

Residential Density Patterns in Milwaukee, Wisconsin

Metropolitan Analysis, Exercise I

13 April 1993

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just great work!  
one of the very  
best papers I've  
reviewed in  
some time.

A+ 100.

A real pleasure  
to read.

### *Introduction:*

More than four decades have passed since Colin Clark first formulated his model of urban population densities.<sup>1</sup> Clark showed that urban population densities in western cities decline with increasing distances from the city center, giving the appearance of an urban "cone" around a peak central density. This regularity could be described with an easily-derived linear function, and while the parameters of the "urban envelope" might vary according to time and place, cities throughout the world -- in a range of unique historical contexts -- conformed to the basic model. Geographers have revised and augmented the simple linear distance-density decay function to portray more accurately the continued stretching, tearing, and remaking of the fabric of the North American city, yet the essential outlines of Clark's model remain intact. The purpose of this essay is to present the results of a simple linear distance-density decay model applied to Milwaukee, Wisconsin, and to examine a few of the local and historical circumstances which further inform the empirical findings.

### *Distance-density decay models of urban residential structure:*

Since the 1960s a number of geographers and urban economists have taken up the question of why the "urban envelope" of the North American city takes the shape it does. Rees, Berry and Horton, Winsborough, and others traced the historical changes of central densities and density gradients, as cities tended to decompact with increasing size, and as transportation innovations fueled deconcentration.<sup>2</sup> Adams modeled this dynamic process, showing that the timing and magnitude of housing construction cycles, combined with the means of intraurban transport technology dominant during each successive building boom, conditioned the urban residential structure of midwestern cities.<sup>3</sup> Newling explored the implications of this process for central areas, presenting evidence of a "critical density" above which the social costs of crowding and

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<sup>1</sup>Clark, C. (1951), "Urban Population Densities," *Journal of the Royal Statistical Society* 114, 490-96.

<sup>2</sup>Rees, P.H. (1968), *The Factorial Ecology of Metropolitan Chicago*, unpublished MA thesis, University of Chicago; Berry, B.J.L., and F.E. Horton (1970), *Geographic Perspectives on Urban Systems*, Engelwood Cliffs, NJ: Prentice-Hall; Winsborough, H.H. (1961), *A Comparative Study of Urban Population Densities*, unpublished Ph.D. dissertation, University of Chicago.

<sup>3</sup>Adams, J.S. (1970), "Residential Structure of Midwestern Cities," *Annals of the Association of American Geographers* 60:1, 37-62.

congestion appeared to accelerate the exodus from the central city.<sup>4</sup> By the 1970s, the pages of the *Journal of Regional Science and Geographical Analysis* offered dozens of urban population density models, most of which were variants on Clark's basic theme.

Clark's descriptive distance-density decay models provided the starting-point for a generation of research on the social and economic *processes* underlying observed patterns: sectoral housing submarkets, intraurban migration and housing search, and inner-city ghetto formation and underclass isolation. In short, geographers have shown that the historical dynamics behind Clark's elegant and simple formulation tell us a great deal about how the urban mosaic grows and changes. How do these processes surface in the results of a simple distance-density decay model applied to today's city?

#### *Distance-density decay patterns in Milwaukee*

The present analysis examines distance-density decay patterns in the city and county of Milwaukee, Wisconsin, the anchor of a Consolidated Metropolitan Statistical Area (CMSA) with a 1990 population of just over 1.4 million.<sup>5</sup> Machine-readable files derived from the 1990 decennial Census of Population and Housing provided 100-percent counts of population and housing units by tract for the county, and a simple distance-density decay model was fitted to the data and several subsets (for complete results see Table 1, at the end of this report).

Modeling population density (or its logarithmic transformation) as a function of distance from the central business district (CBD) yields the familiar negative density gradient the literature leads us to expect, but exhibits a rather weak correlation (Figures 1 and 2). Densities decline from over 10,000 persons per square kilometer near the city center, to near zero in the sparsely-populated townships beyond fifteen kilometers from the CBD. For the 297 tracts in Milwaukee County<sup>6</sup>, an ordinary least-squares regression

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<sup>4</sup>Newling, B. (1966), "Urban Growth and Spatial Structure: Mathematical Models and Empirical Evidence," *Geographical Review* 46:2, 215-40.

<sup>5</sup>The Milwaukee-Racine CMSA recorded a 1990 population of 1,432,149, of which two-thirds (959,275) was in Milwaukee County. The City of Milwaukee's population (628,088) composed two-thirds of the county total. Unless otherwise noted, all data are derived from U.S. Bureau of the Census (1992), *Summary Tape File 3A on CD-ROM*, machine-readable data file, Washington, D.C., USGPO. Additional technical information (measurement units, conversion factors for latitude-longitude figures, etc.) is found in U.S. Bureau of the the Census (1991), *Technical Documentation: Summary Tape File 1 on CD-ROM*, Washington, D.C., USGPO, Appendix A.

<sup>6</sup>Tract designations ending in "99" denote tracts in which all persons were aboard civilian or military ships on Census Day; two tracts in Milwaukee city were thereby excluded from the analysis.

yields an extrapolated central density of 5,943 persons per square kilometer, and a density gradient of -332 persons per square kilometer for each kilometer traveled outward from the CBD ( $R^2 = 0.394$ , significant at  $P = 0.000$ ).

Statistically, such lackluster results might lead us to question the empirical validity of the distance-density decay function: perhaps the city's fabric has been stretched too far, distorted by too many unique historical circumstances, to be portrayed accurately by an abstract model. If we examine these specific local conditions, however, perhaps we can gain further insight on the general processes involved.

*Population densities, housing markets, and urban change in Milwaukee:*

Milwaukee's internal spatial structure may be traced to the late nineteenth-century rail and streetcar eras of midwestern city-building. Initially an outpost of French-Canadian fur traders, Milwaukee grew modestly until German immigration (particularly after 1848) pushed the population to the 100,000 mark by 1875. In the subsequent quarter-century, the city's population nearly tripled.<sup>7</sup>

Railroad corridors along the Menomonee, Milwaukee, and Kinnickinnic valleys had defined residential sectors as early as the 1870s, and today remain devoid of population and housing (Figures 3, 4). Neighborhoods on the southern fringe of the industrial areas of the Menomonee grew into a stable, blue-collar sector, while the hills immediately north of downtown were colonized early on by the city's elite. The northern sector is still the city's preeminent avenue of socioeconomic status.<sup>8</sup> Prospect Avenue, once the anchor of Milwaukee's "silk-stocking" district, is now a magnet for high-density, upscale apartments catering to the young, educated, and upwardly mobile (Figures 3, 4, 5).<sup>9</sup> The area north and west of downtown, then, was left open for the broad path of middle-class residential expansion.

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<sup>7</sup>Schmandt, H.J., J.C. Goldbach, and D.B. Vogel (1971), *Milwaukee: A Contemporary Urban Profile*, New York, Praeger, p. 13 ff. ✓

<sup>8</sup>See Clark, W.A.V. (1976). "Migration in Milwaukee." *Economic Geography* 52, 48-60. In a factorial ecology of Milwaukee city and county, the 'socioeconomic status' factor scores highest along the beachfront stretching from Shorewood and Whitefish Bay to Fox Point, Bayside, and River Hills (known as Milwaukee's "Grosse Point" neighborhoods). Additional peaks appear in the exclusive enclaves of Wauwatosa to the west. ✓

<sup>9</sup>Urban redevelopment in Milwaukee began in the late 1950s in response to the growing problems facing the urban core, but by the mid-1960s local politicians and business leaders also envisioned upscale projects to expand and revitalize the central business district. While the earliest such projects were commercial, by the 1970s Prospect Avenue was lined with new semi-luxury apartment buildings. See Goldbach, et. al., *ip. cit.*, p. 173 ff. Today, tracts north of the central business district register a high proportion of one- and two-person households, above-average median household income, and a high percentage of workers in ✓

With the rise of newer urban centers to the west in the 1870s, Milwaukee was forced to shift from agricultural trading to specialized processing (beer, meat packing) and heavy manufacturing -- and new plants brought new rail networks. As early as 1880 the city's two main employers were outside the city limits -- the Bay View Steel Mills, two miles south on the lakeshore, and the car shops of the Milwaukee Road, two miles west on the Meonomonee.<sup>10</sup> By the turn of the century, the departure of several major firms from the central city foreshadowed the incorporation of industrial satellites in West Milwaukee, South Milwaukee, West Allis, and Cudahy. "Edge cities" of a different sort, these blue-collar industrial suburbs remain anomalies in the urban density cone (Figures 3, 4).

The transition from a commercial to an industrial economic base also changed the local political culture. Milwaukee's business leaders were in many ways quite progressive, but eyed cautiously the city's rapidly growing low-wage working class. Patrick Cudahy responded by financing homeownership for employees of the Cudahy Brothers Packing Company in his company built suburb, today evident as tracts of medium-density housing alongside industrial zones (Figures 3, 4).<sup>11</sup> In city government, the emphasis was on tight regulation of the emerging street railways. Suspicious of competition between lines more interested in suburban real estate speculation than transit, city government was directed towards maintaining low fares, fares that a workingman might afford.<sup>12</sup> Consequently, Milwaukee's streetcar network remained rather limited, yielding high densities in the areas served while postponing the wholesale suburbanization of housing until the 1920s.

Politically, these local circumstances mediated the familiar conflict between suburban municipalities and the central city. The wave of upper-class suburban municipal incorporation began shortly after the turn of the century with Shorewood and Whitefish Bay, promising to underbound Milwaukee in the mold of many American cities. Indeed, an enterprising suburban attorney steered lower municipal

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managerial, professional, and sales occupations (of the total 2,603 persons in Tract 108, for instance, fully 1,105 of those over 25 had at least some college; 693 recorded the aforementioned occupations).

<sup>10</sup>McShane, C. (1974), *Technology and Reform: Street Railways and the Growth of Milwaukee, 1887-1900*, Madison, University of Wisconsin Department of History, p. 42.

<sup>11</sup>*Ibid.*, p. 49.

<sup>12</sup>*Ibid.*, p. 51.

incorporation requirements through the legislature to create "paper cities" in the undeveloped southern townships of Franklin and Oak Creek.<sup>13</sup> But thanks to an annexation program begun in the 1920s, culminating in Mayor Frank Zeidler's aggressive expansion drives of the 1950s, Milwaukee managed to escape the worst of metropolitan balkanization. By mid-century, then, Milwaukee's main northwestern corridor of middle-class residential expansion was left relatively unencumbered by physical or municipal barriers, while physical and political boundaries delineated comparatively stable sectoral submarkets to the north and west. Thus density patterns in those neighborhoods situated at the origins of these expansion corridors reflect the complex forces of intraurban migration and metropolitan growth. The Highland Boulevard area west of downtown once served as gateway to German immigrants, but by the 1960s the street once called "Sauerkraut Boulevard" formed the southern boundary of a 300-block inner-city African-American ghetto.<sup>14</sup> Today, the area is characterized by high densities of population and housing (Figures 3, 4), concentrations of "standing room only" units (Figure 5), and a high rate of tax delinquency and abandonment (Figure 7).

Each of these historical conditions helps explain residuals from the general distance-density decay patterns of Milwaukee (Figures 3, 4, 5). Incorporating these residuals into subsequent tests improves the model's performance considerably (Figure 8, Table 1).

*Conclusions:*

Today, many human geographers are rightly cautious toward abstract models. Yet the generation of research based on Clark's observations on distance-density decay models has shown that examining specific historical processes can help explain observed general patterns, and that at least in this case the idiographic and nomothetic need not be mutually exclusive approaches.

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<sup>13</sup>Schmandt, et. al., *op. cit.*, p. 5.

<sup>14</sup>On a Metropolitan scale, the Menomonee is the barrier to southward migration, and local social critics call the valley the "Mason Dixon." See Schmandt, et. al., *op. cit.*, p. 173.

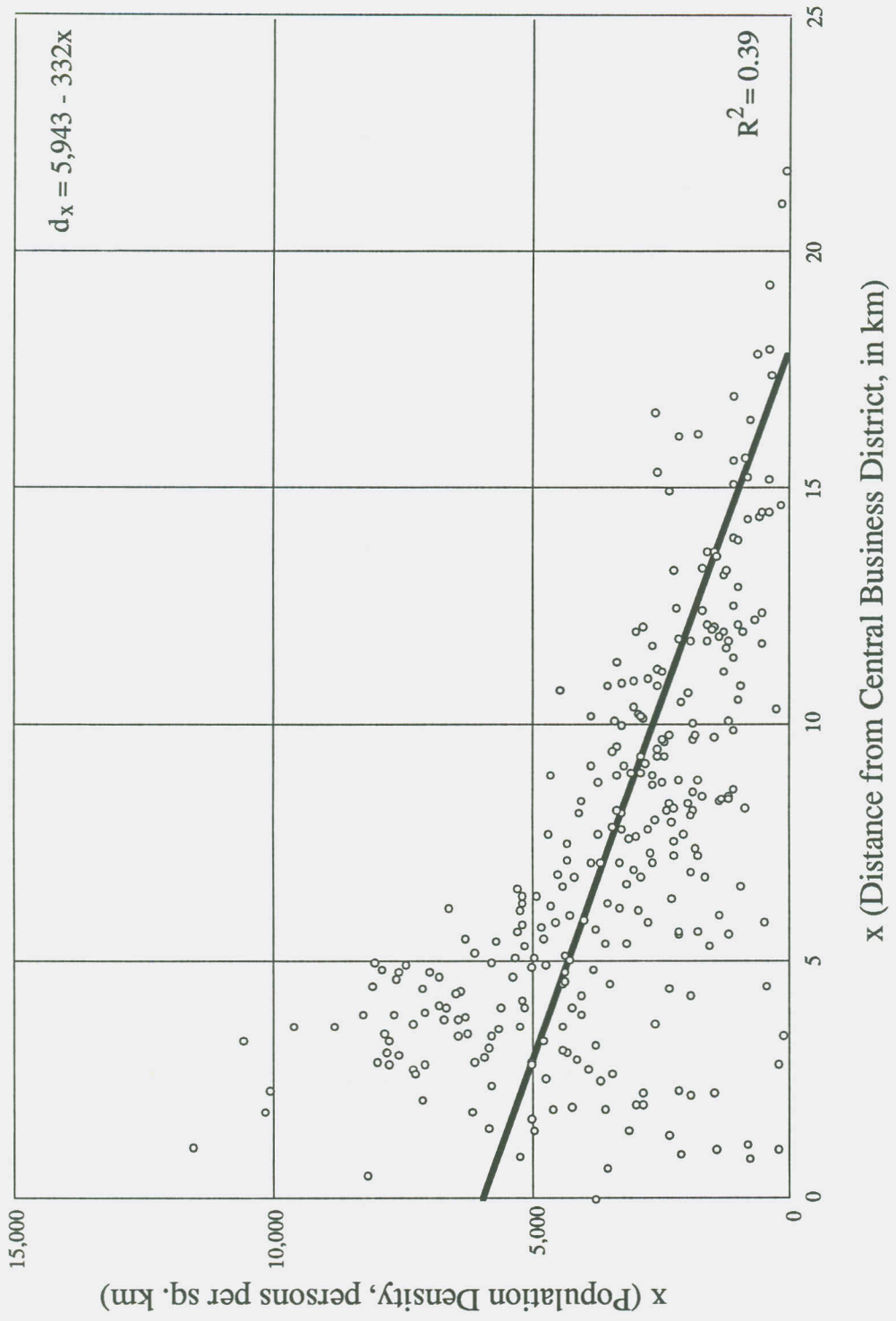


Figure 1. 1990 Population Density as a function of Distance from the Central Business District, Milwaukee County.

Source: computed using data from U.S. Census of Population and Housing.

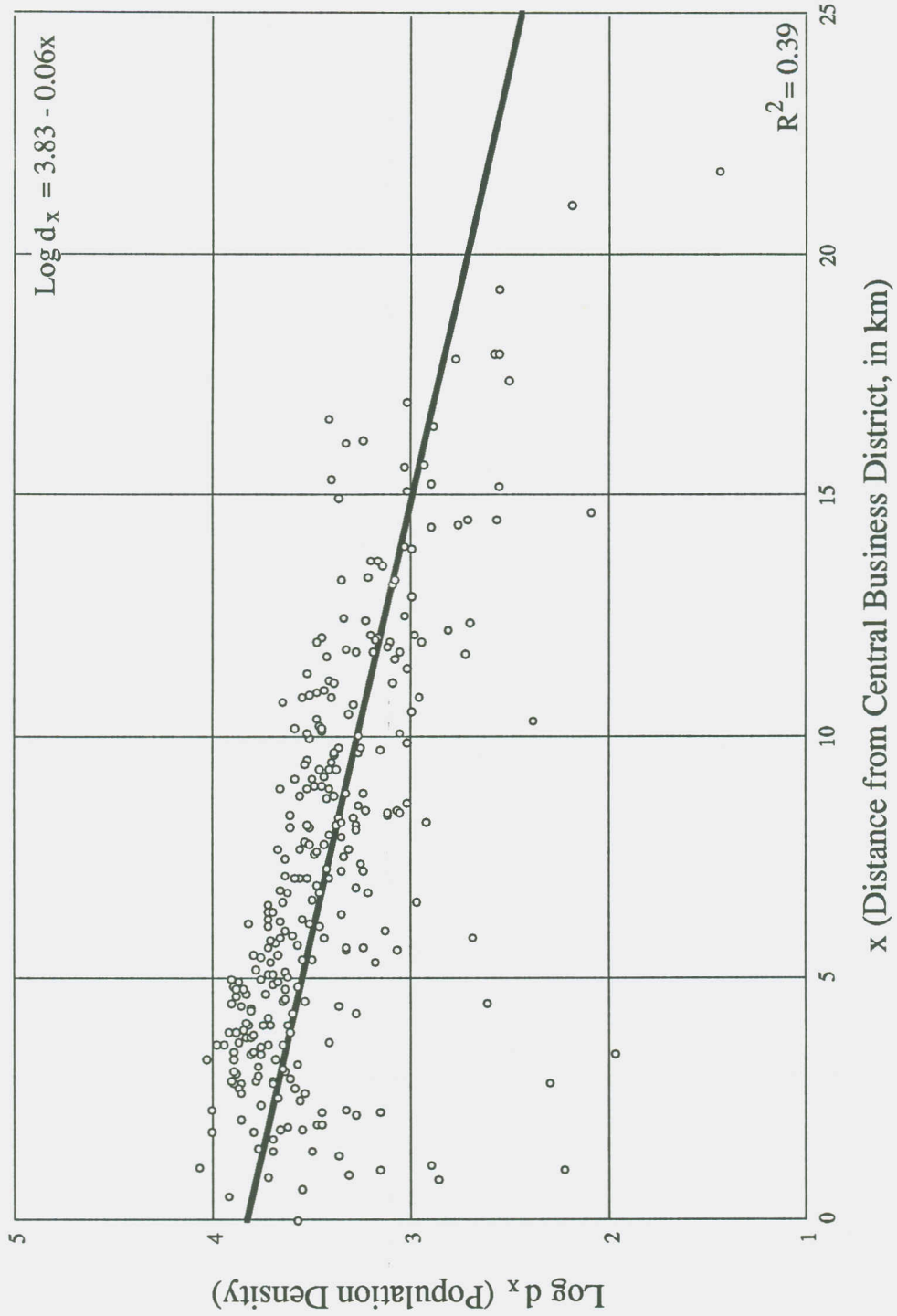
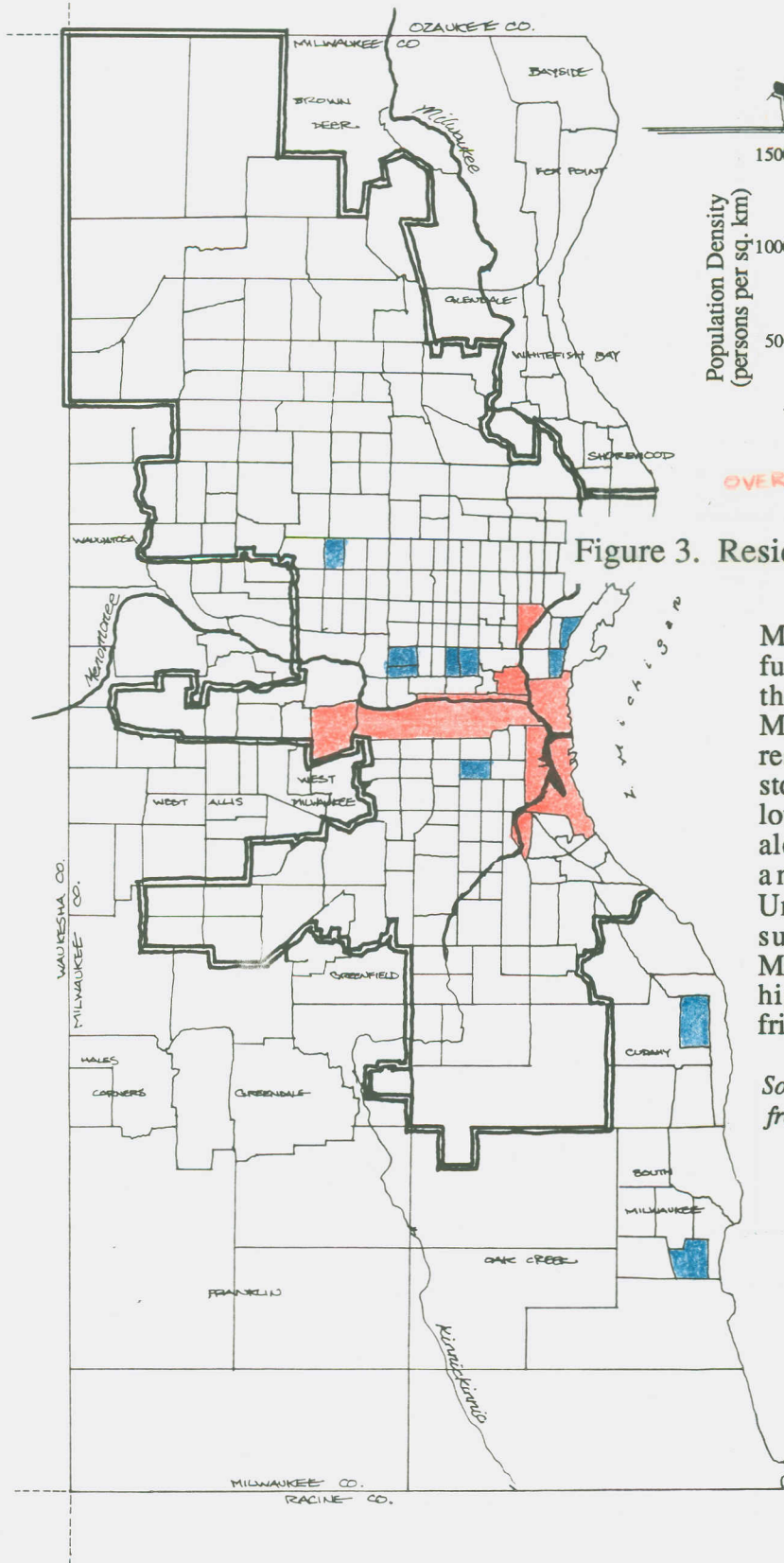


Figure 2. Log of 1990 Population Density as a function of Distance from the Central Business District, Milwaukee County.

Source: computed using data from U.S. Census of Population and Housing.





# MILWAUKEE!

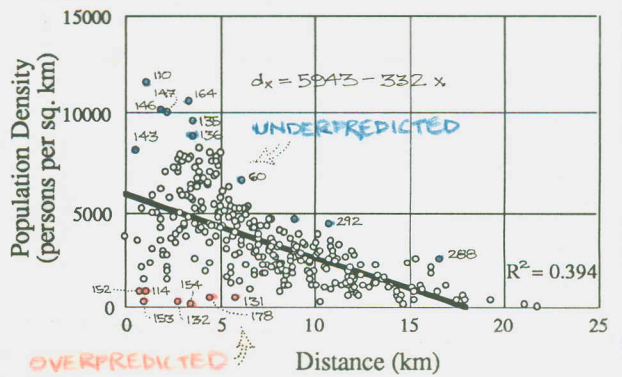
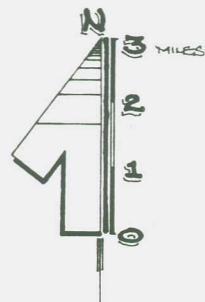
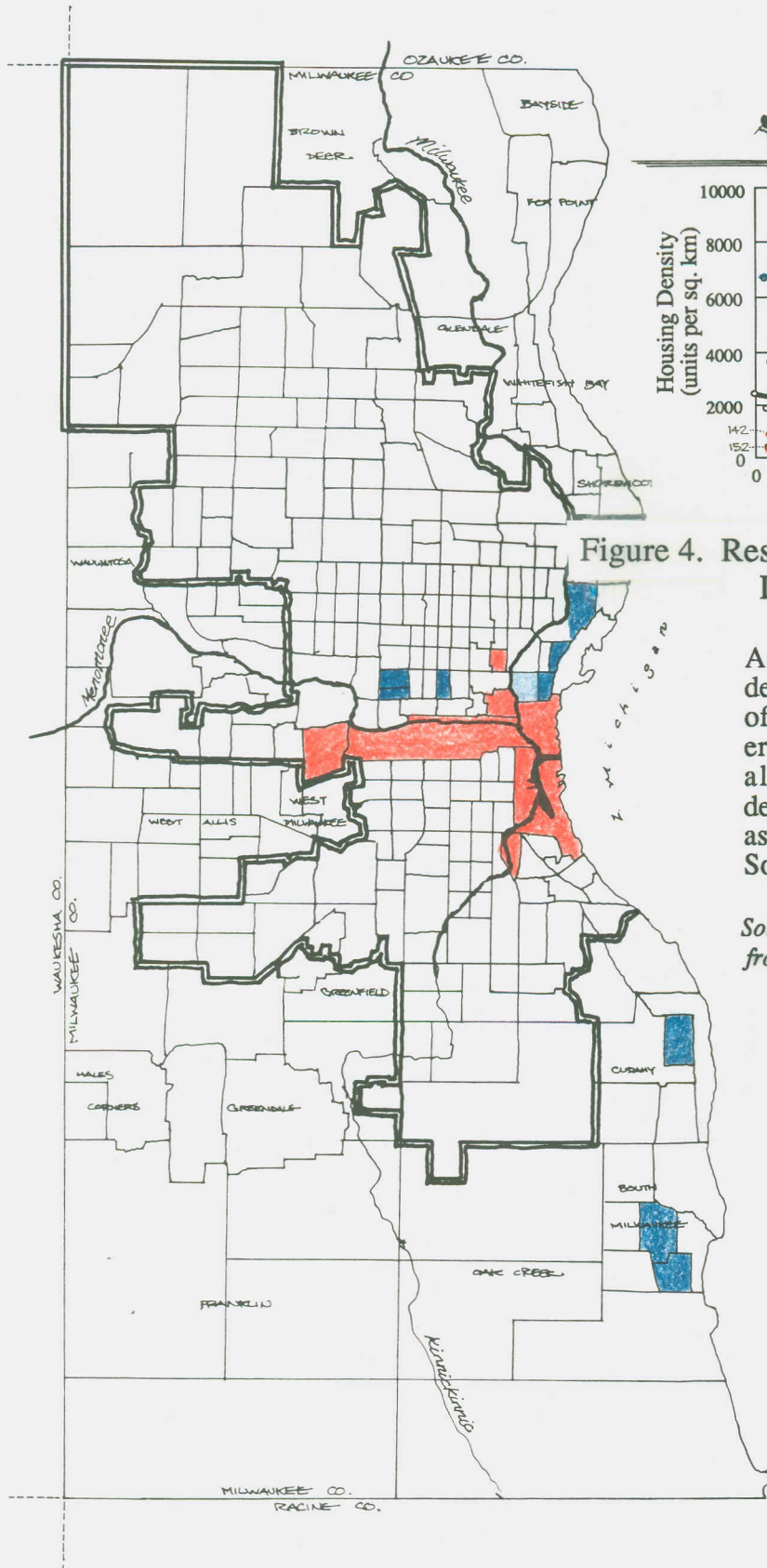


Figure 3. Residuals, Population Distance-Density Decay Model, Milwaukee County.

Modeling population density as a function of distance from the CBD for the entire sample of 297 tracts in Milwaukee County yields meager results, yet each of the residuals tells a story. Overpredicted tracts (those with lower than expected densities) cluster along the industrialized Menomonee and Kinnickinnic (red). Underpredictions include the industrial suburbs of Cudahy and South Milwaukee, as well as parts of the old high-density neighborhoods on the fringe of downtown.

Source: author's computations, based on data from the 1990 U.S. Census of Population and Housing.





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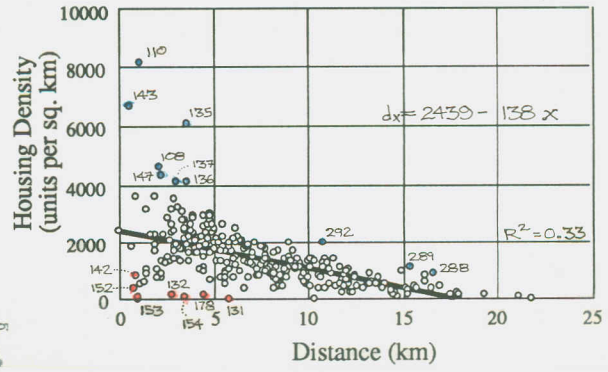
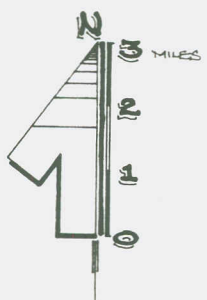
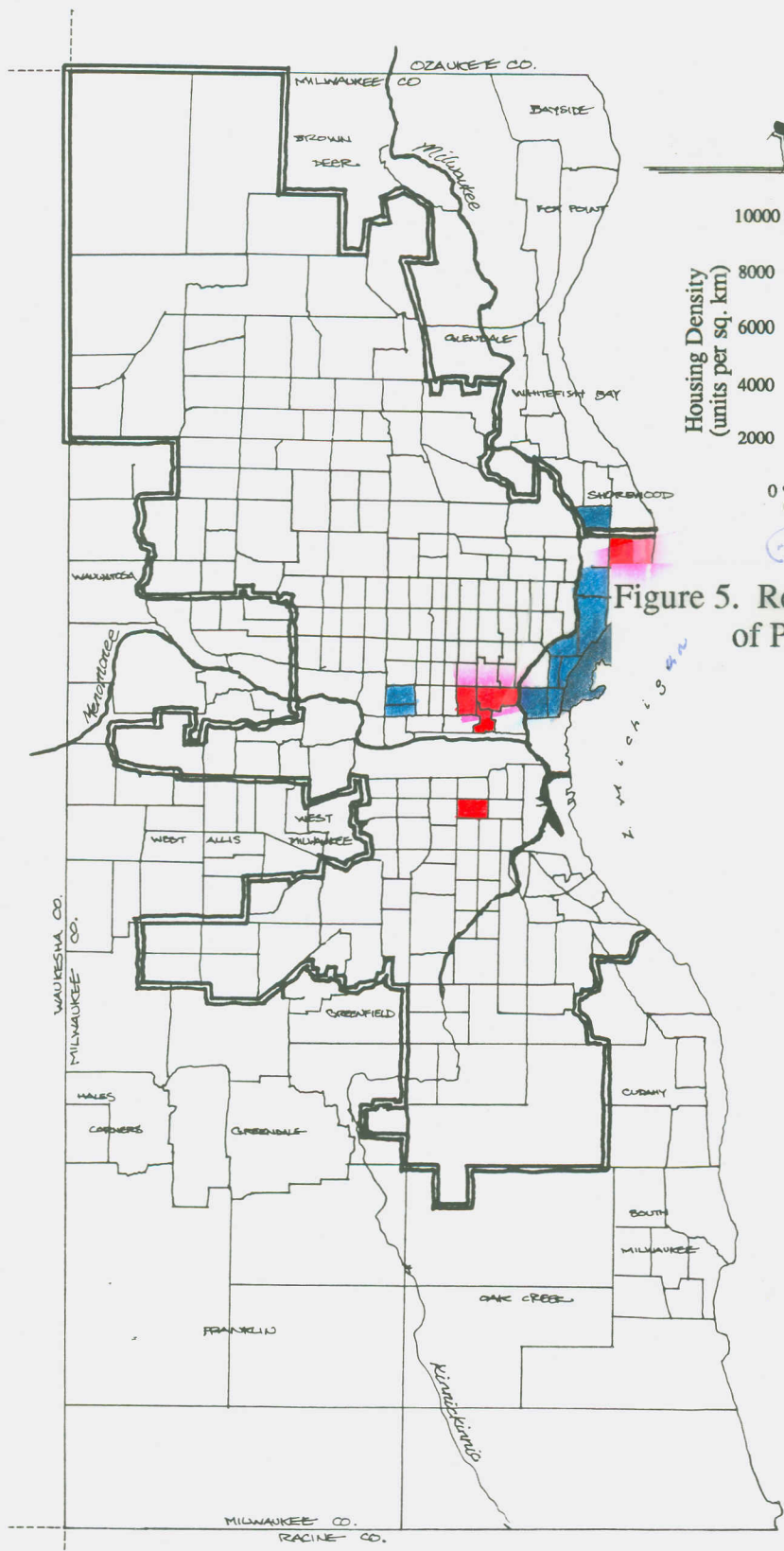


Figure 4. Residuals, Housing Distance-Density Decay Model, Milwaukee County.

As with population density, housing density residuals reflect different cycles of city building in different transport eras. Industry laid first claim to land along the river valleys, and decentralized industrial suburbs appear as high-density residuals in Cudahy and South Milwaukee.

Source: author's computations, based on data from the 1990 U.S. Census of Population and Housing.





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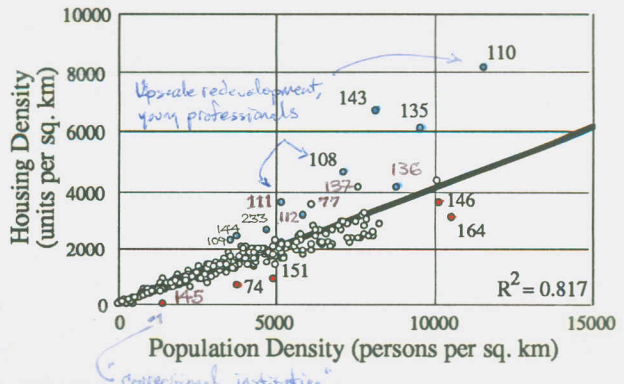
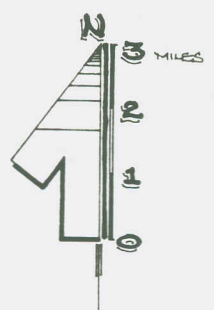


Figure 5. Residuals, Housing Density as a function of Population Density, Milwaukee County.

Housing density is not perfectly correlated with population density. While the residuals are not to be confused with household size (different census variables) they nevertheless reflect differences in housing arrangements. Tract 145, for instance, encompasses an 880-person correctional institute, therefore recording a population density of 1,000 persons per sq. kilometer, with scarcely a dozen housing units.

Source: author's computations, based on data from the 1990 U.S. Census of Population and Housing.



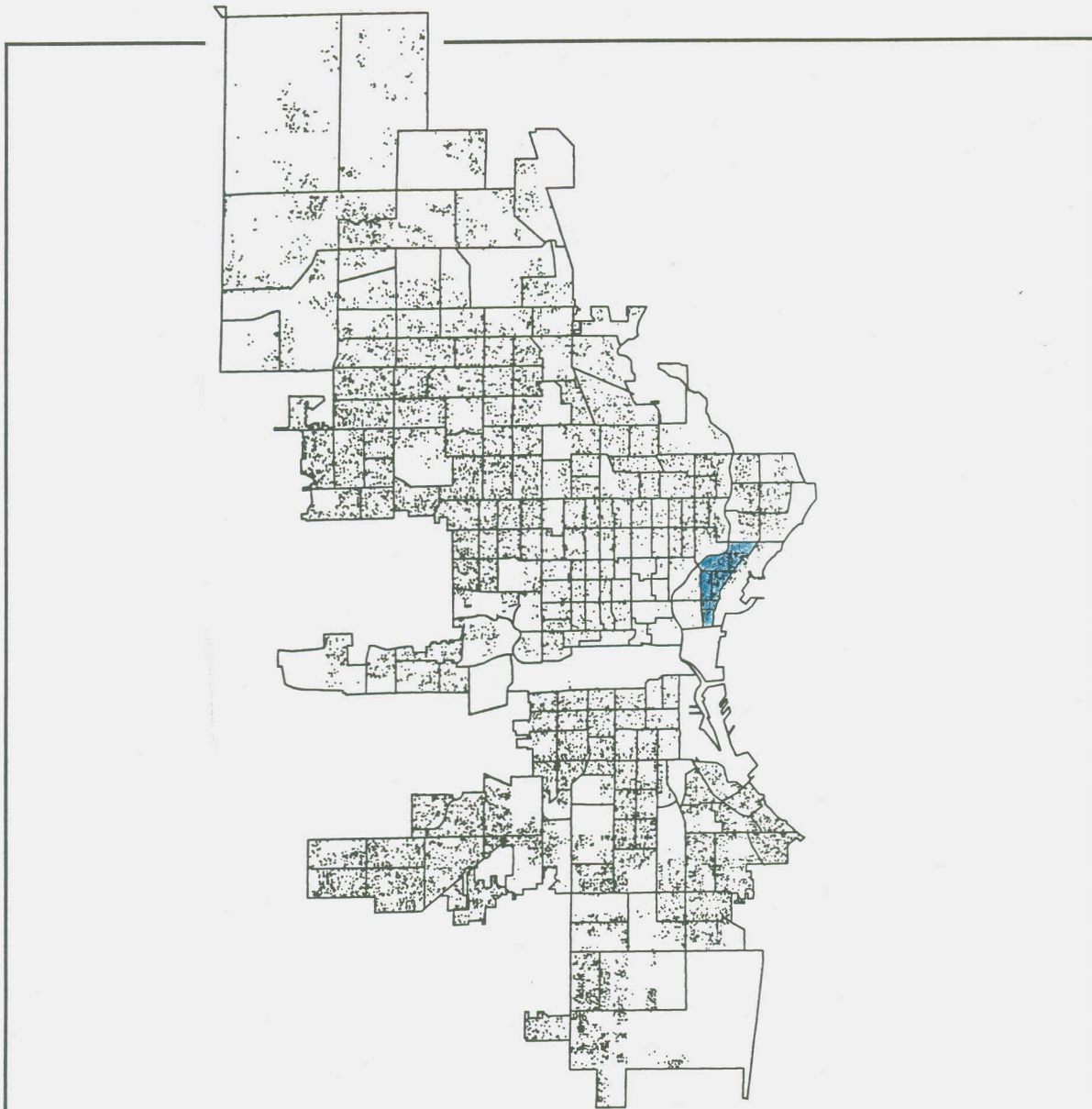
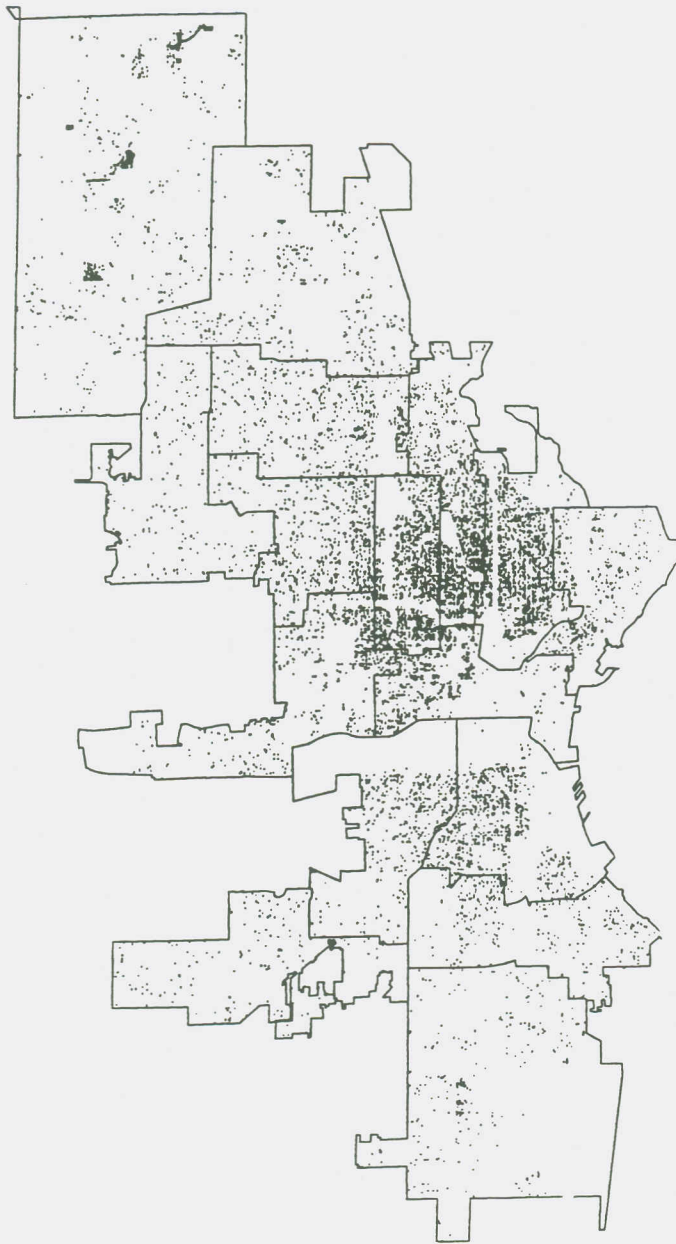


Figure 6. Distribution of Residential Building Permits Issued in the City of Milwaukee, by census tract, c. 1991.

The intraurban distribution of new building permits provides an estimate of housing construction trends, reflecting existing landuse patterns as well as the changing face of the residential landscape. Areas around the port facilities and along the industrial corridors of the Menomonee and Kinnickinnic record virtually no residential construction, while undeveloped land can still be found in some of the outlying townships of the north and south. The most aggressive activity follows the dynamic residential sector toward Wauwatosa (to the northwest) and a swath of available land between the industrial suburbs of West Allis and the greenbelt communities of Greendale (southwest). The northwest fringe of downtown remains an inner-city ghetto area, but recent development helps explain the density-decay residuals of tracts (shaded blue) in the upper-class sector across the river overlooking the lakefront.

*Source: shamelessly swiped from Huxhold (1991), Urban Geographic Information Systems, New York, Oxford, p. 89. Reproduced without permission.*

Figure 7. Tax-Delinquent Properties in the City of Milwaukee, by Aldermanic District, c. 1991.



Intraurban patterns of population density are the result of a dynamic and continuous process of residential mobility, gauged here by the distribution of tax-delinquent properties. New construction on the urban periphery draws movers from sectoral housing markets, setting in motion series of vacancy chains that culminate in deterioration and abandonment near the city center. In Milwaukee, vacancies accumulate in a 300-block area north of Highland Avenue and west of the Milwaukee River, at the origin of the metropolitan area's most dynamic corridor of middle-class residential expansion.

Delinquencies in the northern part of the city provide an insightful window on local economic conditions. Parcels in two suburban subdivisions have been vacant -- and delinquent -- for upwards of four years. City policy provides for legal action only after four years of delinquency, and low penalties encouraged developers to invest at the higher prevailing interest rates until housing demand recovered. (See Huxhold, p. 102 ff).

*Source: shamelessly swiped from Huxhold (1991), Urban Geographic Information Systems, New York, Oxford, p. 108. Reproduced without permission.*

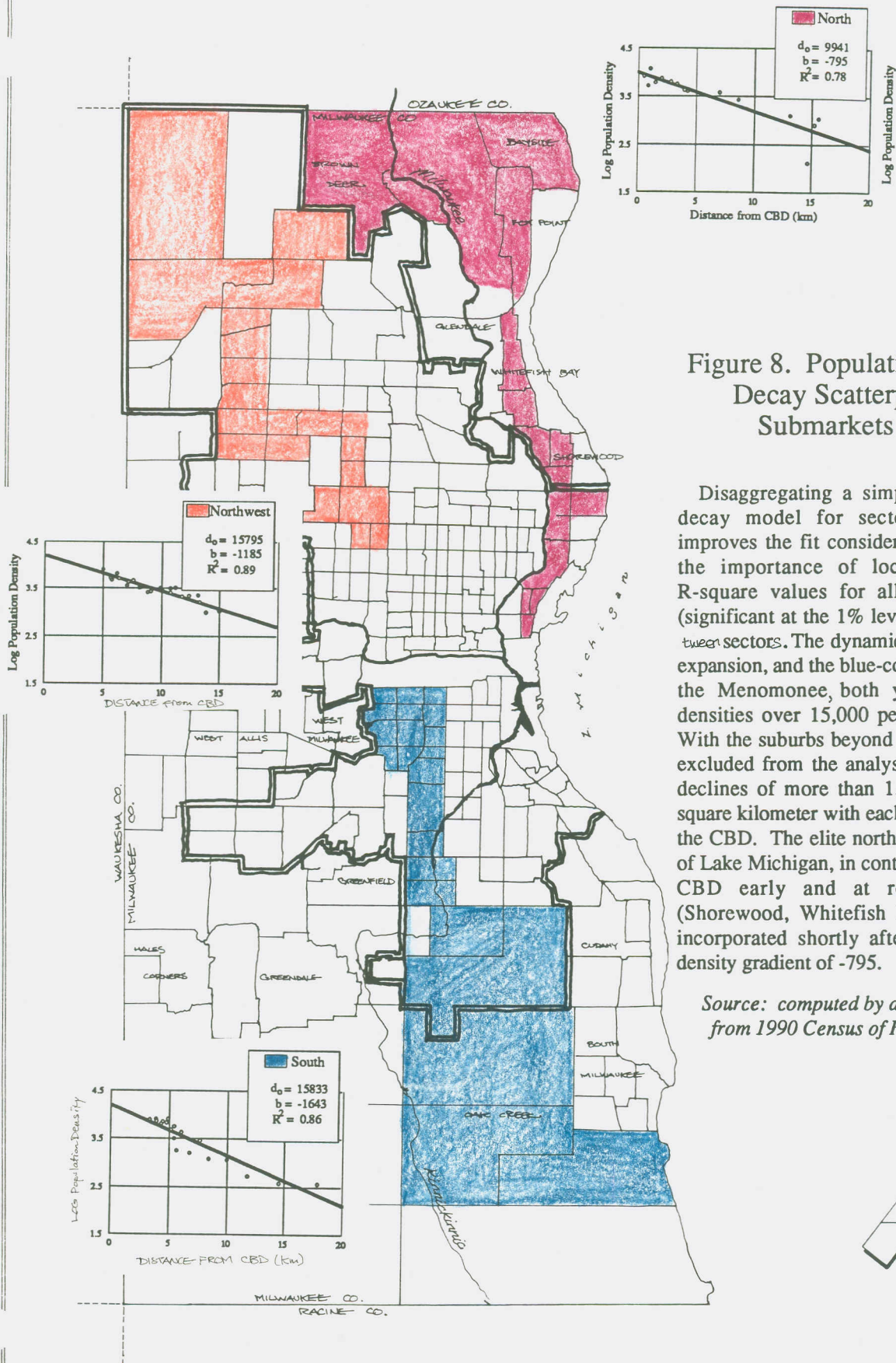


Figure 8. Population Distance-Density Decay Scatterplots for Sectoral Submarkets in Milwaukee.

Disaggregating a simple linear distance-density decay model for sectoral housing submarkets improves the fit considerably, and also underscores the importance of local historical conditions. R-square values for all three tests exceed 0.78 (significant at the 1% level), but parameters vary between sectors. The dynamic corridor of northwestward expansion, and the blue-collar neighborhoods south of the Menomonee, both yield extrapolated central densities over 15,000 people per square kilometer. With the suburbs beyond the Milwaukee County line excluded from the analysis, density gradients imply declines of more than 1,100 and 1,600 people per square kilometer with each kilometer of distance from the CBD. The elite northern suburbs along the shore of Lake Michigan, in contrast, grew outward from the CBD early and at relatively high densities (Shorewood, Whitefish Bay, and Fox Point were incorporated shortly after 1900) yielding a lower density gradient of -795.

Source: computed by author, using data derived from 1990 Census of Population and Housing.

Table 1. Results of Linear Distance-Density Decay Models, Milwaukee, Wisconsin, 1990.

		Population Density <sup>a</sup>						
Test	Sample	Model	N	$d_0^b$	$b^c$	R <sup>2</sup>	R	p
1	Milwaukee County	$d_x = d_0 + bx$	297	5,943	-332.0	0.394	0.627	0.000
2	Milwaukee County	$\text{Logd}_x = \text{Logd}_0 + bx$	297	6,833	-382.7	0.389	0.624	0.000
3	Milwaukee City	$d_x = d_0 + bx$	218	6,068	-338.8	0.260	0.510	0.000
4	Northwest Sector <sup>†</sup>	$\text{Logd}_x = \text{Logd}_0 + bx$	23	15,795	-1,185.0	0.891	0.944	0.000
5	Southern Sector <sup>†</sup>	$\text{Logd}_x = \text{Logd}_0 + bx$	20	15,833	-1,643.7	0.863	0.929	0.000
6	Northern Sector <sup>†</sup>	$\text{Logd}_x = \text{Logd}_0 + bx$	17	9,941	-795.1	0.784	0.885	0.000
		Housing Density <sup>d</sup>						
Test	Sample	Model	N	$d_0$	$b$	R <sup>2</sup>	R	p
7	Milwaukee County	$d_x = d_0 + bx$	297	2,439	-138.4	0.332	0.576	0.000
8	Milwaukee County	$\text{Logd}_x = \text{Logd}_0 + bx$	297	2,635	-145.2	0.300	0.547	0.000
9	Milwaukee City	$d_x = d_0 + bx$	218	2,499	-145.5	0.217	0.466	0.000
10	Northwest Sector <sup>†</sup>	$\text{Logd}_x = \text{Logd}_0 + bx$	23	5,919	-436.2	0.852	0.923	0.000
11	Southern Sector <sup>†</sup>	$\text{Logd}_x = \text{Logd}_0 + bx$	20	6,182	-640.6	0.870	0.933	0.000
12	Northern Sector <sup>†</sup>	$\text{Logd}_x = \text{Logd}_0 + bx$	17	6,158	-590.0	0.812	0.904	0.000

Notes:

a Derived from 100-percent count of persons, by census tract.

b Extrapolated central density, expressed as persons per km<sup>2</sup>.

c Density gradient, expressed as persons per km<sup>3</sup>.

† Sample excludes tracts without significant residential construction activity.

d Derived from 100-percent count of (total) housing units.

Source: Computed by author, using data derived from 1990 Census of Population and Housing.