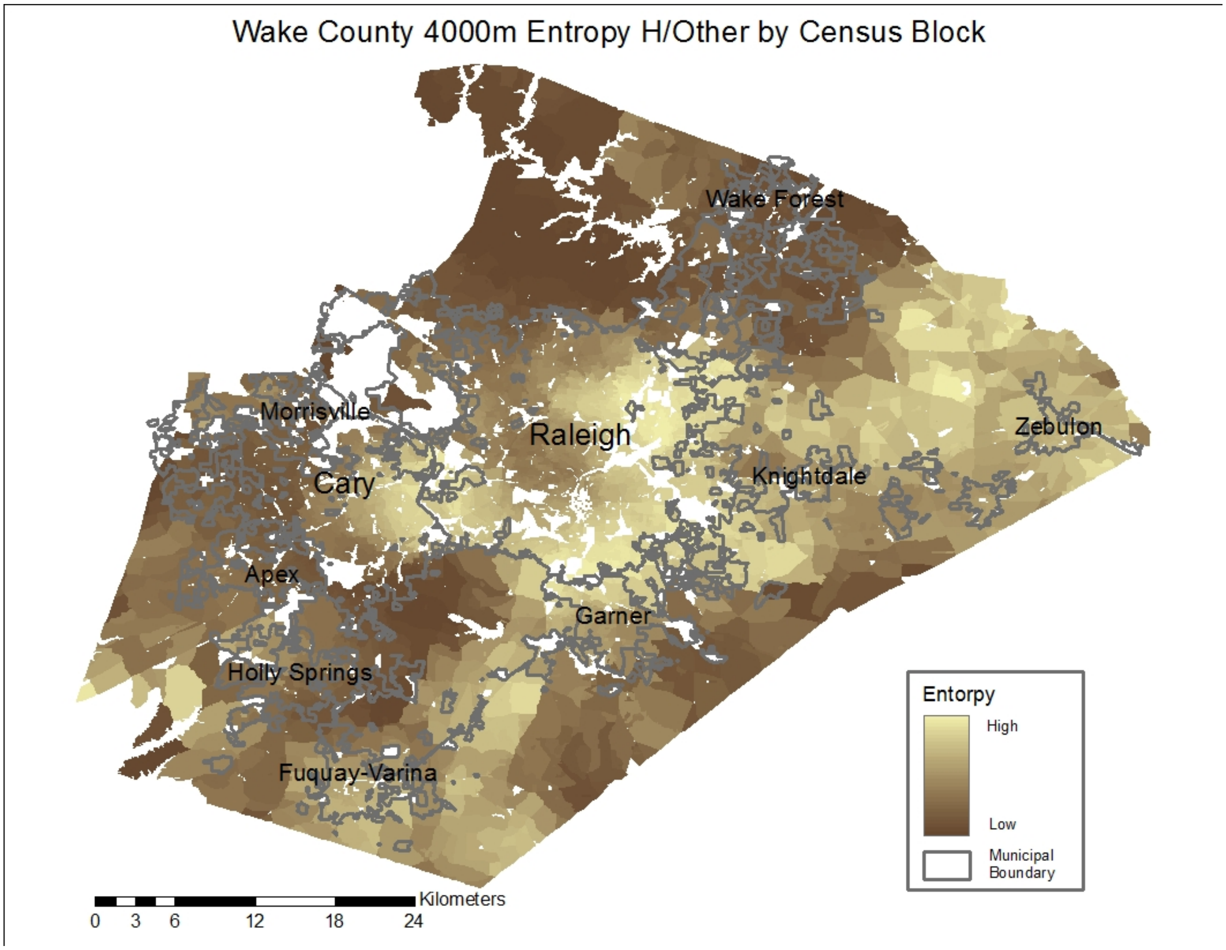
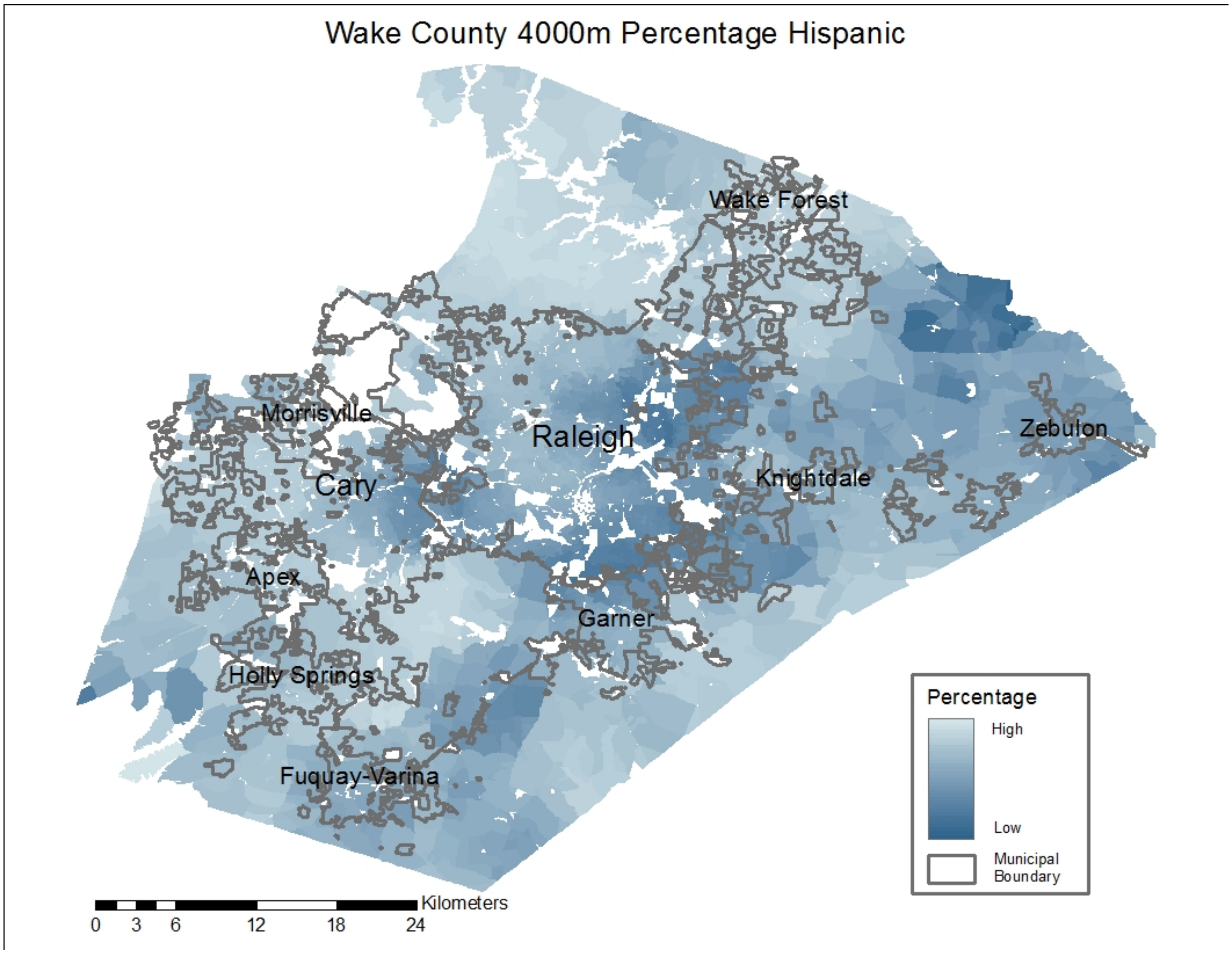


Figure 13 (Continued)



Note: The white Census Blocks have populations of zero and were not included in the measurement of Entropy or proportion.

By examining the difference in the spatial distribution of racial segregation within the five N.C. counties some clear trends have been realized. There is a consistent and clear difference in the spatial patterning of the pairwise Black/Other and Hispanic/Other *H* values. This suggests that different mechanisms may be shaping the segregation patterns of these racial groups. However some similarities are also observed in that the largest concentrations of high segregation tend to occur on or just beyond the municipal boundaries within each county and the lowest levels of segregation occur within the largest cities. This suggests that some common developmental patterns may be causing higher isolation levels on the urban fringe. New suburban development on the urban fringe has been associated with higher levels of income and racial segregation (Rusk 2003, Pendal & Caruthers 2003, Jargowsky 2003, Yang & Jargowsky 2006, Ficsher 2008). It may be that the lack of affordable housing in these areas which is causing high levels of segregation (Pendal & Caruthers 2003).

CHAPTER V

CONCLUSION

The spatial measure employed here adequately addresses the methodological issues of the MAUP and the Checkerboard problems. The MAUP and the Checkerboard problems can only be completely avoided with the use of individual level observations. While they may not be able to completely avoid these issues while using census data, the spatial measures can account for the variation in scale at which segregation is occurring within and between metropolitan areas. The assumption that segregation is a non-increasing function of scale holds here for each measure of segregation, mulitgroup W/B/A/O and pairwise B/Other and H/Other. No increase in segregation was observed as the sample area was increased.

High levels of macro/micro segregation were observed for all five N.C. counties which means that segregation is occurring over a large scale in these N.C. counties. This may be related to the fact that four of the counties considered contain highly sprawling metropolitan areas. The second most sprawling Metropolitan Statistical Area (MSA) in the U.S., according to Ewing et al. (2002), is the Greensboro-Winston-Salem–High Point MSA. Two of these cities are within Guilford County and the other is in Forsyth County. The third most sprawling MSA in the U.S., the Raleigh-Durham MSA, is contained by Durham and Wake counties. These four counties exhibit developmental patterns such as low residential density, poor neighborhood mix of homes, jobs and services, weak activity centers and downtowns and poor accessibility of the street network which contribute to the high levels of sprawl observed in Guilford, Forsyth, Wake and Durham counties (Ewing et al. 2002).

An ANOVA showed significant differences between the *H* values of all five counties and all for radii. There is also a significant difference in the observed W/B/A/O, H/Other and B/Other *H* values. Only the 2000m and 1000m H/Other *H* values and the H/Other *H* values for Mecklenburg and Forsyth were not significantly different. This supports the significance of using a spatial measure of segregation so that the scalar variation in segregation patterns both within and between metropolitan areas can be adequately addressed by anyone attempting to make decisions based on the diversity of an area. Racial differences are observed as the macro-scale segregation generally accounts for a larger share of the H/Other segregation than the B/Other segregation. This is likely the result of the very small Hispanic population in all five counties which caused the diversity levels to be extremely low for most radii. Differences in the spatial patterning of B/Other and H/Other *H* values is also observed. Reardon et al. (2008) also observed differences between the racial groups they considered. They concluded that the Asian population is subject to a different set of mechanisms than either the black or the Hispanic population which has notably different segregation patterns.

Before including a plethora of individual racial groups, future research should be careful to ensure that the populations they are considering are present in large enough numbers to accurately reflect their isolation levels. If the population is very low, high isolation levels will be observed for most of the areas as only a few contain a significant percentage of Hispanics. These low percentages translate into low levels of diversity and as a result high levels of H/Other H. This high level of H may not mean that the group is isolated from other racial groups but that they are simply not present in significant numbers to translate into low diversity levels anywhere in the study area.

It is concluded that Spatial measures, even when dependent on aggregated census data, provide a more adequate measure of the scale at which segregation is occurring. An aspatial measure of segregation like the tract based Entropy Index, the Isolation Index and the Dissimilarity Index would overlook any variation in the segregation values take at various scales while the Entropy Index taken at various scales along with the segregation profile and the corresponding macro/micro segregation ratio indicate just this difference.

Racial segregation patterns are spatial in nature and this thesis has focused on the application of a measure which can adequately assess the scale of segregation patterns. The wealth of previous research on the causes and the observed consequences of segregation could be expanded upon by an explicit consideration of scale and how sprawl and other factors affect the observed scale of segregation. The role of the physical environment (vegetation and topographic barriers), the built environment, residential preferences, housing discrimination, housing policy, economic factors like income inequality, and the spatial concentration of labor should all be considered scalar in nature. Limitations imposed on the built environment by the local topography should be considered a potential contributor to the resulting scale of residential distribution. Pick and Green (2006) note the very hilly and broken terrain in Pittsburgh, as well as in other similar cities (e.g. Cincinnati and San Francisco), has a good deal to do with forming and preserving neighborhood identity. Smaller street networks constrained by the local environment, like in Ashville NC, may experience more micro-level segregation and less macro-level segregation. Cities with large, unbroken street networks, like Greensboro NC, may experience more macro-level segregation and less micro-level segregation.

The consequences of segregation may vary at different scales for different populations. Low mobility in children may result in their being more affected by their local micro-level environment (e.g. schools) while adults with higher mobility rates are subjected to macro-level characteristics (e.g. job opportunities). Moreover the consequences may vary by population subgroup. Macro-level segregation may have substantial consequences for the employment opportunities of minority workers but relatively less consequence for white workers (Reardon et al 2008).

Future analysis should also consider the change in macro-level and micro-level segregation over time. If the micro-level segregation declined at a higher rate than macro-level segregation we would observe a gradual flattening of the segregation profile. On the other hand the segregation profile would increase in slope over time if the macro-level segregation decreased more rapidly than the micro-level segregation, indicating increasing localized patterns of isolation. The effect of planning policies like urban growth boundaries and downzoning at the periphery to encourage mixed use high density development could be related to these changes in slope to see if and how they may be changing the scale of segregation within a metropolitan area. The application of this method in a comparison of cities such as Rusk’s (2003) elastic and inelastic cities may provide additional insight into the metropolitan area characteristics which cause different types of spatial segregation patterns. This may link changes in the slope of the segregation profile to “elastic” cities with the ability to expand geographically and “inelastic” cities which cannot.

The regression of spatial segregation values on indicators of segregation such as income, education, number of single mother households, population density, and percent poverty may provide insight into the causes and consequences of certain scales of segregation. This could aid in the creation of planning policy which more adequately addresses the equity issue. Planners would be better informed concerning the scale of segregation and what metropolitan characteristics are most strongly related to the observed segregation patterns within a given metropolitan area. This knowledge would hopefully lead to the creation of scale appropriate policy.

Racial segregation occurs at many levels, in the neighborhood, the city and the metropolitan area as a whole. This connotation of scale is one which regional planners should fully grasp as it provides them with the ability to more effectively consider the macro and micro scale effects of planning policy. For example, the racial and socioeconomic enclaves are different in Los Angeles, Chicago, and New York. One region may be characterized by large expanses of relatively homogenous areas socioeconomically and racially (Los Angeles) and another may be characterized by segregation at a smaller scale over shorter distances (New York). The ‘one size fits all’ approach, historically used in state sponsored growth management strategies, has become an obsolete concept since states vary dramatically in population size, density, growth rates, and political cultures. Spatial measures of segregation which can measure segregation both within and between regions are a more appropriate measure of segregation for the emerging growth management paradigm which is moving away from state-dominant models to a partnership approach based on fully integrated regional variations, intergovernmental mediation, and local participation in determining local growth rates and priorities. Aspatial methods consider the metropolitan area as a single unit and therefore miss any intra-metropolitan segregation patterns.

Since the 1970s development patterns have largely been that of Vance's Urban Realm (1964) and Garreau's Edge Cities (1991) characterized by the emergence of suburban sectors independent of the central business district. These development patterns occur over different scales with varying densities. Spatial measures attempt to account for these differences and provide a view on segregation missed by aspatial methods. For example, the degree to which within-city, within-suburb, and within-city-and-suburb segregation levels explain the overall metropolitan segregation levels. This can provide insight into how migration of minorities within a metropolitan area has changed the segregation level of the metropolitan area as a whole.

To be more conclusive, an attempt to trend the scale of segregation against variables such as elasticity, topography and planning policy guidelines (e.g. urban growth boundaries, upzoning or downzoning to affect minimum lot size) should include a much larger sample of cities than included in this thesis and in Reardon et al. (2008). Considering that the segregation profile and segregation ratio have been shown to reflect a unique aspect of residential isolation (Reardon et al. 2008), future research has a sound base on which to begin a more comprehensive examination of the metropolitan characteristics associated with various scales of segregation.

The local environment here has been defined as radii ranging from 500m to 4000m. They represent a range of concentric local environments likely to be experienced by an average person. A 500m-radius should be considered to correspond to a pedestrian neighborhood containing activities outside of work like walking the dog, visiting neighbors and shopping for groceries. A 1000m radius corresponds to a local institutional neighborhood, about the size of an average elementary school attendance zone, a police or fire substation zone. The 4000m radius, encompassing $50km^2$ is over 60 times as large as the 500m radius pedestrian neighborhood. This is larger than almost all but the largest macro-scale suburban neighborhoods. It is however smaller than the average commute to work. It should none the less be considered the largest area which can still have any sense of a neighborhood community containing high school attendance zones, shopping, and social activities (Reardon et al. 2008).

These definitions should be considered generalizations however, as the mobility patterns may be considerably variable within a metropolitan area due to the spatial distribution of labor markets, institutions, and commercial activities (dense in a downtown area or spread out in a suburban overspill location). Also, the speed and efficiency with which people can travel may be variable as a result of the transportation network and the ease of accessing public transit. The accessibility of a location should be considered a function of distance and mobility. Better road networks and public transit systems increase the ease with which a person can travel a certain distance increasing the scale of interaction and the racial diversity of social interaction within a given area. The degree to which residential isolation can be overcome by increased mobility should be considered a function of the scale at which segregation is occurring and the distance minority groups are required to travel to find work, go to school, and take advantage of other social and professional opportunities.

At this point in time we are still dependent on data collected and grouped according to areal census boundaries. We should look forward to data taken at the individual level to completely avoid the MAUP inherent in such group statistics. In the interim however, application of weights to the point data derived from areal unit sample boundaries is necessary to counterbalance the effects of the MAUP which manifests itself as a decline in segregation values as sample radii increases. While this study focused on the measurement of segregation related to race, the information theory index should be considered applicable to many other residential characteristics like income or commuting time.

Few of the proposed spatial segregation measures have been used in published empirical segregation research (Reardon & O'Sullivan 2004). This is due in part to the fact that they tend to be more difficult to compute than the aspatial measures. There is also little publicly available software to compute spatial segregation measures - ArcGIS and MapInfo. This limitation, however, is likely to become less relevant with the increased availability and ease of use of geographical information system software. Finally, it should be considered important that future research is focused on a small number of different measures, so that findings can be easily compared across studies.

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