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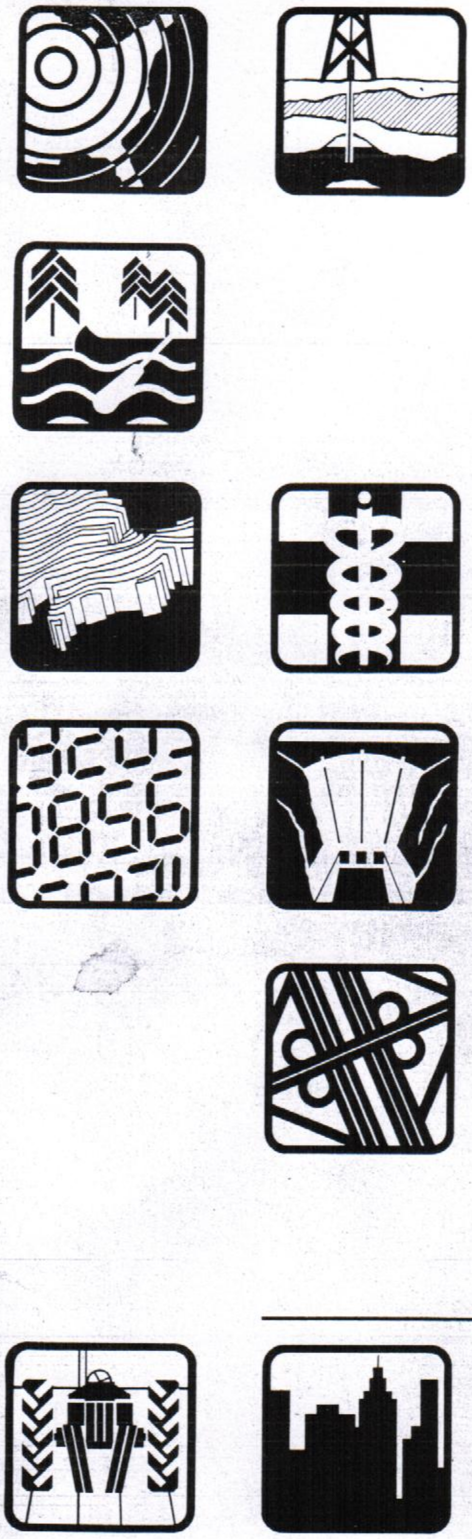

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RETAIL COVERAGE AND MARKET EQUILIBRIUM
THE CASE OF FOOD STORES IN ALBUQUREQUE, NEW MEXICO

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1. INTRODUCTION

The Albuquerque metropolitan region has exhibited a consistent pattern of growth and development. From a population of around 15,000 in 1900, the metropolitan area in 1980 contained 454,499 residents; in the last decade (1970-1980), the city itself grew by over 35 percent (11). Because of the rapid development which has occurred in Albuquerque, there is a constant demand for retailing services to keep pace with areas of new growth.

This study analyzes a relationship between the 1970 and 1980 residential population density in Albuquerque and the location of retail food stores. It is hypothesized that there is a positive and significant relationship in both 1970 and 1980. A further hypothesis is that there is a lag between the initial wave of residential development and the location of retail food stores, as well as a redistribution of retail food services in previously developed areas.

In order to test these hypotheses, a complete field survey of all the food stores in the Albuquerque area was conducted and a measure of retail coverage devised that takes into consideration store locations and the extent and magnitude of their service. In addition, information concerning actual population density was compiled from existing census sources. The statistical comparison of the data, along with the task of data processing, statistical model construction and cartographic presentation were facilitated by the employment of a geographic information system (12).

An additional portion of this study is devoted to an evaluation of levels of retail food service. A concept of market equilibrium is presented based upon the determined relationship between retail coverage and population density in both 1970 and 1980. As the field of marketing geography has been traditionally concerned with such applied problems of marketing, this study will use its results to map what appear to be over and under-serviced areas of Albuquerque in 1970 and 1980. Further, it will determine whether under-serviced areas in 1970 are adequately or over-serviced in 1980.

2. DATA BASE

Several steps were involved in acquiring the pertinent statistical information and constructing the computerized data base. Four major data files were created: the retail food store file and population density file for both 1970 and 1980.

2.1 POPULATION DATA

The population files and associated population density maps (Figures 1 and 2) were prepared using information obtained from the 1970 and 1980 Censuses (10). Area measurements were derived using a digital planimeter calibrated to acres. Enumeration districts were selected as the areal units of analysis for 1970 and precincts for 1980, because it was felt that areas at this scale would provide better resolution than census tracts and would be easier to manage than blocks.

The areal units varied widely in size. Some of the units were not contiguous or were irregular in shape. Further, several of the peripheral census tracts did not have sufficient population in certain enumeration districts or precincts to warrant their separate inclusion. Given these problems, a few of the areal units were merged with adjacent ones, deleted or aggregated up to a census tract. The result was 275 contiguous areal units for 1970 and 318 for 1980.

The population density surfaces shown on Figures 1 and 2 were based on a linear interpolation of irregularly positioned control points. There was one control point for each enumeration district and precinct. In addition, thirty zero valued control points were positioned on the periphery of the study area in unpopulated locations. This was necessary in order to force the contouring algorithm to depict a realistic surface in which the peripheral locations actually reached zero.

The comparison of the 1970 and 1980 population density maps focuses on the middle category of 5 to 9.9 persons per acre. For the sake of discussion this can be considered the median population density for the city. Figure 1 shows that by 1970 the eastern, south-central, and north-central parts of the city had reached at least this median value. By 1980 the median population plateau had expanded in the newer and more rapidly developing portions of the city. It is particularly apparent east of Tramway Blvd., north of Montgomery Blvd., particularly along Second Street, and in the western part of the city along Coors Road. The same general pattern of ridges (10-14.9 persons per acre) and peaks (15 or more persons per acre) is visible on both maps. But in 1980 there is an expansion of these higher density areas in the northeastern part of the city and along Coors Road. This is the result of both development and the areal units used in this study. Precincts are more uniform in size and shape than enumeration districts. This has contributed to the expansion of ridges in 1980 as compared to 1970.

2.2 RETAIL INFORMATION

The retail data files for this study were derived from several sources. All of the food stores included in the analysis were listed in either the 1970 or 1980 Albuquerque City Directory (3), 1970 or 1980 Albuquerque Metropolitan Telephone Directory (6), or both. Locational coordinates for each of these stores were derived from plotting their locations on a 1:126,720 computer generated road map. Floor space and other specific information about a store were gathered from a complete field survey of the Albuquerque metropolitan area.

FIGURE 1
POPULATION DENSITY
ALBUQUERQUE, N. M.
1970

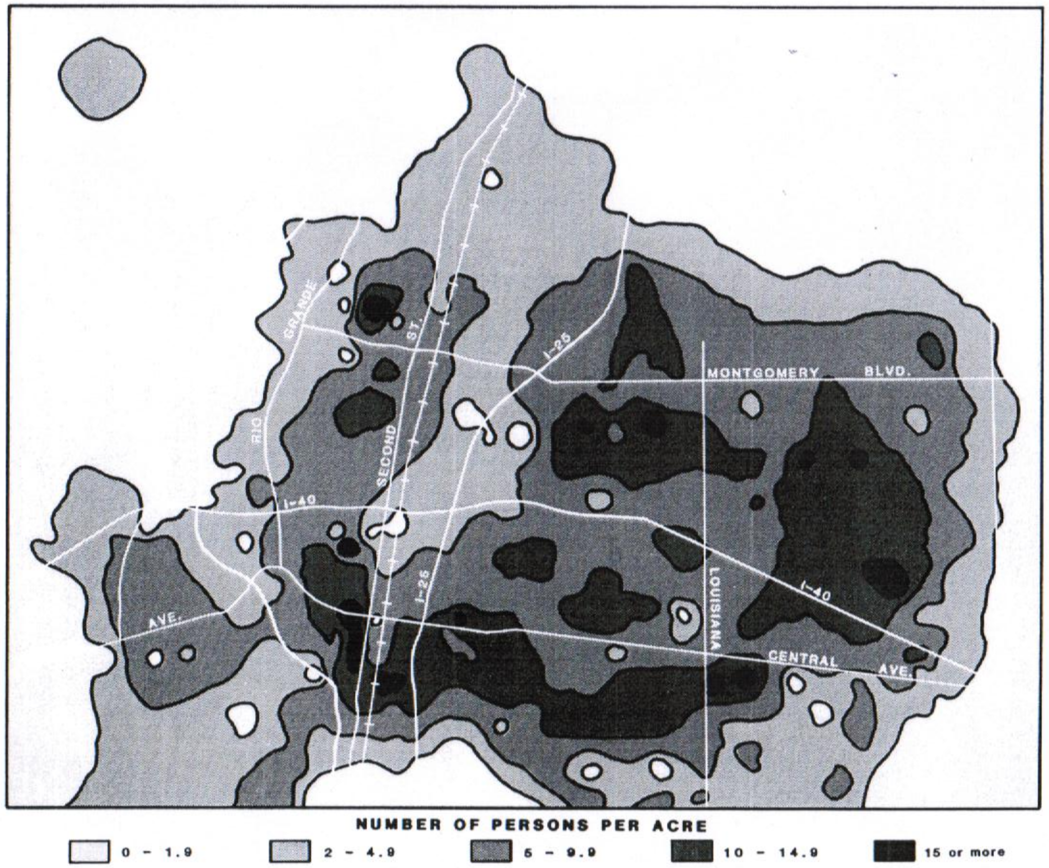
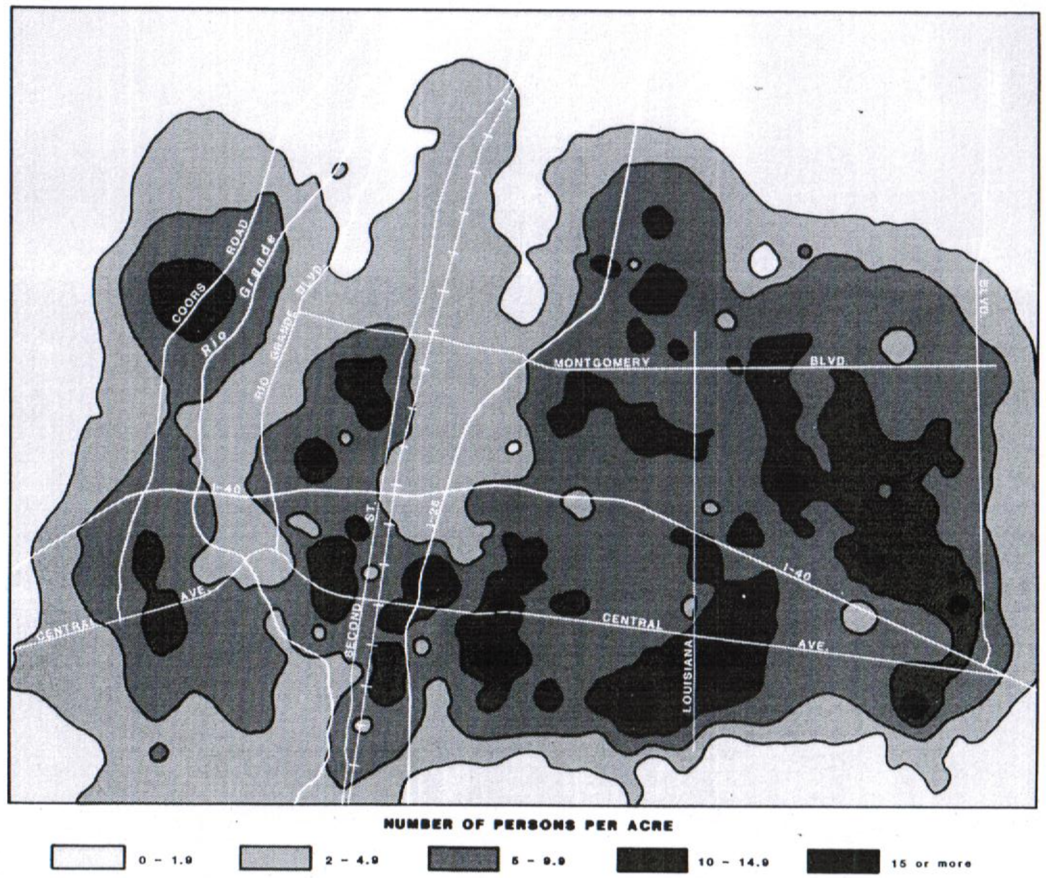


FIGURE 2
POPULATION DENSITY
ALBUQUERQUE, N. M.
1980



The data were gathered in 1980. Several problems were encountered in the use of the 1980 survey as the base for the 1970 analysis. If a store was present in both periods (at least by street address), it was assumed to have the same dimensional characteristics in 1970 that it had in 1980. If a store was not present in 1980 but existed in 1970, a process of architectural estimation or statistical interpolation was used to approximate what its dimensions may have been. That is, specific estimations were based upon knowledge of the store's classification, which was derived from the city directory (grocery type, convenience store, specialty shop), and whether or not there was still architectural evidence of the store. Although the estimation procedure must be regarded as including a certain amount of error, it does seem to approximate reality.

3. METHODOLOGY

The data files (population and retail) were used as the statistical base for this analysis. The problem was to make these two files comparable so the relationship between population density and the location and magnitude of retail food service could be determined. An easy alternative would have been to identify which food stores were located within each statistical area. This would have resulted in a numerical summation of floor space for each area. Although this method would have been easy to operationalize, its utility and results would have been questionable.

A closer examination of the manner in which the statistical areas are arranged reveals the nature of the problems that would have been encountered if this method was used. The census areas are irregular in size and spacing. In most cases the borders are derived from the road pattern, with a tendency to use major arterials as boundaries. Retail stores usually are located along major roadways in a free-standing context or in specific commercial centers. A particular areal unit may include several stores on one side of a street, while an adjacent areal unit on the other side of the street may not have any stores. To assign a measure of retail coverage to an areal unit having little or no retail outlets, but whose adjacent areas are well endowed is misleading. There is obviously interaction between stores and consumers which transgresses the borders of areal units.

An appropriate measure of retail coverage (location and magnitude) must take into consideration the unbounded nature of retail servicing over distance. It must not impose arbitrary boundaries. Rather, it should somehow measure a level of retail opportunity provided by all area stores to a consumer residing at a particular point in space. This opportunity should be measured in relative terms, and should be comparable with any other point in the city. A measure of retail coverage should not attempt to rigorously predict consumer shopping behavior, but only to define the level of opportunity provided by the size and proximity of all stores to a resident. The consumer has free will to act in his or her own manner. He or she may or may not be influenced by the closeness of stores or the size and number of stores.

Various types of spatial interaction models (8) provide a precedent for this type of measurement in geography, particularly those concerned with shopping. The central concept behind this research is the realization that many social, cultural and economic flows (information, shopping, migration, etc.) take place over the landscape and tend to decrease in magnitude with increasing distance from a point of origin. The manner in which these flows interact with geographic and social factors is partially responsible for many observable patterns on the landscape.

Attempts to mathematically model the variables which characterize particular types of flows has led to what may be termed spatial interaction theory. Perhaps one of the most important elements in any of these models is distance. Specifically, most of these models consider the friction of distance (distance decay). Interaction is perceived to diminish with increasing distance from the point of origin. The use of appropriate variables to measure distance and the choice of appropriate mathematical functions to describe decay have characterized a large portion of this research. In fact, the relationship between interaction and distance is perceived by many researchers to be a fundamental aspect of geography (8).

In the development of many models of shopping interaction, distance has also played an important role. Most of these models are of a gravity type, similar to the original breaking-point model derived by Reilly in 1931. In most cases they have either attempted to predict the probability of a consumer at a particular point in space frequenting a particular shopping center (4), or to estimate how much a consumer will spend at a particular center (5). None of these shopping interaction models have attempted to estimate the amount of retail opportunity provided to a consumer residing at a particular point in space.

This is the type of measurement this study will attempt to construct. The measure of retail coverage utilizes the standard geographic concept of distance decay. Like the models of shopping interaction and other standard distance decay models (9), it relies upon a negative distance exponent to approximate the friction of distance. It is further assumed that larger stores contribute more to the measure of coverage than smaller ones. Therefore, for a given spatial reference point, a closer, larger store will contribute more to the measure than a farther, smaller store. The measure can be expressed as follows:

$$C_{ij} = \sum_{j=1}^{K} \frac{A_j}{D_{ij}^{a}}$$

Where:

$$1 \leq D < \infty$$
$$0 \leq C_{ij} \leq 1$$

Where:

C_{ij} = Measure of retail opportunity provided to a consumer at a given point of residence i with respect to all the available stores of a particular class j in a definable area. (This measure is normalized -- $0 \leq C_{ij} \leq 1$.)

A_j = The size of a particular store measured in terms of total square feet of selling area devoted to food sales.

D_{ij} = Actual (straight-line) distance measured in map units (.05 miles) from a consumer residing at point i to a store located at point j.

a = A distance decay parameter.

The distance variable was allowed to vary between one map unit and the maximum for the study area. One map unit was used as the minimum distance, because it was assumed that this distance is reflective of the minimum distance a consumer will walk from home to a place to shop without questioning its excessiveness. It represents a region of acceptable travel, in which all stores within this area can be frequented with relatively equal effort. It can also be envisioned as an area in which all the stores are competing on a relatively equal footing for that consumers business. This assumption has been given some empirical support in a study by Clark (2).

This zone of undiminished and alternative choice was built into the measure for mathematical as well as the above mentioned empirical reasons. By keeping the distance parameter greater than or equal to one, division by zero (if a retail store and the center of an areal unit has the same coordinates) was avoided. It also seemed logical, given the results of Clark's study, to assume that any store within an acceptable distance from the consumer should have a relatively equal chance of being frequented, and hence contribute in an undiminished manner to the measure of coverage.

The measure of retail coverage used in this study will assign a value ranging from 0 to 1 to all areal units. This is a ratio determined by dividing store size (total selling area) by the distance between a particular store and the center of an areal unit. This process is repeated for all stores, resulting in an additive measure for each areal unit. Once this has been completed for all the areal units, the additive measures are normalized. The result is a standard and numerically comparable value for each area which can be compared with any other area over the entire surface of the city.

The major problem encountered in implementing this technique was deriving a framework in which the exponent on the distance variable could be empirically justified. Most interaction and distance decay models are based upon actual flow and interaction data. Therefore, certain goodness-of-fit tests, such as regression analysis, can be used to calibrate the parameters of the model. These methods of fitting the most appropriate exponent to the distance variable cannot be employed for several reasons. First, no strict assumptions about consumer interaction with the stores are made, only the level of retail coverage is determined. Second, there does not seem to be any independent method (other than the proposed measure) to calculate retail coverage. Hence, it is impossible to use standard goodness-of-fit estimation procedures.

Given this problem, and the realization of the importance of choosing suitable exponents, an alternative method of estimating goodness-of-fit was devised. As the central goal of this study was to evaluate the relationship between the location of retail food stores (the shopping opportunities or coverage they provide) and the distribution of residential population, the distance exponent that best fit the variation in population was selected. That is, several alternative exponents were used in the calculation of retail coverage, and the one which provided the best correlation with the distribution of population was chosen.

Several ways of evaluating the relationship between the locational tendencies of food stores and population density were thereby available. First, the correlation statistic should indicate the overall strength of the spatial covariation of these measures. Second, the choice of an exponent, although dependent upon the correlation and the overall patterning of stores, should indicate the degree to which the influence or coverage of stores decreases with increasing distance. The larger the exponent, the more rapidly the influence or coverage of stores will tend to diminish with increasing distance. Third, contour maps of retail coverage and population density should indicate if stores tend to group in areas with high population density.

4. ANALYSIS

The measure of retail coverage was calculated for all retail food stores operating in 1970 and the analysis was repeated for 1980. A previous study (7) examined the differences in results for several categories of food stores (supermarkets, small groceries, convenience stores and specialty shops) in 1970, and a planned study will include a similar discussion for the 1980 data.

Table 1 shows the correlations between population density and the measure of retail coverage in 1970 and 1980, using distance exponents ranging from 0.5 to 3.0. All the coefficients are positive, indicating that as population density increases there is also an increase in retail coverage. A maximum correlation coefficient is reached in both 1970 and 1980 when the distance exponent equals 1.0.

In a previous study (7) that examined each category of food stores operating in 1970, it was found that the exponent that yielded the highest correlation varied from one category to another. A lower exponent, 0.5, provided the highest correlation between population density and supermarkets, convenience stores and specialty shops. A larger exponent, 1.5, provided the highest correlation between small groceries and population density. The distribution of stores seemed to influence which exponent yielded the highest correlation. Small groceries were clustered, while supermarkets, convenience stores and specialty shops were more evenly distributed throughout the city. Further, a larger exponent indicated that the influence of a particular store dropped off more rapidly with distance and vice versa. Thus one would expect a composite grouping such as all stores to yield an intermediate exponent. The exponent thus reflects the different distributional characteristics, as well as the varying threshold populations and ranges for the different types of stores.

TABLE 1
CORRELATION COEFFICIENTS AND DISTANCE EXPONENTS
ALL FOOD STORES
1970 AND 1980

Distance Exponent	Correlation Coefficient		Correlation Coefficient	
	All Units		Outliers Deleted	
	1970	1980	1970	1980
0.5	.534	.526		
1.0	.545	.534	.610	.564
1.5	.412	.496		
2.0	.235	.387		
2.5	.138	.290		
3.0	.090	.236		

All correlations are significant at the .01 level

Source: Compiled by authors

The correlation coefficients reported in Table 1 were based on all the enumeration districts in 1970 and all the precincts in 1980. But given the size and shape of the areal units, there are bound to be units with very high and low population densities. Therefore, a simple linear regression procedure was used to identify the outliers (standard residual $\pm$ 3). In 1970 there were four enumeration districts and in 1980 one precinct with a very high or low standard residual. These areal units were deleted and the correlation analysis repeated using a distance exponent of 1.0. Correlation coefficients were slightly improved in both instances. The data sets with the extreme residuals deleted were then used to produce the maps of retail coverage.

Figure 3 shows that the area of denser coverage (0.4 and greater) is within the median population plateau in 1970, but lagging behind the population growth in the area between Louisiana Blvd. and Tramway Blvd. There are also several peaks of high coverage (0.7 and greater) in the older parts of the city northwest of Louisiana Blvd. and Central Ave., northwest of Central Ave. and Second St., and south of Central Ave. and the Rio Grande.

The map of retail coverage for 1980 (Figure 4) shows an obvious expansion of the area of denser coverage (0.4 and greater), so that most of the areas of median or greater population density in 1970 (Figure 1) were well serviced in 1980. The only exception was the area northwest of Second St. and Montgomery Blvd. When comparing the 1980 retail coverage map (Figure 4) and the 1980 population density map (Figure 2), a similar lag is apparent in the western part of the city along Coors Road. But retail coverage has caught up to or kept pace with most of the new population growth west of Tramway Blvd. and north of Montgomery Blvd.

The comparison of the maps, along with the results of the correlation analysis, tend to support the major hypothesis of this study: There is a significant relationship between the population plateau and the denser areas of retail coverage. Further, advancement of the population plateau tends to precede advancement of increasing retail coverage.

FIGURE 3
RETAIL COVERAGE
ALBUQUERQUE, N.M.
1970

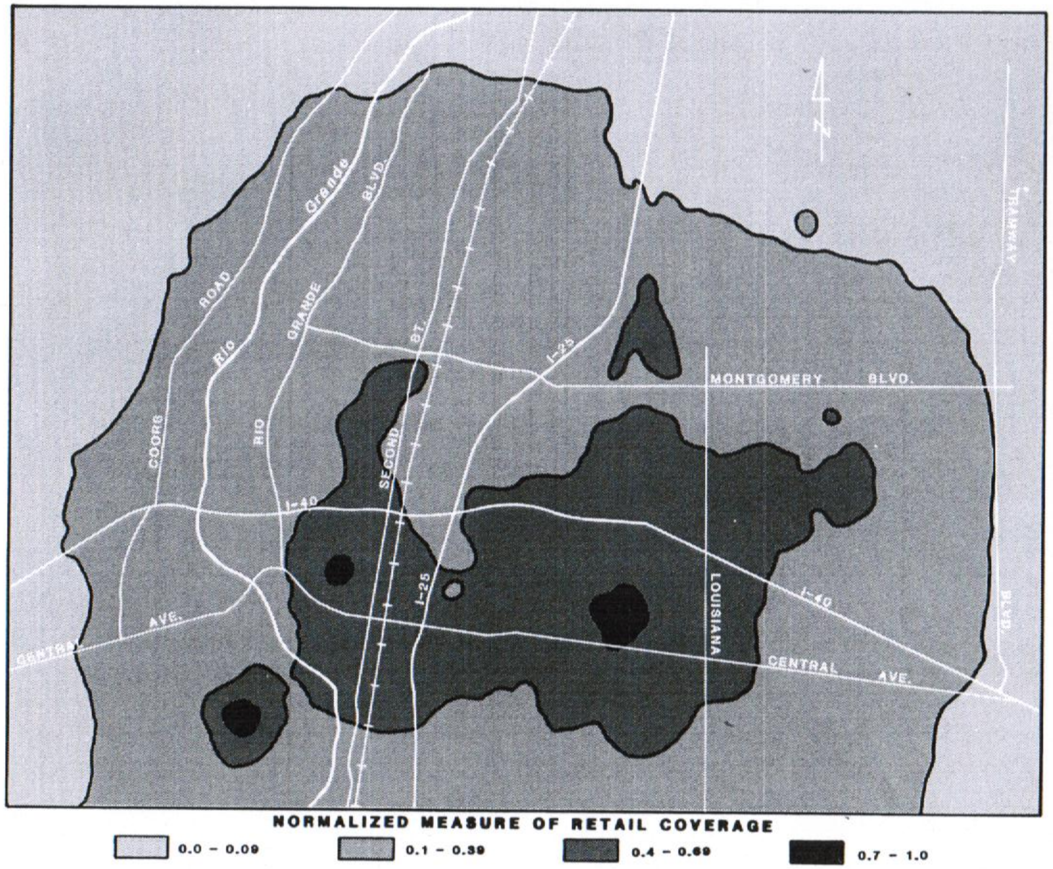
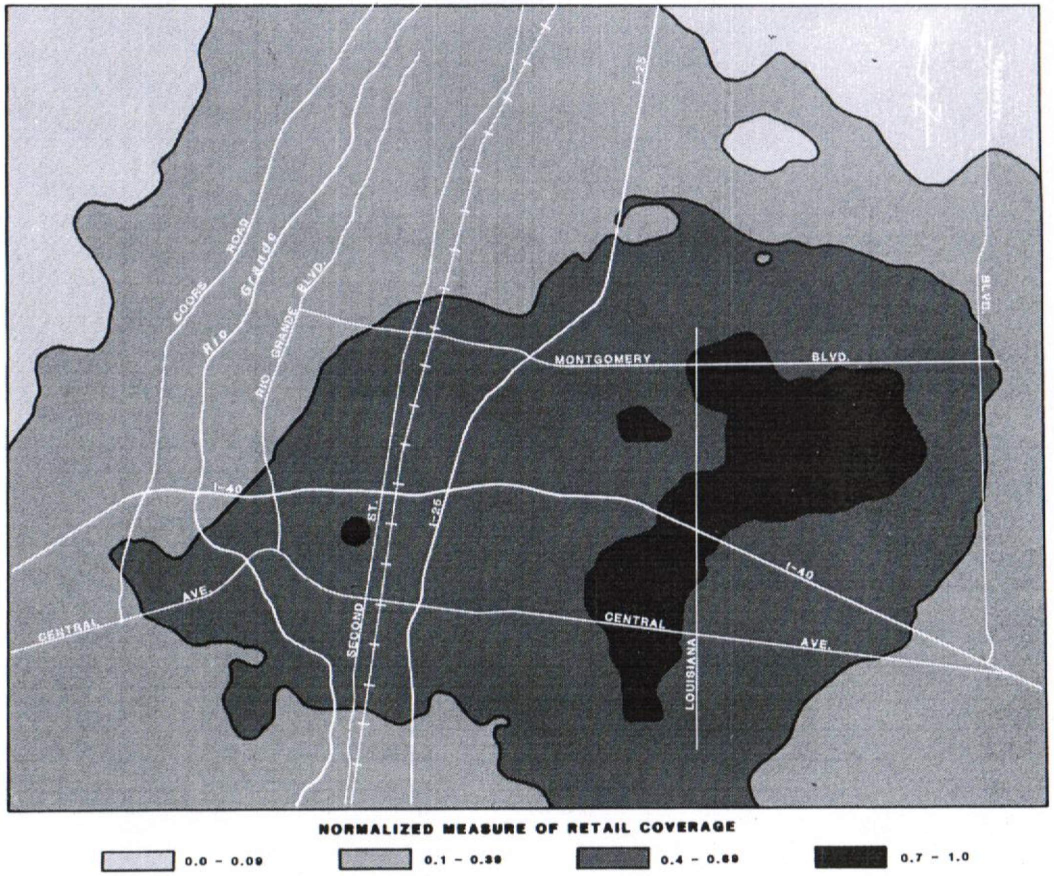


FIGURE 4
RETAIL COVERAGE
ALBUQUREQUE, N. M.
1980



4.1 MEASUREMENT OF STORE SATURATION

This section will apply the results of the previous analyses to the problem of measuring retail store saturation or servicing as it existed in Albuquerque during 1970 and 1980. It draws primarily upon some of the concepts discussed in articles by Appelbaum and Cohen (1), particularly the concepts of market equilibrium and store saturation.

After the regression equations were computed, residual scores were calculated. The standardized residuals for the regression between retail coverage and population density were used as a measure of store saturation or servicing. Values for retail coverage using the distance exponent that provided the best correlation with population density were used for each year. These standardized residuals were then mapped (Figures 5 and 6). Under-serviced areas have standardized residual values less than or equal to -2; moderately under-serviced areas have values between -1 and -1.99; adequately serviced areas have values between -.99 and .99; moderately over-serviced areas have values between 1 and 1.99; and over-serviced areas have values greater than or equal to 2.

In 1970 (Figure 5) there is a large under-serviced area northwest of Tramway Blvd. and I-40. By 1980 (Figure 6) most of this area is adequately serviced. Also in 1970 there are three peaks of over-servicing (northwest of Louisiana Blvd. and Central Ave., northwest of Central Ave. and the railroad, and south of Central Ave. and the Rio Grande). These are older, well established areas of the city. By 1980 the high standard residuals in these areas have mostly disappeared. Between 1970 and 1980 stores were closed in the over-serviced areas and opened in the under-serviced areas.

The 1980 standard residual map (Figure 6) shows that the over-serviced area has expanded and shifted more northeasterly into the newer, rapidly developing portions of the city. In addition, a new under-serviced area has developed in the western part of the city along Coors Road. This area is well within the 1980 population plateau, but retail coverage is lagging behind population growth.

5. CONCLUSION

The simple map review plus the statistical results of the correlation and regression analysis tend to empirically support the concept of dynamic market equilibrium. The maps show retail densities shifting with population densities. Newer, developing areas are generally under-serviced, and older, more established areas have a tendency to become over-serviced. Adjustments to over-servicing result in closures, while new stores are opened in under-serviced areas. When reading the conclusions, Willie Sutton's reply when asked why he robbed banks might come to mind. He said: "Because that's where the money is." Similarly, it seems obvious that food stores will locate where the people are. But it is not that simple. First, you must locate the people, then determine the location and magnitude of the food stores and finally assess

FIGURE 5
VARIATIONS IN
RETAIL SERVICING
ALBUQUERQUE, N. M.
(STANDARD RESIDUALS)
1970

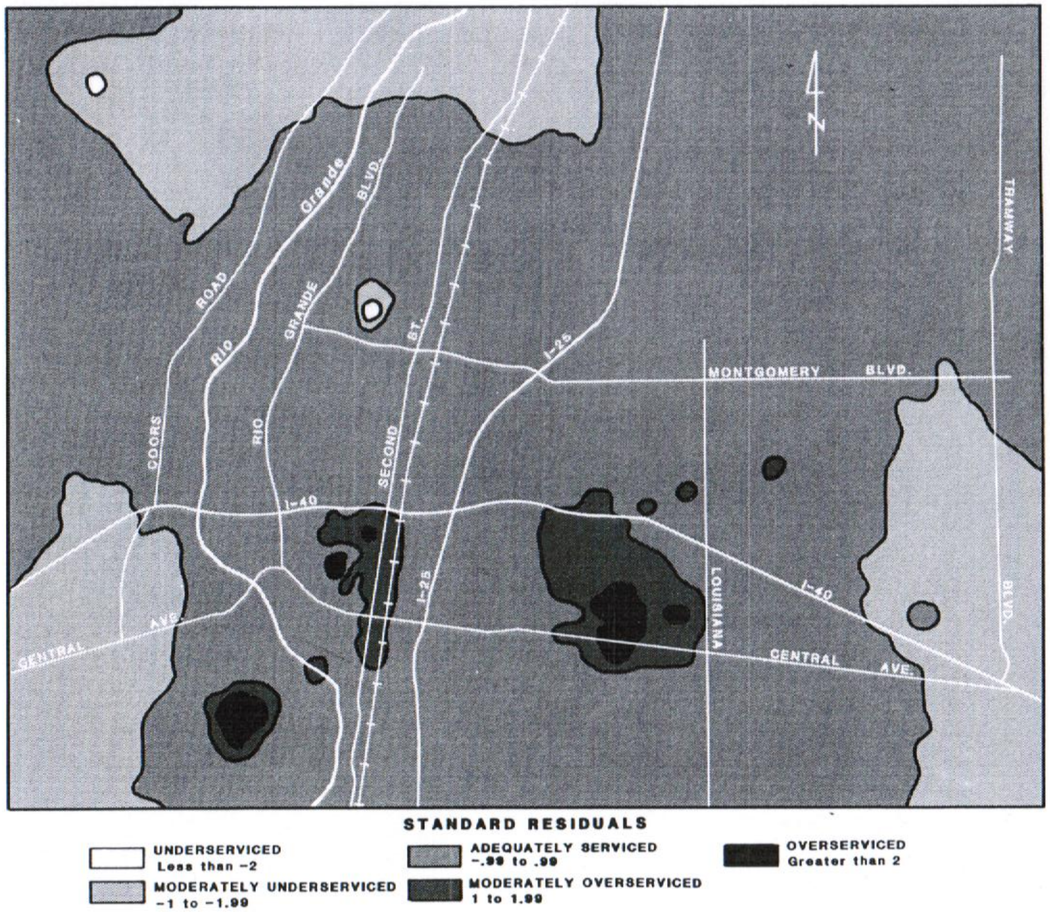
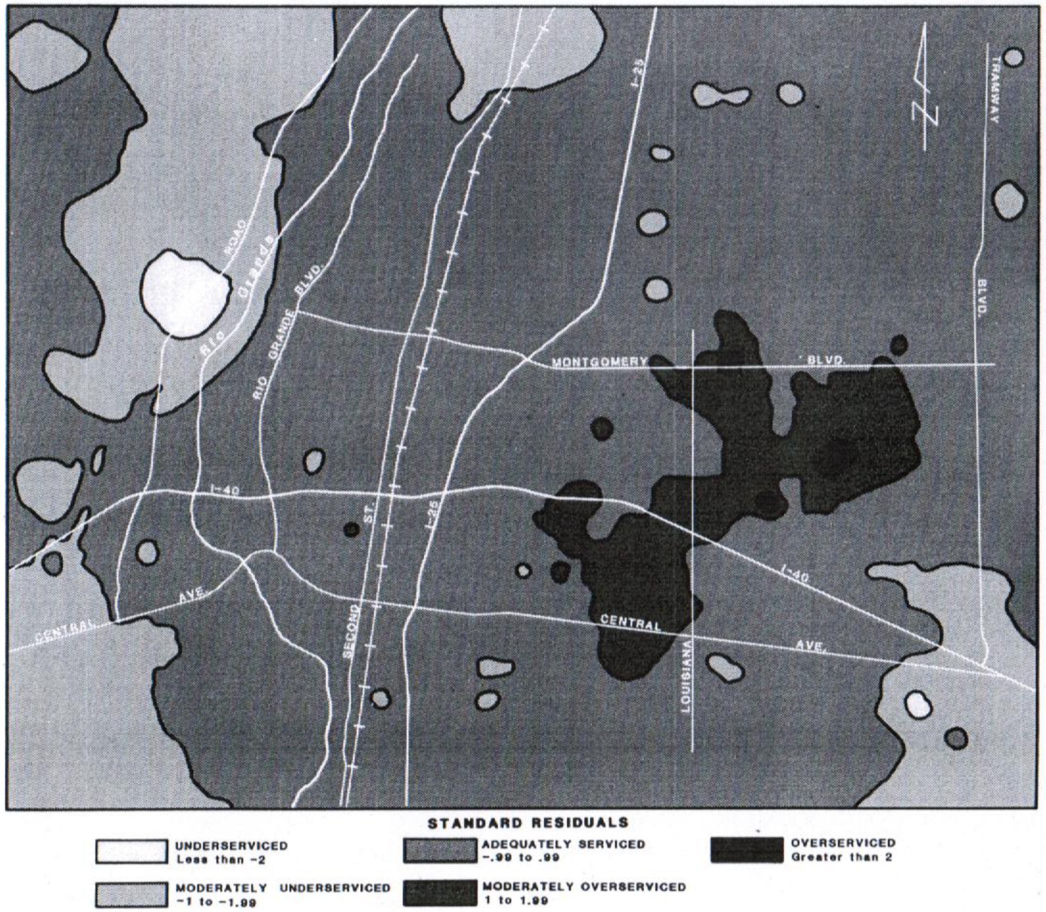


FIGURE 6
VARIATIONS IN
RETAIL SERVICING
ALBUQUERQUE, N. M.
(STANDARD RESIDUALS)
1980



whether an area is adequately, under-serviced or over-serviced. This would be difficult to determine qualitatively, even by an experienced businessman. It requires the development of a realistic model of retail opportunity.

The methodology employed in this paper represents an initial attempt towards constructing such a model. When more fully developed, similar techniques can prove invaluable as tools for planners and businessmen in their assessment of retail locational patterns. These early results, however, need to be interpreted with caution. We do not yet understand how the socio-economic characteristics of neighborhoods, entrepreneurial decisions and other area specific factors (zoning ordinances, lending policies, etc.) combine to influence the distributional arrangement of retail facilities. It is obvious that much more research needs to be undertaken.

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