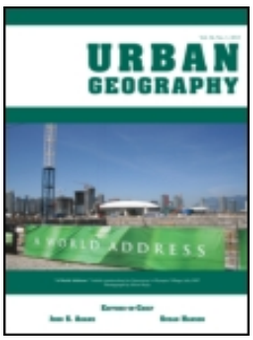

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A MODEL FOR IDENTIFYING GENTRIFIED AREAS WITH CENSUS DATA[1]

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Abstract: Empirical research on gentrification suffers from a dichotomy between richly detailed neighborhood case studies and macro-scale, census-based analyses, perpetuating uncertainty over the extent and timing of gentrified areas in American cities. We develop a model relating tract-level census statistics to the results of a detailed field survey of 24 census tracts in Minneapolis-St. Paul. We use stepwise and canonical discriminant analysis to select nine variables distinguishing gentrified neighborhoods and to classify all central-city tracts for each decade between 1960 and 1990. Results indicate a moderate level of overall accuracy, and the model is more than 90% accurate in distinguishing areas of heavy reinvestment from stable, middle-class districts. Compared with other techniques, our approach more accurately distinguishes gentrification from other types of inner-city redevelopment, providing a useful tool for identifying the phenomenon with a measurable degree of precision.

Research on gentrification in North American cities has grown rapidly in the last two decades. In urban geography, most recent work has been theoretical, representing a significant departure from the empirical case-study approach common in the 1970s. Consequently, alternative theories of the causes and implications of the phenomenon have advanced considerably, while important empirical questions remain shrouded in mystery. After nearly 20 years of research, analysts still disagree on the extent, timing, and location of gentrified neighborhoods in American cities.

The uncertainty over the extent of gentrification stems not only from the complexity of the process, but also from the difficulty of observing and measuring the phenomenon. The U.S. census is the most comprehensive and comparable source of data on changes in urban neighborhoods, but the use of census variables to identify gentrification is highly problematic. These limitations prompt many geographers to eschew census data in favor of intensive field surveys or other qualitative methods to document inner-city reinvestment. There is thus a substantial dichotomy between neighborhood-based studies, which provide little comparability between different settings, and extensive census-based analyses that include little attempt to verify results. With few exceptions, scholars fail to integrate fieldwork with rigorous analysis

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of census data. What changes in gentrifying areas are most easily observed in aggregate census data? Which variables help to distinguish gentrifying areas from other kinds of urban neighborhoods?

In this paper, we present the initial results of a model to integrate field research with census-derived indicators of gentrification, as a step toward comparative work on the extent and timing of the phenomenon in North American cities. We use Minneapolis–St. Paul as a case study, developing a simple model to identify gentrified neighborhoods with the use of tract-level census data. We adopt a strategy best described as "ground-truthing" census data. First, we undertake a field survey to document the extent and nature of neighborhood change in the inner city, consulting local experts and published work as well as our own familiarity with the area. We then use discriminant analysis to calibrate a series of models with tract-level indicators of gentrification. The resulting models provide reasonably accurate classifications, and encourage us to refine the approach in order to apply similar methods in other cities.

BACKGROUND

Urban scholars have studied gentrification in many neighborhoods, described the processes by which inner-city neighborhoods undergo reinvestment, and offered several alternative explanations for the phenomenon.[2] Yet with few exceptions, scholars have failed to test the methods used to identify gentrified areas. As a consequence, we are left with an unclear picture of the extent, timing, and location of gentrification, and analysts disagree over its significance for urban theory (e.g., Bourne, 1993).

Among those empirical studies systematically analyzing the extent and location of gentrification, there has been an enduring dichotomy between detailed case studies and census-based analyses. On the one hand, the local case-study approach relies on local informants or detailed field surveys to identify areas undergoing revitalization, providing richly detailed accounts of neighborhood change at a block-by-block level (e.g., Gale, 1979; Fusch, 1980). Yet these surveys yield few comparable results, and few studies examine the relations between survey- and census-derived indicators.

On the other hand, attempts to compare the extent of gentrification across different cities rely on aggregate statistics, with little attempt to evaluate the results in the field (Lipton, 1977; Ley, 1986). These studies typically draw on census data to identify neighborhoods experiencing changes in hypothesized indicators of gentrification: income, occupation, education, housing value, and rent. Analyzed separately, however, these indicators often fail to distinguish gentrification from other types of neighborhood change. While an influx of affluent professionals typically boosts average levels of income and rent, for example, the same statistical portrait often emerges after publicly subsidized housing redevelopment for low-income households.

As a consequence of the fieldwork/census dichotomy, the extent, timing, and location of gentrified areas remain unclear. In the absence of any well-developed alternative, comparative examinations of gentrification necessarily rely on problematic methods, such as surveys of public officials (e.g., Black, 1975) or surveys of published accounts (e.g., Beauregard and Cousins, 1981). In this study, we develop an alternative method and seek to bridge the gap between the neighborhood case-study

TABLE 1.—CRITERIA USED TO IDENTIFY IMPROVED STRUCTURES

I. Surrounding neighborhood must have experienced sustained period of decline, disinvestment, and poverty

II. Structure must show visible evidence of reinvestment and renovation:

Single-family homes:
Structurally sound
Reconstruction of:
Latticework
Gutters
Steps
Porches
Windows and frames
Fences
Renovations to accessory structures
Security system

Multiple-unit buildings (4 or more dwelling units):
Structurally sound
Sandblasted brick
Prominent entryway and signage
Lobby and foyer appointments
Porch furniture
Security system

and census-based approaches. First, we conducted a house-by-house field survey to identify gentrified neighborhoods in Minneapolis and St. Paul. Second, we developed a multivariate statistical model to select census variables distinguishing gentrified areas from other types of urban neighborhoods. The encouraging results of this analysis suggest that the approach may be applied in different settings, as an initial step toward building a comparative database of gentrification in American cities.

METHODS

Field Survey

In early 1994 we conducted a field survey of selected neighborhoods to develop a map of gentrified areas in Minneapolis and St. Paul. We adopted a working definition of gentrification as the replacement of low-income, inner-city working-class residents by middle- or upper-class households, either through the market for existing housing or demolition to make way for new upscale housing construction.[3] We studied 24 census tracts, selected on the basis of our familiarity with the cities and by consulting published materials and local experts (Martin and Lanegran, 1983; Adams and VanDrasek, 1993). We surveyed all tracts in Minneapolis–St. Paul that showed any indication of gentrification, including several neighborhoods where reinvestment appeared to be in the formative stages. All of these areas experienced sustained periods of decline, followed in some by an influx of investment in residential property. We identified reinvestment by evaluating the physical condition of each house and multiple-unit structure according to a predetermined set of criteria (Table 1).

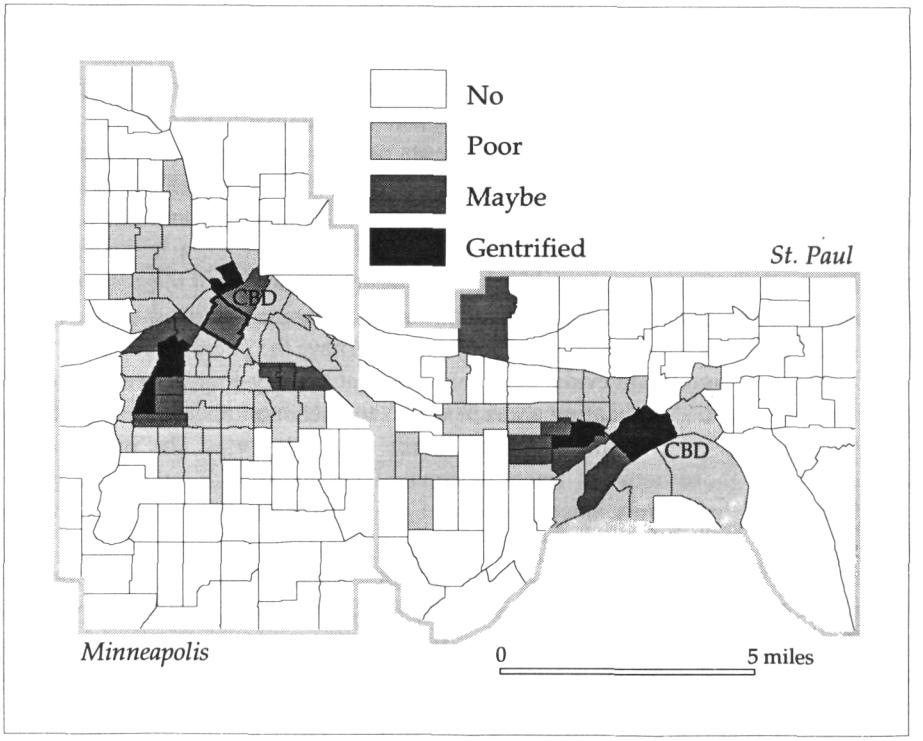

Fig. 1. *A priori* classification of census tracts in Minneapolis-St. Paul. Categories were defined on the basis of house-by-house field survey in 24 census tracts in the "poor," "maybe," and "gentrified" areas during January 1994.

Gentrification is a social and economic phenomenon, but visible evidence of reinvestment in the housing stock is a near-universal byproduct of the process, providing a good indicator for our study. We paid particular attention to a wide range of improvements that reflect significant reinvestment in residential structures, such as the quality and style of repainting, the degree of ornamentation, and reconstruction of latticework, steps, and porches. On multiple-unit apartment houses, we examined the prominence and style of lobbies, entryways, signs, and other appointments. We classified each structure in the 24 selected census tracts as "improved," "unimproved," or "new," the latter category depicting upscale housing units built after 1960.[4]

On the basis of the results of the field survey, we classified each census tract in Minneapolis-St. Paul into one of four distinct categories (Fig. 1). First, tracts must have experienced a sustained period of decline in order for subsequent neighborhood change to conform to conventional definitions of gentrification. We identified tracts with median household income below the central city median in 1960.[5] This group constitutes the set of neighborhoods with the *potential* for gentrification; from this pool of tracts, we identified gentrified and partially gentrified areas. Second, we labeled seven tracts that had experienced substantial reinvestment as "gentrified." As a general rule, these tracts have at least one improved housing structure on a majority

of the blocks, and at least one-third of all structures show evidence of reinvestment. The latter threshold, however, may be slightly lower if the level of reinvestment in each structure appears to be unusually high; conversely, the proportion of improved structures must be higher if the level of investment in individual structures is more modest. Third, we labeled 16 borderline cases as "maybe." Reinvestment in these areas is at a comparatively lower level, or confined to such a small area that we questioned whether the changes are significant at the neighborhood level. These tracts also must have a minimum of one improved structure on a majority of the blocks, but only a minimum of one block where at least one-third of the structures are improved. Fourth, any remaining tracts with median incomes below the central city median in 1960 were labeled as "poor"—these areas have the potential for gentrification, but show no significant evidence of reinvestment activity. Finally, we designated all other tracts as "no," indicating areas in which socioeconomic changes should not be confused with gentrification. Among these four categories, the most crucial distinctions are those between tracts designated as "gentrified" and those in the "poor" and "no" categories, since our central goal is to separate inner-city reinvestment from other types of neighborhood change.

The map of gentrified areas is the product of several decades of neighborhood change. For a metropolitan area of its size, the Twin Cities has experienced substantial gentrification in the last 25 years. The metropolitan economy has remained healthy even through the last several recessions, and Minneapolis, in particular, has succeeded in expanding its downtown base of high-paying white-collar jobs. Both cities have good supplies of sturdy, late-Victorian houses that are easily renovated into attractive homes with historic character. In St. Paul, the central business district (CBD) remains physically separated from the surrounding neighborhoods, resulting in a concentration of historic structures in the Ramsey Hill area on the bluffs west of downtown. By contrast, the expansion of the Minneapolis CBD over the last half-century has replaced much of the housing on the fringe of downtown with commercial uses. Yet Minneapolis also included upscale residential redevelopment in urban renewal efforts after the 1960s, aided by tax increment financing (TIF) and similar mechanisms. The result is a downtown core bordered on the north and south by new high-rises occupied mostly by middle- and upper-middle-class residents.

The Loring Park neighborhood provides an example of this type of redevelopment (Fig. 2). The area was targeted as a suitable site for private investment in the early 1970s, and the local development agency encouraged redevelopment through TIF districts. The 1920s-era apartment houses and a few remaining turn-of-the-century mansions were leveled, and the resulting redevelopment produced a mix of market-rate and subsidized units. Since the late 1970s the Loring Park area has seen the construction of nearly 2,000 luxury tower and townhouse units (Adams and Van-Drasek, 1993, p. 78). Just a few blocks to the southwest, in what is known as the "Wedge," high-density residential development along a prominent streetcar line left dozens of small apartment houses interspersed with sturdy, late-Victorian houses that were renovated beginning in the 1970s, so no new construction was completed (Fig. 3).

The map of categories is only a snapshot of conditions at the time of our survey. It represents the results of three decades of change, but most gentrified areas had

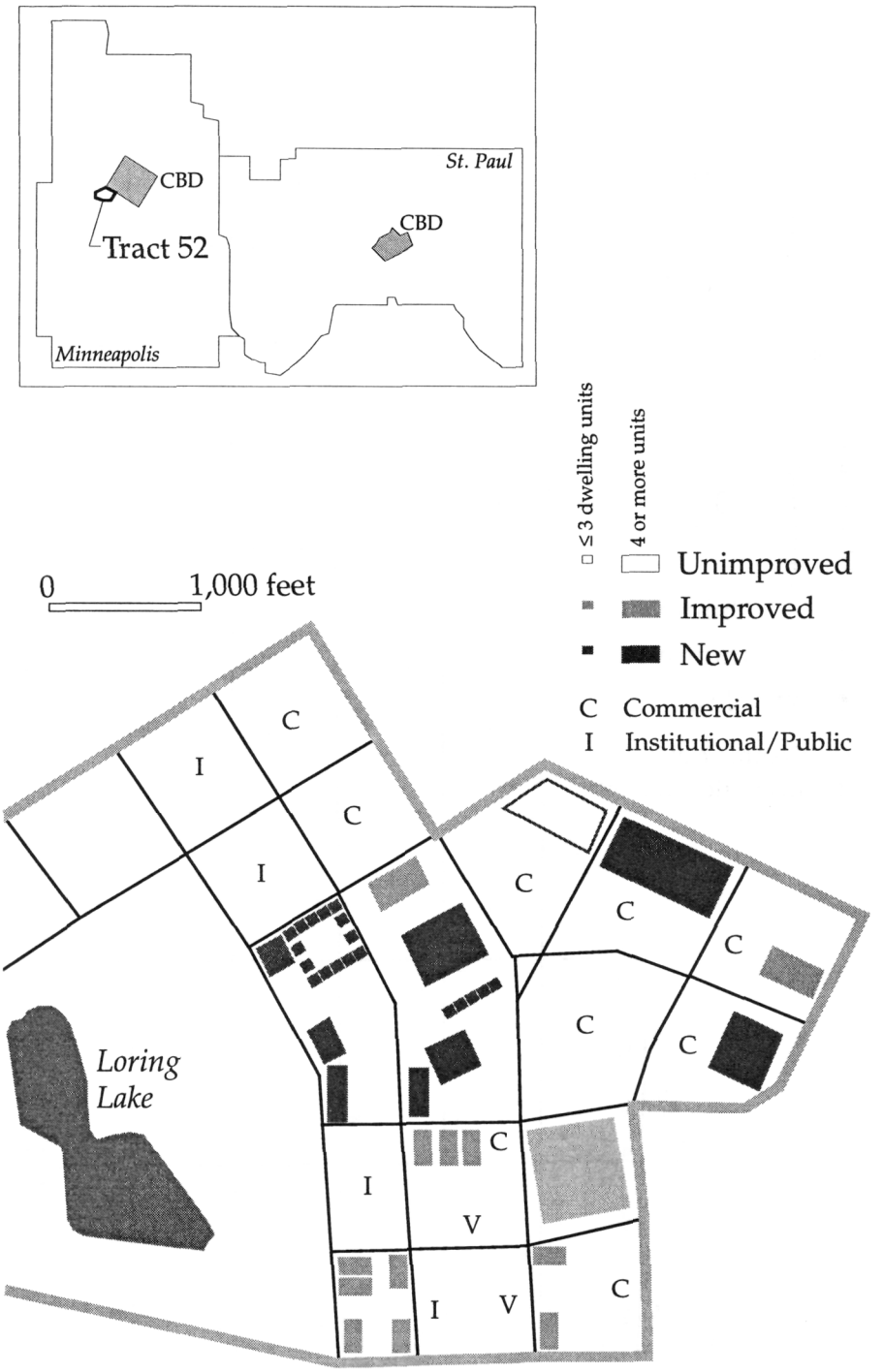

Fig. 2. Loring Park. Tract 52, on the southwest fringe of the Minneapolis CBD, experienced significant demolition and new construction in the late 1970s and early 1980s.

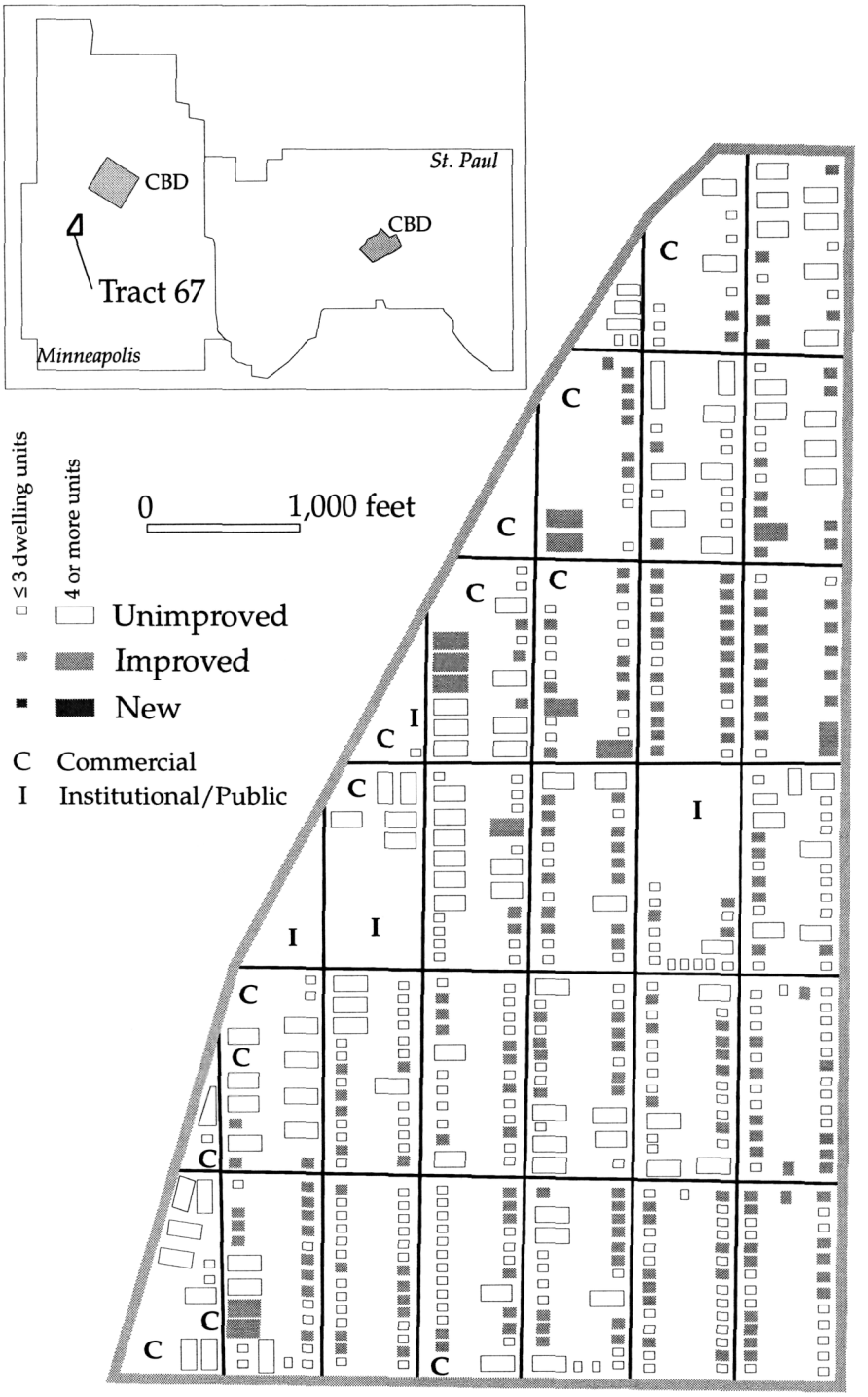

Fig. 3. The Wedge. Tract 67 includes scores of upgraded Victorian-era houses interspersed with streetcar-era apartments; no residential structures were constructed after 1960.

experienced some activity by the mid-1970s. Our approach, therefore, is to compare these categories with census data for each decade since 1960. We expect no interpretable results for the 1960s, since there was as yet little gentrification activity. We also expect some complications from the timing of downtown residential construction, which straddles census enumerations. Land was cleared for construction of most of the downtown upscale high-rises of Minneapolis, for example, in the late 1970s, but these structures were not completed until the mid-1980s.

By using data sets spanning three decades to identify currently gentrified neighborhoods, we operate under the explicit assumption that the phenomenon is a cumulative historical process. Although census-based indicators in 1970 may appear unrelated to the condition of the housing stock in the early 1990s, the changes in these indicators over the intervening years constitute the distinguishing feature of gentrified neighborhoods. For example, the Ramsey Hill neighborhood (west of downtown St. Paul) began to experience intense reinvestment in the early 1970s, as poor families were displaced by comparatively affluent households seeking out the historic apartment buildings and Victorian-era frame houses (Martin and Lanegran, 1983). By the middle of the 1980s, however, the process had largely run its course. Consequently, 1980 or 1990 indicators alone are insufficient to distinguish this neighborhood from stable middle-class areas of south Minneapolis that have changed relatively little in their aggregate socioeconomic profile since the 1920s (Adams, 1991; Adams and VanDrasek, 1993).

Variable Selection

The decennial Census of Population and Housing (U.S. Bureau of the Census, 1962, 1972, 1983, 1992) provides the most comprehensive and consistent source of data on urban neighborhoods, but suffers from serious limitations in gentrification research. First, the correspondence between census geography and gentrifying areas is imperfect and variable, with the phenomenon often straddling tracts. Some analysts suggest using block-group data (e.g., Schuler et al., 1992), but these data have limited availability prior to 1980 and suffer from repeated boundary shifts. In order to analyze the growth of gentrified areas over time, we therefore used tract-level data. We attempted to minimize the scale problem by defining two categories of gentrification ("gentrified" and "maybe"), thereby distinguishing marginal or small-scale reinvestment from areas undergoing pronounced and widespread change.

The second problem with census data involves the identification of the phenomenon. Although there is a well-developed literature on the kinds of social and economic changes resulting from gentrification processes, analysts disagree on which variables and thresholds provide the most reliable indicators. Our approach is to incorporate a variety of measures, analyzing their relative discriminatory power both separately and in combination. Household income is the most readily apparent index of the changing class composition of inner-city neighborhoods, but the measure fails to capture the full range of socioeconomic changes brought about by singles and young professionals who have not yet reached their peak earning years. Consequently, most analysts add variables to identify well-educated professionals and managers, and also examine changes in house value and rent (Lipton, 1977; Maher, 1978; Clay,

TABLE 2.—VARIABLES USED IN DISCRIMINANT ANALYSIS[a]

Socioeconomic variables:

1. Median household income
2. Change in median household income
3. Percentage of workers in managerial, professional, or technical occupations
4. Change in percentage of workers in managerial, professional, or technical occupations
5. Percentage of persons age 25 and over with 4+ years of college[b]
6. Change in percentage of persons with 4+ years of college[b]

Housing variables:

7. Median rent
8. Change in median rent
9. Change in median house value

Total population variables:

10. Persons
11. Employed persons
12. Workers employed in managerial professional or technical occupations
13. Persons age 25 and over with 4+ years of college[b]

[a]Change variables represent percentage change over previous decade; all other measures refer to end of decade.

[b]For 1990, percentage with bachelor's degree or higher.

1979; Gale, 1979; O'Loughlin and Munski, 1979; Hamnett and Williams, 1980; Ley, 1986).[6] We included six baseline and rate-of-change variables describing the socioeconomic composition of census tracts, and tabulated three indices depicting housing market conditions (Table 2).[7] Some studies use the racial composition of the neighborhood as an indicator of the displacement resulting from gentrification, but we chose not to use this variable for two reasons. First, changes in racial composition do not appear to be applicable for the majority of gentrified neighborhoods, particularly in the Twin Cities. Second, racial change is not an inherent feature of the gentrification process, which is fundamentally a class-based phenomenon.[8] Increase in population also has been identified in some instances (e.g., Ahlbrandt and Brophy, 1975), so we included four "total population" variables in an attempt to distinguish redevelopment in sparsely populated districts. In total, we used 13 variables drawn from the tract reports of the U.S. Census of Population and Housing, adjusting the values for boundary changes among tracts between census enumerations. We performed the analysis separately for each decade between 1960 and 1990.[9]

Discriminant Analysis

Our goal was to determine the degree to which summary census variables can distinguish between the types of neighborhoods we identified in the field survey. To develop a model for this purpose, we employed discriminant analysis, a multivariate statistical procedure commonly used to evaluate the validity of *a priori* classifications.

TABLE 3.—RESULTS OF STEPWISE DISCRIMINANT ANALYSIS

Model	Variables (in order of entry[a])	Wilks Lambda
1960-1970	1. Change in median household income (1960-70)	0.46
	2. Median rent (1970)	0.44
	3. Percentage with 4+ years of college (1970)	0.41
1970-1980	1. Median householdincome(1980)	0.70
	2. Change in median household income (1970-80)	0.55
	3. Percentage managerial, professional, and technical (1980)	0.48
	4. Change in median rent (1970-80)	0.45
	5. Median rent (1980)	0.42
	6. Change in median house value (1970-80)	0.40
	7. Percentage with 4+ years of college (1980)	0.38
	8. Number of employed workers (1980)	0.37
	9. Number of persons (1980)	0.35
1980-1990	1. Median household income (1990)	0.78
	2. Percentage with bachelor's degree (1990)	0.61
	3. Change in median household income (1980-90)	0.54
	4. Change in median rent (1980-90)	0.50
	5. Number of employed workers (1990)	0.46
	6. Percentage managerial, professional, and technical (1990)	0.43
	7. Number of persons (1990)	0.41
	8. Change in median house value (1980-90)	0.39

[a]Significance level to enter model = 0.15; level to stay = 0.15.

We first used stepwise discriminant analysis to select a set of census variables that best distinguished gentrified areas from other central-city neighborhoods. We then used this set of indicators to calibrate a canonical discriminant analysis, classifying each of the tracts in Minneapolis and St. Paul for each of the three decades in the study period.

We used stepwise discriminant analysis to evaluate the relative ability of each census variable to distinguish between the four predefined categories. At each step of this iterative procedure, the indicator best able to discriminate between the categories was added to the model, and that contributing least was removed. The iterations stopped when no variables met a specified criterion of statistical significance for inclusion or exclusion; given the exploratory nature of our analysis, we set $\alpha = 0.15$. Wilks lambda, the ratio of within-group to between-group variation, measures the discriminatory power of the model. Lambda values range from 0 to 1, with lower values signifying better classifications.

The model yields the best results for the 1970s data set, with only one-third of the total variation remaining within the categories (Table 3). Nine independent variables differentiate among the *a priori* categories, with income, occupation, and rent contributing most to the model. As expected, this approach fails to distinguish the categories in the 1960s data set. Similarly, the model's accuracy declines in the 1980s. Many gentrified neighborhoods reached their peak by the late 1970s or early 1980s, and changes in socioeconomic indicators moderated over the remainder of the 1980s.

TABLE 4.—RESULTS OF CANONICAL DISCRIMINANT ANALYSIS

Model	Canonical variable	Eigenvalue	Percentage of variance	Canonical correlation	R^2	F
1960-1970	I	1.61	90.73	0.78	0.62	9.45[b]
	II	0.14	7.81	0.35	0.12	1.91[a]
	III	0.02	1.46	0.16	0.02	0.70
	Totals		100.00		0.76	
1970-1980	I	1.29	83.85	0.75	0.56	8.99[b]
	II	0.22	14.63	0.43	0.18	2.87[b]
	III	0.02	1.52	0.15	0.02	0.64
	Totals		100.00		0.76	
1980-1990	I	0.95	75.78	0.70	0.49	8.08[b]
	II	0.25	20.02	0.45	0.20	3.63[b]
	III	0.05	4.20	0.22	0.05	1.49
	Totals		100.00		0.74	

[a]Significant at $P \leq 0.05$.
[b]Significant at $P \leq 0.01$.

TABLE 5.—CANONICAL STRUCTURE

	1960-1970		1970-1980		1980-1990	
	I	II	I	II	I	II
Median household income	0.93	-0.20	-0.71	0.30	-0.66	0.27
Change in median household income	0.27	-0.25	0.41	-0.19	0.12	-0.02
Percentage managerial, professional, and technical	0.14	-0.15	0.10	0.38	0.04	0.57
Change in median rent	0.10	-0.07	0.16	0.38	0.38	0.45
Median rent	0.72	-0.01	-0.64	0.27	-0.43	0.50
Change in median house value	0.07	-0.06	0.34	0.31	0.27	0.20
Percentage with 4+ years of college	-0.08	0.04	0.19	0.10	0.19	0.37
Number of employed workers	0.33	-0.30	-0.37	0.33	-0.46	0.45
Number of persons	0.42	-0.17	-0.38	0.19	-0.52	0.20

To sort out the discriminatory power of alternative combinations of these measures, we performed a canonical discriminant analysis (Manley, 1986; SAS Institute, 1994). This technique typically provides better classifications than conventional linear discriminant functions, since it can isolate substantial between-group differences even when the original variables, analyzed separately, fail to do so.[10] Canonical variables may be interpreted in much the same way as unrotated (but nonorthogonal) principal components.

We entered the nine variables identified in the 1970s stepwise procedure into the canonical discriminant analyses for each of the three data sets (Table 4). This approach yielded similar results for each decade, with the first two canonical variables accounting for approximately three-quarters of the total variation. The third variable extracted failed significance tests in all cases (see F-ratios in Table 4).

TABLE 6.—TRACT CLASSIFICATION SUMMARY

Model	Source category	Predicted category				Percentage correctly classified	
		Gentrified	Maybe	Poor	No	By category	Total
1960-1970	Gentrified	0	0	0	7	0.0	
	Maybe	0	0	1	16	0.0	
	Poor	1	0	7	56	10.9	
	No	5	44	56	7	6.2	
							4.3
1970-1980	Gentrified	6	1	0	0	85.7	
	Maybe	3	7	6	1	41.2	
	Poor	3	15	32	14	50.0	
	No	0	6	6	103	89.6	
							66.6
1980-1990	Gentrified	5	2	0	0	71.4	
	Maybe	4	7	4	1	43.8	
	Poor	4	16	35	10	53.8	
	No	0	4	13	102	85.7	
							63.7

The first canonical accounts for over half of the total variation in the 1970s and 1980s data sets, and primarily reflects neighborhood differences in income and rent (Table 5). Significantly, the 1970s model suggests a negative relation between income and income growth, most likely reflecting a combination of middle-class suburbanization and inner-city reinvestment in some of the city's poor neighborhoods. The second canonical accounts for approximately one-fifth of total variation, and measures occupation, change in rent levels, and several additional variables (Table 5). The distribution of loadings in the middle range (e.g., 0.30 to 0.60) suggests no single, reliable discriminatory power; rather, a combination of variables is required to separate the *a priori* categories.

To relate these composite measures to our field survey, we calibrated a canonical discriminant function for the 1970s data set. Since the canonical variables change considerably over time, we held the analysis constant by applying the 1970s classification to all three data sets (Table 6). Although this approach extrapolates social and economic relations in a somewhat artificial manner, it allowed us to examine whether similar indicators helped distinguish gentrified areas in different time periods.

RESULTS

Period One, 1960-1970

As anticipated, the analysis yields uninterpretable results for the 1960s data. The model correctly classifies only 4% of all tracts, providing less accuracy than a random assignment of the four categories (Table 6). Yet the model correctly rejects the *a priori* "gentrified" designation in all cases. Gentrification did not begin in earnest until the

early 1970s, and these results provide a crucial test of the model's rejection of the "gentrified" designation prior to the occurrence of the phenomenon. The remaining errors in the 1960s classification consist of exchanges between the "poor" and "no" categories, suggesting a high degree of sensitivity to the changes in urban neighborhoods over the course of the decade.

Period Two, 1970–1980

The model correctly identifies most of the gentrification activity that swept several inner-city districts in Minneapolis and St. Paul during the 1970s. It correctly classifies two-thirds of all central-city census tracts, and yields greater precision in the "gentrified" and "no" categories (Table 6). The model correctly identifies six of the seven "gentrified" tracts and indicates 90% accuracy in the "no" category. None of the tracts designated as "no" are placed into the "gentrified" category, providing a crucial test of the model's ability to distinguish areas of heavy gentrification activity from stable, middle-class neighborhoods.

The model misclassifies half of the tracts in the two intermediate categories, however, and inspection of these cases reveals the strengths and limitations of our approach. First, the model rejects our "maybe" designation in a majority of cases. Three tracts just west of downtown St. Paul are incorrectly identified as gentrified (Fig. 4). Immediately adjacent to St. Paul's best-known gentrified neighborhoods, these tracts today show sporadic evidence of upgrading interspersed with blocks of deteriorating structures. These misclassifications may reflect changes between the 1970s and our field survey, suggesting a dissipation of inner-city reinvestment as deepening poverty spread through the core neighborhoods of the Twin Cities in the 1980s (Adams and VanDrasek, 1993). Alternatively, these misclassifications may reflect the model's sensitivity, suggesting that it is able to identify areas of sporadic gentrification activity.

The second type of misclassification reflects socioeconomic changes in sparsely populated neighborhoods. Although the inclusion of several "total population" variables helps to minimize this problem (see canonical loadings in Table 5), the model fails to classify one extreme case. Tract 35 encompasses part of the old warehouse district of Minneapolis (Fig. 4a), and has seen an influx of artists and young professionals living in converted lofts. With only 200 housing units, however, the changing composition of this area is extremely limited in significance.

Finally, a third set of misclassifications highlights the difficulty of distinguishing gentrification from urban housing redevelopment. Northwest of downtown St. Paul, tract 336 lies at the historic core of the city's African American community (Fig. 4a). The Rondo neighborhood was devastated by Interstate highway construction in the late 1960s, however, and virtually none of the pre-1960 housing stock remains. Only 16 of 375 occupied units were built prior to 1960, most of them dilapidated two-story apartments along an old commercial strip. Most of the housing stock consists of public-assistance housing (apartments) and semi-detached housing units. A similar pattern prevails in tract 47, just east of downtown Minneapolis (Fig. 4a). This area is dominated by a large "new town-in town" urban renewal effort of the 1970s, conceived as a mix of market-rate and moderate- to low-income high-rise apartments

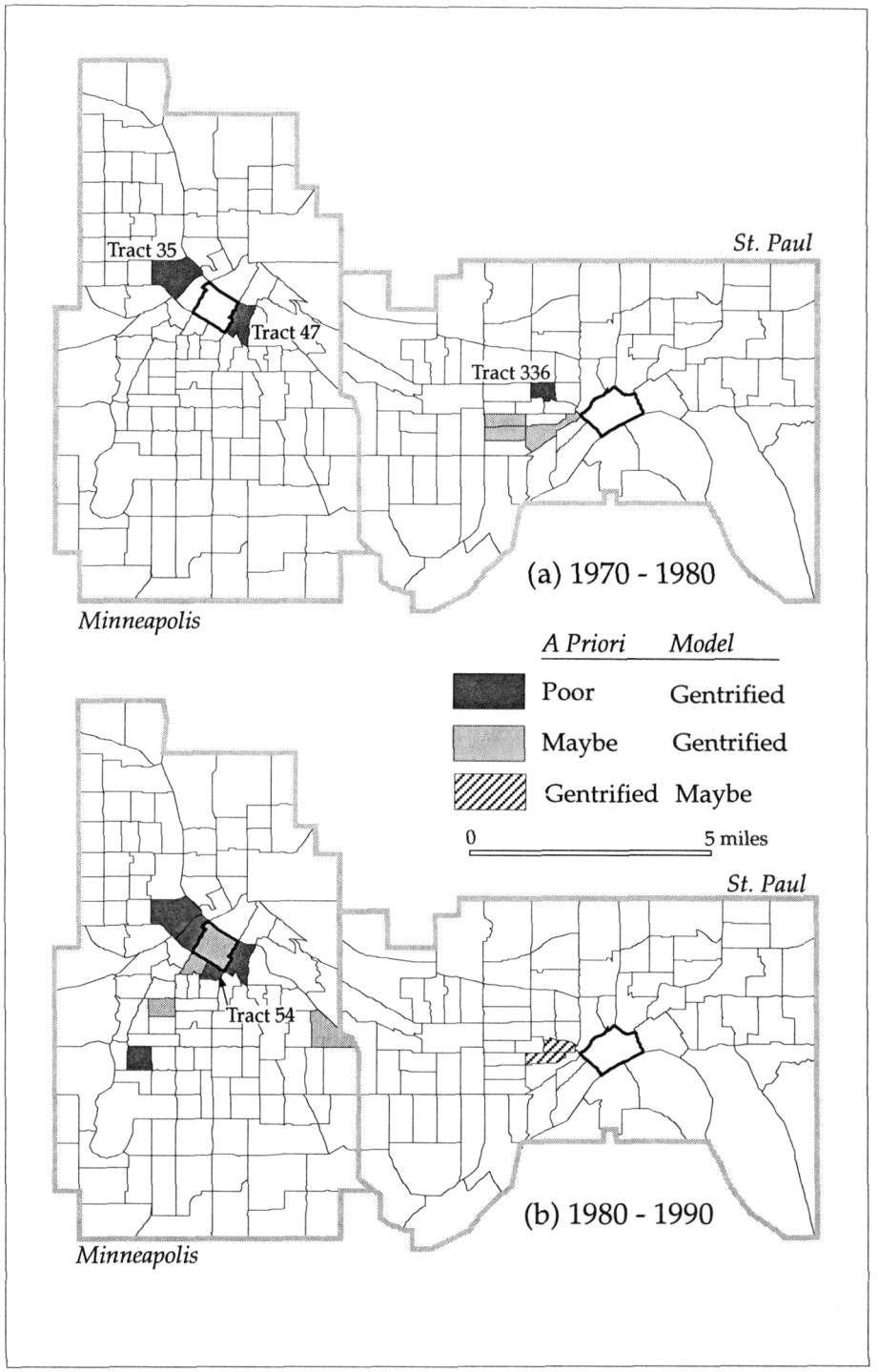

Fig. 4. Classification errors for the canonical discriminant functions, 1970–1980 and 1980–1990.

(Martin, 1978). Halted by local resistance when only one-tenth complete, the complex accounts for two-thirds of all housing units in the tract.

Period Three, 1980–1990

Gentrification activity increased rapidly between the mid-1970s and early 1980s in Minneapolis and St. Paul. The model correctly classifies most tracts for the 1980s data set—particularly in the crucial "gentrified" and "no" categories—but falls short of the accuracy obtained in the 1970s analysis (Table 6). This reduced accuracy reflects the continued presence of small-scale gentrification in areas with few housing units, as well as a slowing of the process in neighborhoods undergoing substantial reinvestment in the 1970s.

In addition to several areas of marginal reinvestment ("maybe" to "gentrified"), the most notable misclassifications fall into two categories. First, a pair of tracts at the heart of St. Paul's gentrified Ramsey Hill area are misclassified as "maybe," almost certainly reflecting the moderation of rapid socioeconomic changes experienced in the 1970s (Fig. 4b).

The second set of misclassifications presents more serious problems. As in the earlier analysis, the model fails to distinguish gentrification from publicly assisted housing redevelopment or changes in sparsely populated areas (Fig. 4b). Yet an examination of the neighborhoods in question suggests that the model fails only in the most extreme cases. In addition to the misclassifications of the 1970s data set (tracts 35 and 47), the model errs in tract 54, which includes a number of publicly assisted housing units interspersed among luxury high-rises on the southern fringe of downtown Minneapolis (Fig 4b).

The Composite Map

Gentrified areas in the Twin Cities reflect the cumulative effects of socioeconomic changes over the past 25 years, and trends in many neighborhoods straddle census enumerations. To evaluate the overall results of our approach, we constructed a composite map of classification errors for the 1970s and 1980s analyses. We considered all tracts as "gentrified" if thus classified by the model in *either* decade, and compared the results to our *a priori* designations to generate two maps of composite errors (Figs. 5a and 5b).

Type-I errors signify incorrect rejection of the *a priori* designation of gentrified neighborhoods, thereby underestimating the extent of the phenomenon. The model yields few errors of this type, mostly in transitional areas between poverty concentrations and lower-middle-class neighborhoods (Fig. 5a). The model successfully classifies all of the gentrified areas. In only one case does the model underestimate the extent of gentrified areas, placing one "maybe" tract into the "no" category (Tract 302, Fig. 5a). This tract encompasses stable middle-class neighborhoods as well as Energy Park, a sizable mixed-use development constructed on former railroad and industrial land (Adams and VanDrasek, 1993). The diverse mix in the housing stock led us to designate this tract as "maybe," but boundary changes and/or the distinct character of this large tract appear to trigger the model misclassification.

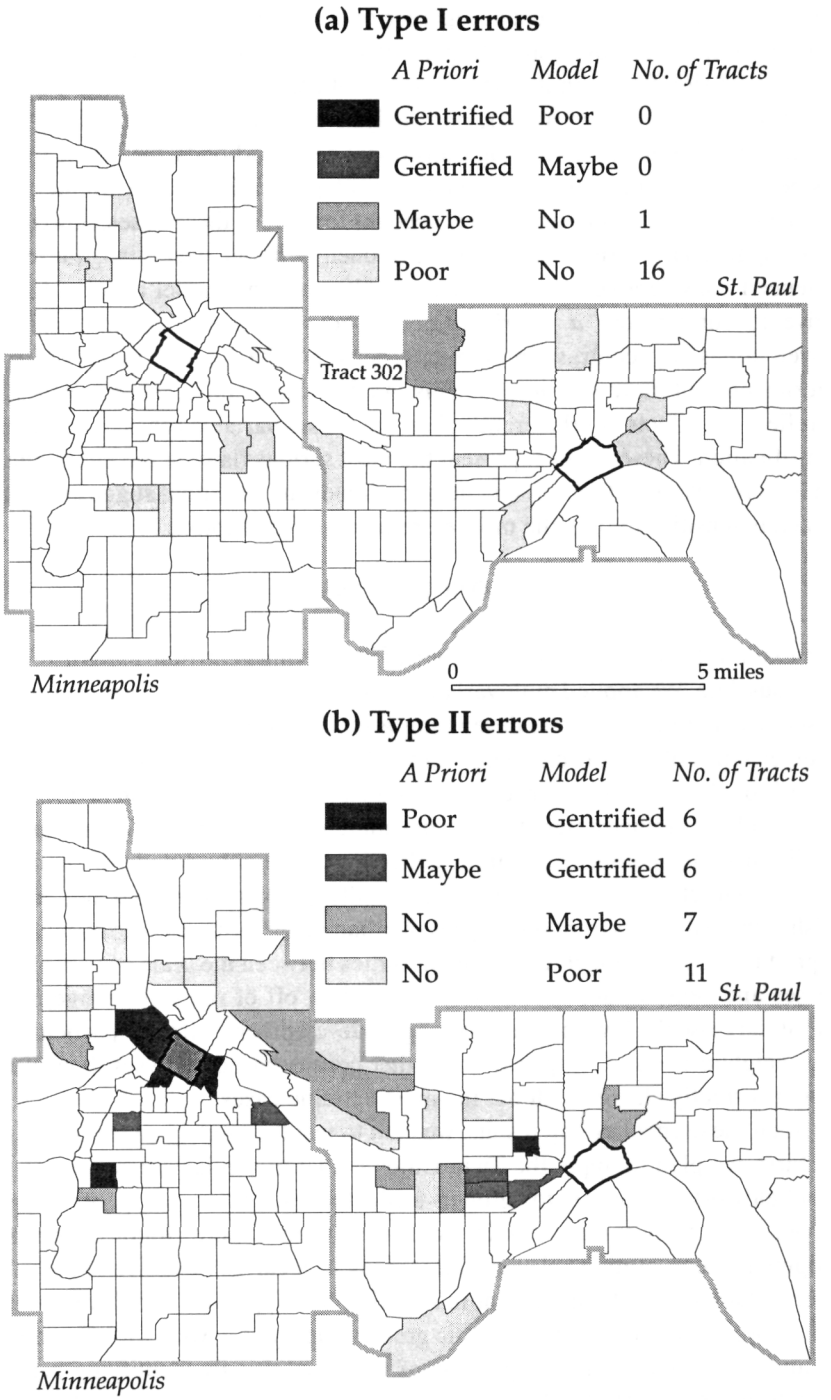

Fig. 5. Composite errors for the canonical discriminant functions, 1970–1990. Progressively darker shades of gray indicate more significant errors; movements from the "poor" to "gentrified" categories represent the most serious errors of the model.

Type-II errors signify incorrect acceptance of the *a priori* designation of gentrified neighborhoods, thereby overestimating the extent of the phenomenon. Errors of this type represent significant limitations in the use of census data to identify gentrification and, as in many other studies, our analysis encounters serious difficulties. In addition to misclassifications among transitional neighborhoods, the model yields 12 errors between gentrified areas and the other categories (Fig. 5b). Movements from the "maybe" to "gentrified" categories account for half of these cases, however, and do not suggest any serious flaws in the model. Without exception, these tracts experienced considerable change over the 1970s, but the model is not sufficiently sensitive to confirm our *a priori* distinction between gentrified and marginally improved areas. By contrast, movements between the "poor" and "gentrified" categories present more serious problems. As described above, these misclassifications reflect the effects of urban renewal on the census variables chosen as indicators of gentrification. These errors represent the most serious flaws in the entire analysis, but a careful examination of the neighborhoods in question suggests that our approach is sensitive to only the most extreme cases (cf. Lipton, 1977).

CONCLUSIONS

Our goal was to develop a simple method of identifying gentrified areas using tract-level census data. We applied multivariate statistical procedures to a set of commonly used socioeconomic measures, developing a model to distinguish gentrified areas from other types of central-city neighborhoods. The model correctly classifies over two-thirds of all central-city census tracts and yields greater precision in distinguishing areas of heavy reinvestment from stable, middle-class districts. Gentrifying areas in the Twin Cities comprise a varied collection of neighborhoods of remarkably disparate character, but the model successfully groups them together and distinguishes these districts from other types of urban neighborhoods. The misclassifications produced by the model reflect incongruities between the scale of gentrification processes and census tract boundaries, the leveling off of rates of change, and the effect of large-scale low-income housing redevelopment efforts, particularly in smaller neighborhoods. Compared with other census-based analyses, however, our approach correctly classifies all but the most extreme cases.

Based on these encouraging results, we plan to test the model in a sample of other cities. First, we plan to apply the Twin Cities model to similar cities, using a more modest fieldwork component to "ground-truth" the results. Second, for other types of cities, we plan field surveys similar to that described here, followed by model development incorporating relevant differences in local context. We expect that a number of factors may be important in applying this approach to different settings, including overall metropolitan economic growth, supply of downtown office employment, and racial and ethnic composition of the inner city. By identifying gentrified areas with a measurable level of precision, our method provides a useful tool for comparative analysis of the extent and timing of inner-city reinvestment in different American cities.

NOTES

[1]This paper is a substantially revised version of work presented at the 1994 Annual Meeting of the Association of American Geographers in San Francisco. We gratefully acknowledge the helpful comments and suggestions of John S. Adams and two anonymous reviewers. Any remaining errors of fact or interpretation are our own. Partial financial support was provided by a computing grant from the University of Minnesota's Computing and Information Services.

[2]Smith and Williams (1986) identified two periods of gentrification research. The initial period consisted mainly of description of gentrification and its effects, with an emphasis on case studies. The second period began in the mid-1970s in Great Britain, when researchers started to question the assumed causes of gentrification (Williams, 1976, 1978) and emphasized alternative explanations centered on housing policy. By the late 1970s, much research had taken a strong theoretical turn and three conflicting explanations appeared (Smith, 1979; Berry, 1980; Ley, 1980). Throughout the 1980s these arguments were refined (Ley, 1981; Smith, 1982, 1984, 1986; Berry, 1985; Cybriwski, Ley, and Western, 1986) and some empirical evaluation was completed (Ley, 1986; Schaffer and Smith, 1986; Clark, 1987; Badcock, 1989).

[3]The U.S. Department of Housing and Urban Development defines the phenomenon as "the process by which a neighborhood occupied by lower-income households undergoes revitalization or reinvestment through the arrival of upper-income households" (U.S. Department of Housing and Urban Development, 1979, "Whither or Whether Urban Distress." Working Paper, Office of Community Planning and Development, p. 4 [cited in Nelson, 1988, p. 8]. Our working definition, and that of HUD, are the subject of considerable controversy, however. For one of the early reviews of this debate, see Laska and Spain (1980).

[4]To ensure that our field survey corresponds as closely as possible with conditions on Census Day, 1990, we classify obviously recent changes as "unimproved."

[5]This step is important in cities such as Minneapolis-St. Paul, which have significant areas in the central cities that have never experienced disinvestment. These areas, termed "in-city suburban" by Martin and Lanegran (1983) often have similar socioeconomic profiles as gentrified tracts.

[6]Some studies have used age structure to identify revitalized areas (Maher, 1978) but most have had no success with this method. Other variables (e.g., building permits) have been used successfully in identifying gentrified areas, but are not widely available or consistent.

[7]Since median house values sometimes are not disclosed for tracts with few specified owner-occupied units, we substituted change in median rent levels where necessary.

[8]Some gentrified neighborhoods show declines in the percentage of African-American persons, reflecting the displacement resulting from the in-migration of white, middle-class professionals. This finding appears to vary widely among cities, however. O'Loughlin and Munski (1979) identified substantial changes in the racial composition of two New Orleans neighborhoods, as do Schuler et al. (1992) in Cleveland's Ohio City district; yet Spain (1980) found no evidence of such changes in New Orleans, and Clay (1979) concluded that only half of the gentrified neighborhoods in the 30 largest American cities were primarily African American at the time they underwent reinvestment.

[9]To minimize the loss of accuracy involved in averaging tract statistics, we compared boundary changes with topographic and street maps, adjusting values only where boundary movements affected residential land uses. Additionally, we constructed three separate data bases (1960-1970, 1970-1980, and 1980-1990) to minimize the effect of repeated or cumulative boundary movements.

[10]Canonical discriminant analysis extracts linear combinations of the independent variables that maximize the multiple correlation with a set of dummy variables coded for each of the categories. This approach typically yields higher between-group variance than the original,

untransformed variables, but interpretation may be difficult because the canonicals are not orthogonal (see Manley, 1986).

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