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Racial Segregation in Indianapolis, 1990–2010: A Spatial Perspective[*]

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ABSTRACT

The index of dissimilarity is the most widely used method for measuring racial segregation. When applied to Indianapolis, this index has returned results showing the city to be among the most segregated in the country. The resulting measure, however, suffers from two shortcomings. First, the index of dissimilarity is sensitive to the census-defined geographic unit chosen for the analysis; thus, this index returns different (though proportionate) results depending on whether the population data are aggregated to larger or smaller enumeration units. Second, the index of dissimilarity cannot account for the influence of spatial proximity; adjacent census blocks interact regardless of administrative boundaries. In place of the index of dissimilarity, we apply the segregation index in order to treat the phenomena as a surface that is simultaneously smooth and continuous. In this article, we calculate the segregation index for Indianapolis from 1990 to 2010 using the kernel density estimation method. The results of the analysis are presented in three pairs of decennial maps. These maps add to the understanding of residential segregation by resolving in a statistically reliable manner the phenomenon's geographic component. Our visualization of segregation confirms its presence in distinct clusters, its growth over time, and a strong bias of this growth to be contiguous. In a manner akin to examinations of residential segregation's impact on education attainment and health outcomes, careful description of segregation's spatial aspect leads to a more nuanced understanding of phenomenon's pervasiveness across social life.

KEY WORDS Segregation; Index of Dissimilarity; Segregation Index; Indianapolis

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Nationally, residential segregation is in decline: In 1970, 61 percent of African Americans lived under conditions described as "hypersegregated"; in 2010, the percentage was 32 (Massey and Tannen 2015). Significantly, these declines are not evenly distributed across the country. Older industrial cities, especially in the Midwest, continue to report scores on segregation indices in excess of national averages (Massey and Tannen 2015). Indianapolis is emblematic of these trends; residential segregation remains an enduring aspect of the city's human geography. Although the proportion of African Americans living in segregated conditions in Indianapolis decreased between 1990 and 2010, the decline is modest in that two-thirds of African Americans continue to reside in census blocks that are racially homogeneous. The relative lack of change in Indianapolis's segregated spatial distribution is anomalous in the face of segregation's national decline and of the ongoing trend toward residential suburbanization. The enduring fact that African Americans in Indianapolis continue to reside in neighborhoods that are nearly homogeneously black and contiguous to one another suggests the persistent operation of segregation's post-de jure drivers: economic disparity, white residential preferences, and discrimination (Glasmeier 2014; Kaplan and Holloway 1998). Clearly, change is underway at the national scale, but its impact is differentiated by region. What is it about residential segregation in the Midwest—and Indianapolis in particular—that makes it more stubbornly resistant to change than in other regions of the country? Indianapolis is ideally situated as a case study, given its Midwestern location and its economic growth above the regional average. Simply put, if a growing city like Indianapolis remains segregated to such a high extent, what's going on?

One necessary step toward unraveling the regional conundrum of segregation's uneven decline is to carefully describe the pattern. This paper reports the results of a geographical analysis of residential segregation in Indianapolis from 1990 to 2010. The results demonstrate that even in the face of a modest decline in the city's segregation statistics, the city's residential landscape remains thoroughly segregated. The resulting maps depict the city's changing landscape of segregation at a finer scale than has been done in the past. As a result, we can see the operation of continuous expansion—parcels converting from heterogeneous racial composition to nearly homogeneous African American composition—associated with a tipping-point dynamic (Clark 1993). Combined with evidence of ongoing real-estate agent practices of steering and discriminatory lending (Kaplan and Holloway 1998), the presence of a tipping point suggests that social processes first disclosed in the 1950s remain salient (Lipsitz 2011).

Implicit in our approach to mapping segregation is the proposition that conventional statistical methods for examining segregation produce maps that obscure the finer-grained patterns associated with the phenomenon (O'Sullivan and Wong 2007). This lack of small-scale visibility is troublesome for two reasons. First, by relying on geographic parcels defined by the Census Bureau, conventional segregation maps overlook the segregated conditions within parcels. This lack of intraparcel specificity matters because amenities are not equally distributed *within* parcels; the same census tract (i.e., the typical unit of spatial analysis of segregation) may have blighted and gentrified residences in close but statistically overlooked proximity. Related to this matter of scale is a second reason to reconfigure how we map segregation: Traditional measures of residential segregation do not consider the influence of adjacent areas—neighborhoods, street corners, transit centers, interstate highway corridors—on a parcel's demographic makeup (O'Sullivan and Wong 2007). This condition of spatial autocorrelation—the influence of proximity understood in a probabilistic manner—requires specialized statistical techniques. Among techniques for considering proximity's influence, kernel density estimation (KDE) is ideal for our purposes because the resulting maps clearly depict segregation's geographic footprint. Visualizing segregation with KDE maps allows activists and researchers to take the small but necessary step of accurately reporting segregation's location. What is more, visualization lends rhetorically powerful credence—seeing is believing—to the efforts of those who call attention to segregation's deleterious social effects.

BACKGROUND

Longitudinal measures of residential segregation indicate that it has simultaneously declined and endured as a social phenomenon (Massey and Tannen 2015). Indianapolis is emblematic of an emerging regional pattern in which segregation has declined nationally but differs significantly among regions. For instance, residential segregation in cities in the American South and Midwest appears more resistant to change than in cities in the Southwest and Northwest (Massey and Tannen 2015). Indianapolis is an exemplar of this regional variation: a Midwestern city in which the overall proportion of African Americans residing under segregated conditions is decreasing, yet the decrease is modest compared to the overall national trend.

One approach to setting this spatial variation among regions into context is to recall the inherently spatial ideal that was among the motivations of those who designed fair-housing legislation 50 years ago (Lipsitz 2011). Prior to the 1968 Fair Housing Act and several congressional measures from the 1970s that targeted discriminatory lending practices, the legality of housing discrimination varied among state and local governments. These local variations, widely interpreted as prima facie evidence of discriminatory practices of various types, changed abruptly from one jurisdiction to another. In the wake of fair housing and lending legislation, however, local variation (discrimination) was, theoretically, replaced by the application of an overarching national regulatory plan that upheld notions of justice and equal access. Ideally, the consistent application of such law was to result in a map of uniform housing and lending practices across jurisdictions and administrative units. Cartographically, the map of housing and residential finance-related regulation and practice was intended to move from being a complex, fractured, jurisdiction-specific patchwork quilt to a smooth, continuously uniform regulatory surface.

The ongoing reality of residential segregation makes clear that the ideal of fair housing has not been realized. African American residential choice remains constrained. Subsequently, African Americans are disproportionately exposed to disamenities associated with food deserts, ambient lead, failing schools, and police profiling (Wilson 2007). What we propose here is to use a technique that begins with the assumption of uniformity, and measures how far we are from that ideal. When we consider the crucial *where* of segregation and model the city's residential landscape as a smooth, continuously variable phenomenon, how has the map of segregation in one city—Indianapolis—changed over time in response to a new judicial environment?

The dissimilarity index (Duncan and Duncan 1955) has been used extensively to describe segregation because of the index's ease of calculation and the wide availability of census data (Massey and Denton 1989; O'Sullivan and Wong 2007). It also has the added advantage that it allows us to compare regions across the country longitudinally, regardless of differences in area and population. There are, however, several drawbacks to indices of segregation such as the dissimilarity index for a study like ours. Though useful in quantifying the level of segregation, it does not show *where* the phenomena are distributed geographically in a local sense—for example, among a city's neighborhoods.

These tabular indices of segregation rely on the tacit assumption that the observations are independent and identically distributed (IID). The assumption of independent and identical distribution, however, confounds a fundamental principle of spatial analysis. Stated as an epigram, this key insight into the condition of spatial phenomena reads, "Everything is related with everything else, but near things are more related than distant things" (Tobler 1970). The assumption that individual observations are independent of their surroundings does not adhere in instances such as racial segregation, wherein adjacency and proximity clearly matter (Dwyer and Jones 2000; Lipsitz 2011). Spatial statistical analysis examines the likelihood that adjacent neighbors have an impact on one another. For example, if there is a high prevalence of influenza cases in Marion County, there is a higher likelihood of influenza spreading to neighboring counties than to counties farther away. That is, the likelihood of influenza spreading to adjacent counties is much higher than the likelihood of spreading to nonadjacent counties. Additionally, this likelihood of transmission reduces in proportion to a county's distance from Marion County. This, setting aside the assumption of independent and identically distributed observations that underpins tabular indices in favor of carefully examining the influence of adjacency and proximity—more technically, spatial autocorrelation—is important in analyzing spatial phenomena such as segregation.

A second, related, problem arises when the results of conventional indices of segregation are depicted on maps using census geography. These maps rely on arbitrary, administratively defined spatial units—e.g., census block, tract, or county—that misrepresent the phenomena of segregation. Counted for census enumeration, people are discrete phenomena. The necessity of privacy concerns, however, dictates publishing population counts as sums and proportions aggregated to enumeration units ranging in size from blocks to the entire country. The maps that derive from these aggregated data are problematic for spatial analysis because residents are not uniformly distributed within enumeration units. In the most basic case, residents cannot be uniformly distributed in, for instance, a county because some territory is uninhabitable or is zoned for nonresidential use. In the more specific case of residential segregation, the assumption of uniform population distribution is unhelpful because the very essence of de facto segregation is the geographic sorting of racial groups into spatially dependent clusters; for example, the fact of proximity among groups in turn influences their residential choices. These clusters may or may not conform to the boundaries of census enumeration units. When we map demographic phenomena such as residential segregation using administratively defined units, our map reflects the published data rather than the underlying phenomena (Krygier and Wood 2016).

One response to this problem of segregation maps marred by data artifice (e.g., misleadingly abrupt boundaries separating enumeration areas) is to treat segregation as a smooth, continuous varying phenomenon that is independent of enumeration units. Among methods that incorporate proximal space into the investigation phenomenon, KDE offers a reliable alternative to tabular calculation of segregation in which the phenomenon is conceived as varying across a surface (O'Sullivan and Wong 2007). KDE infers a probability density function of a population from finite data samples, extended to the spatial domain (Diggle 1985; O'Sullivan and Unwin 2003:68–71). KDE allows us to control for the aspatial assumptions described above as well as to visualize the changing spatial distribution of racial segregation. A brief description of KDE extended to spatial domain follows.

KDE is a nonparametric method of estimating probability distribution function of a random value about a population from data based on a finite data sample (Silverman 1986). It is written as

$$y(x) = \frac{1}{n}\sum_{i=1}^{n} K\left(\frac{x - X_i}{h}\right)$$

where y is the estimated probability density function, $X_i, \ldots, X_n$ X_i, …, X_n are the sample data, and K is a kernel function with bandwidth h. The commonly used kernel functions are the Gaussian function and the quartic function. The quartic function is defined as

$$K(x) = \begin{cases} c(h)\left(1 - \left(\frac{x}{h}\right)^2\right)^2 & \text{where} \quad x \le h \\ 0 & \text{otherwise} \end{cases}$$

and

$$c(h) = \frac{15}{16h}$$

where h is the kernel bandwidth and $c(h)$ is a scaling factor to ensure that the function sums to 1. KDE can be extended to the spatial domain by incorporating some distance, usually radially symmetric, from some central point (Diggle 1985), which changes the kernel function to

$$K(r) = \begin{cases} c(h)(1-(\frac{r}{h})^2)^2 & \text{where} \quad r \leq h \\ 0 & \text{otherwise} \end{cases}$$

and

$$c(h) = \frac{3}{\pi h^2}$$

where r is a radius around a central point. Because we are using block-level aggregation data, the population is treated as multiple data points at a single location, the block centroid. The only stipulation that we have to ensure is that the radius of the kernel function crosses the boundary of the administrative units to capture interaction of populations across administrative boundaries.

KDE has been used in crime analysis (Chainey, Reid, and Stuart 2003) and population visualizations (Wood et al. 1999). We apply KDE to see how segregation has evolved over time. A segregation measure can be derived from KDE by using the following formula:

$$\begin{aligned} S = & \ \frac{\sum_i \max(p_{w_i}, p_{b_i}) - \sum_i \min(p_{w_i}, p_{b_i})}{\sum_i \max(p_{w_i}, p_{b_i})} \\ = & \ \frac{\sum_i | p_{w_i} - p_{b_i} |}{\sum_i \max(p_{w_i}, p_{b_i})} \end{aligned}$$

where p_{w_i} and p_{b_i} are proportions of populations of two subgroups in n areal aggregation

units with $\{w_1, ..., w_n\}$ $\{w_1, ..., w_n\}$and$\{b_1, ..., b_n\}$ population counts and

$$\sum_i p_{w_i} = \sum_i \frac{w_i}{W} = 1 \quad \text{and} \quad \sum_i p_{b_i} = \sum_i \frac{b_i}{B} = 1.$$

A more thorough treatment of the relationship between segregation index and KDE can be found in O'Sullivan and Wong (2007).

DATA AND METHODS

Data

Decennial demographic census data at the block census enumeration level for the years 1990, 2000, and 2010 were downloaded from http://www.census.gov. Since the merger of the City of Indianapolis and Marion County in 1969, the city and county boundaries have become coterminous, forming a single statistical and administrative entity (Blomquist and Parks 1995). The Marion County boundary geographic shapefile was also downloaded from the Census website. The demographic data were joined with the geographic shapefile. All census blocks within 10 kilometers (O'Sullivan and Wong 2007) of Marion County boundaries were selected for this analysis so the generated surfaces needed for the calculation do not have abrupt values due to edge effects. The centroids of these blocks, with the demographic attributes, form the points used for KDE surface generation. The block centroids within this 10-kilometer buffer are shown in Figure 1, and the demographics associated with these blocks are listed in Table 1.

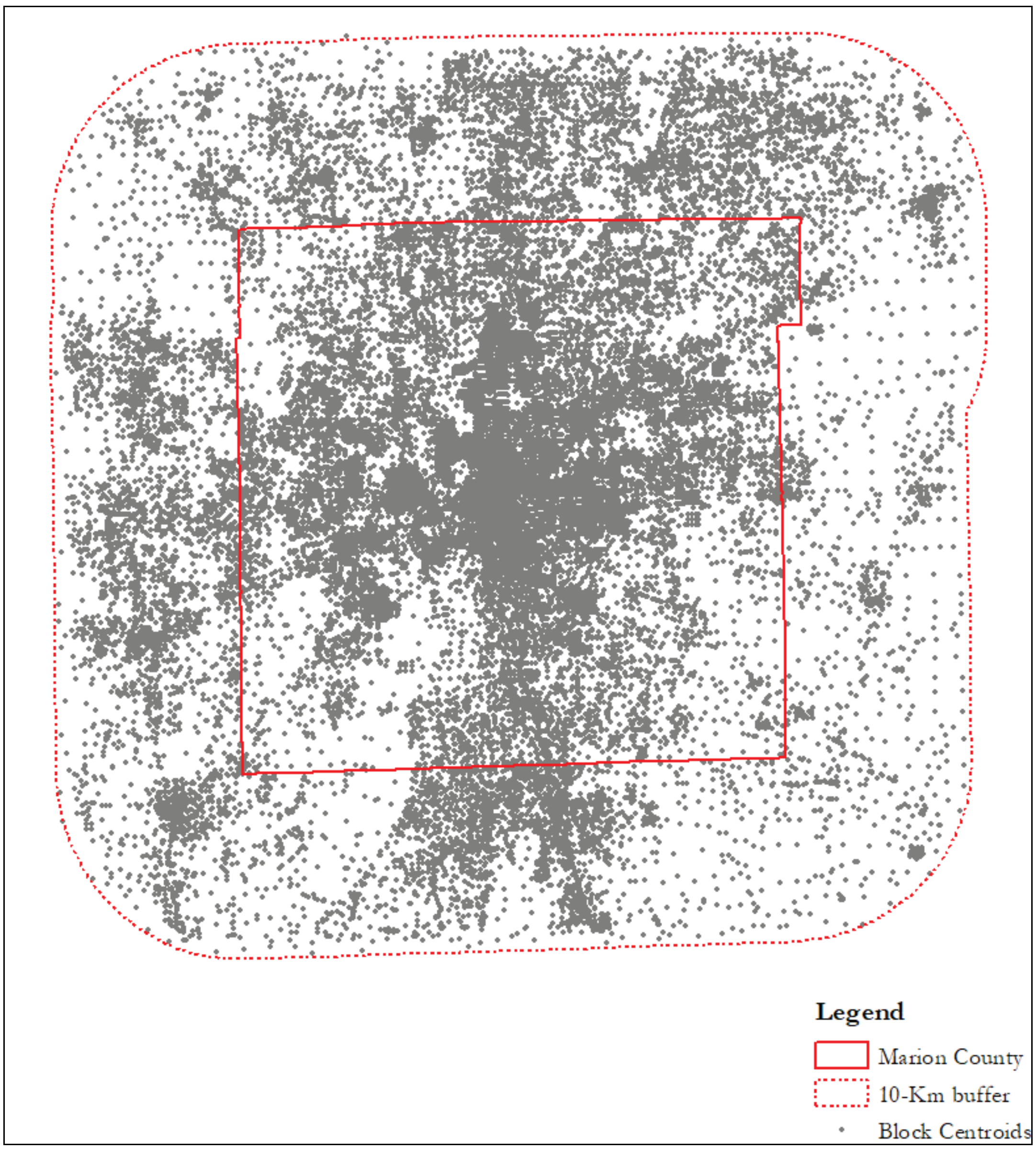
Table 1. Demographic Totals for Marion County plus 10-Kilometer Buffer

Description	1990	2000	2010
White residents	845,917	941,544	1,016,209
Black residents	170,845	211,765	259,220
Other residents	15,108	56,858	129,469
Total residents	1,031,870	1,210,167	1,404,898
Blocks within 10 km of Marion County	16,936	21,565	27,652

Method

As discussed in the previous section, KDE is a method of capturing the local density of a pattern at any location in the study region by counting the number of events in a region, or *kernel*, centered at the location where the density is to be estimated. Different geometric shapes can be used as kernels, and empirical heuristics exist for choosing various parameters that accompany these kernel functions. Instead of using the simple circular kernel, we used the quartic distance-weighted kernel-fitting procedure, which accounts for the distance of point to be estimated from events in the pattern. This requires selecting a simple kernel bandwidth, r, which will be used in the kernel function. This bandwidth will have a strong effect on the resulting estimated surface. Selecting too small a bandwidth results in a surface that focuses primarily on local individual events and on assigning zero values to remote locations from any events. Selecting too large a bandwidth yields a smoother surface at the cost of missing the local pattern in the event data. The choice of a bandwidth can be made less arbitrary by selecting a distance derived from a heuristic or that reflects the situation's empirical context. For instance, crime investigation might warrant a bandwidth that reflects patrol-vehicle response time or precinct boundaries (O'Sullivan and Unwin 2003:70). In the context of segregation, a bandwidth that reflects the culturally relevant borders is desirable—for example, a kernel that mimics the area of a suburban housing development, an urban street-gridded block, a district bounded by disamenities.

Figure 1. Census Block Centroids in 10-Kilometer Buffer around Marion County



We used SAGA GIS (Conrad et al. 2015) to perform KDE analysis of the decennial census data because it allows us to choose different kernel functions and parameters needed for running KDE. We used similar parameters as were used for the Washington, DC, and Philadelphia case studies listed in O'Sullivan and Wong (2007). We chose a quartic kernel with a 2,500-meter radius for the kernel function and a cell size of 250 (meters). The changes in the distribution of white and black population are shown in Figures 2 and 3, respectively.

Figure 2. Kernel Density Estimation of White Population, 1990–2010

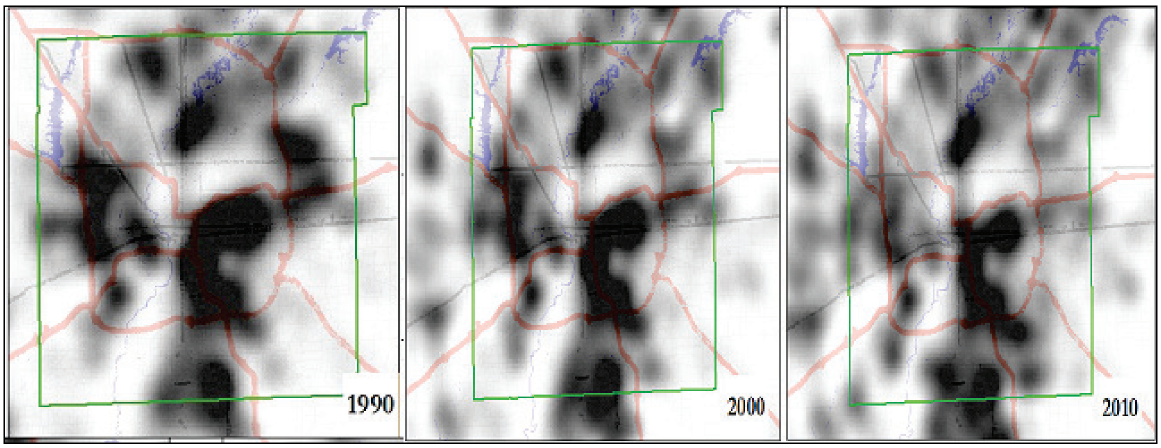
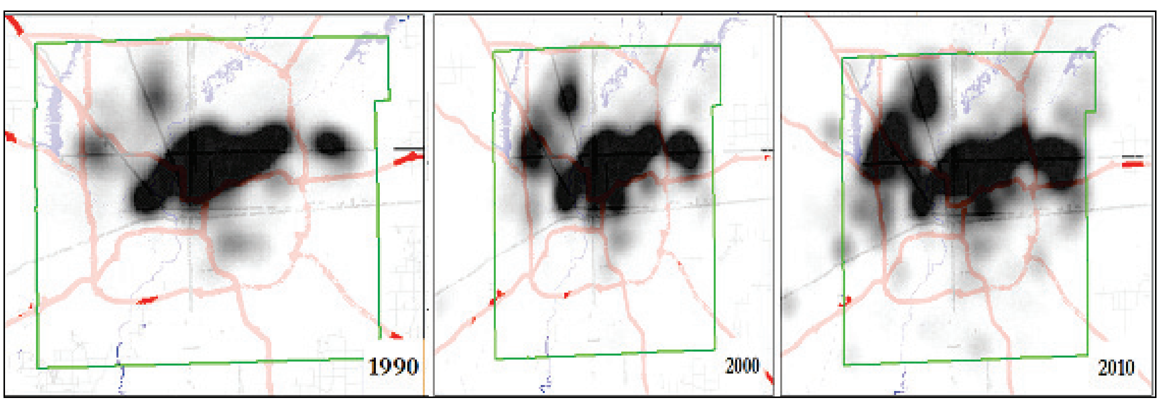


Figure 3. Kernel Density Estimation of Black Population, 1990–2010



RESULTS

The results of applying the dissimilarity index and segregation index to the blocks around Indianapolis are listed in Table 2. The segregation index (*S*) can be interpreted in the same way as the dissimilarity index (*D*). Both indices range in value from 0 to 1; a completely integrated population will have the value $S \approx D = 0$, and a completely segregated population will have the value $S \approx D = 1$ (O'Sullivan and Wong 2007). Integration in this model is the presence of identical portions of blacks residing in both the city and its constituent subareas; for example, a city with a population that is 15 percent African American would be considered integrated if every subunit within its borders included the same proportion of black residents. The value of S indicates the proportions of blacks that would need to relocate elsewhere in the city so each subarea would conform to the proportion of African American population in the entire city.

Table 2. Dissimilarity Index and Segregation Index for Indianapolis, 1990–2010

Index	1990	2000	2010
Dissimilarity index (D)	0.8026	0.7555	0.7045
Segregation index (S)	0.7686	0.7711	0.7366

The maps in Figures 2 and 3 display the population probability surface by decade for whites and blacks. The grayscale on the map ranges from areas that are lighter in color (integrated, heterogeneous) to those darker (segregated, homogeneous). The grayscale intensity of these blotches and smudges allows us to visually recognize the extent of residential homogeneity (darker color) and heterogeneity (lighter color) that characterizes Indianapolis's landscape of racial concentration and clustering. Significantly, the relatively sharp boundaries of African American clusters correspond to the high score of S for each decade and depict the presence of a highly segregated population.

SEGREGATION AND INDIANAPOLIS, 1990–2010

The maps for 1990 show five racially homogeneous residential areas: four white and one black. The four homogeneously white residential districts occupy ground stretching outward in broad arterial wedges from downtown's margins toward the city's ring road, Interstate 465. Clockwise from the north, the first cluster is a compound of several swarms of white neighborhoods that focus on either side of Meridian Street and then reliably drift northeast. North of 38th Street, Meridian Street has hosted several elite white neighborhood developments since the early 20th century (Monroe 1994; Pierce 2005). The compound cluster is bound on the west by Michigan Road and on the east by Interstate 69. The second cluster straddles the city's original east-west artery—Washington Street/U.S. 40/National Road—and then curls north along I-465, wedged on the east between Interstate 70 and a vast network of rail-repair and siding yards to the south. This eastern cluster corresponds to a welter of neighborhoods developed shortly after World War II. The third cluster, extending south alongside Interstate 65 toward the neighboring city of Greenwood, intersects the second cluster near downtown to form a kidney-shaped swarm of white neighborhoods stretching east and southeast of downtown. The fourth cluster visible on the 1990 map is a constellation of neighborhoods in and around Speedway and stretching beyond the I-465 ring to define the city's west side. The fifth cluster, a dense collection of majority–African American neighborhoods—trends northeast from a point near downtown at the intersection of Lafayette Road and the White River, centered east to west along 38th Street. Importantly, this black residential cluster is located on land—soggy and poorly drained, dissected by highway interchanges and industrial brownfields—that corresponds neatly to the gap near the center of the four white residential clusters (Thornbrough 2000).

For whites, the maps for 2000 and 2010 show erosion among clusters within the I-465 ring and widely dispersed well beyond bounds, trending north and east toward Carmel and Fishers, and south toward Greenwood along interstate highways. In contrast to the white pattern of erosion and dispersion, the main body of black residential clusters has been augmented east and west, moving toward the city's original suburban developments along Arlington Road and Lafayette Road. Three smaller African American clusters visible on the 1990 map—at that time satellites of the larger body, visible to the east across I-465, west near Eagle Creek Reservoir, and northwest along Michigan Road—have all grown in directions that reinforce the impression of a homogeneous distribution of black residential concentration along the main east-west orientation of 38th Street, with a northern arc along Michigan Road. Whereas white concentrations gravitate toward areas outside the ring road served by limited-access highways, black neighborhoods gravitate toward the city's older suburbs served by surface streets. This specific pattern of sprawling, leapfrog growth among whites and of adjacent accretion by black residential areas corresponds to the more general understanding of constrained residential choices for African Americans, neighborhood racial transition, and subsequent white flight (Clark 1993; Massey and Denton 1993).

DISCUSSION

Four decades since Congress acted to eliminate discrimination in housing and lending, residential segregation affects a smaller proportion of African Americans than in the past (Massey and Tannen 2015). In Indianapolis since 1990 (Table 2), however, these scores remain above the threshold established by researchers when studying hypersegregated metropolitan areas (Massey and Denton 1989). Although housing and lending-related law is national policy—in effect, a de jure level playing field, to use another spatial metaphor—local variation in its application persists, as evidenced by stubbornly resistant levels of de facto segregation reported by *D* and *S*.

KDE and the segregation index allow us to cartographically visualize residential segregation in Indianapolis. Maps of the segregation index show that African Americans remain clustered in a contiguous area within the city's ring road. This black residential cluster has grown since 1990 and remains distinct from surrounding white clusters. Clearly, residential segregation remains a systemic characteristic of the city's housing market. Specifically, Midwestern cities such as Indianapolis appear stuck in an old dynamic of racial residential change. Given the ongoing salience of residential segregation as a factor contributing to a raft of societal ills and injustices (e.g., compromised civil rights, hazardous environmental conditions, health and educational disparities, and the necessity of unraveling the seeming contradiction of present-day segregation—and specifically its de jure illegality and de facto endurance), it is critical that researchers and activists seek to understand social (in)justice under present conditions of capital accumulation and the ongoing divestment from African American lives (Lipsitz 2011; Wilson 2007). Carefully describing the geography of segregation in Indianapolis by tracking segregation within parcels and examining the influence of spatial contiguity offers a modest contribution to a larger vital project.

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