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THE RELATIONSHIP BETWEEN THE OVERBOUNDEDNESS OF CITIES AND THE URBANIZATION OF RURAL SETTLEMENT PATTERNS

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ALFORD PAUL TRIBBLE

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THE RELATIONSHIP BETWEEN

THE OVERBOUNDEDNESS OF CITIES AND THE URBANIZATION

OF RURAL SETTLEMENT PATTERNS

APPROVED BY

DISSERTATION COMMITTEE

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CHAPTER I

INTRODUCTION

The population of cities in the United States since World War II has been steadily shifting away from city centers and increasing at the peripheries (Blumenfeld, 1954, 1959; Boyce, 1966; Newling, 1969). Peripheral growth will constitute the dominant form of future urban population expansion, obscuring the growth attributable to new cities and satellite communities (Downs, 1970).

Analyses of growth in peripheral areas has been undertaken by several scholars. None, however, has attempted to associate the growth with the amenities related to the extension of city political boundaries. This new approach to the analysis of peripheral growth is undertaken in this research.

The horizontal growth of cities has been analyzed by social scientists of various disciplines. Geographic and kindred literature describing urban spatial growth has been concerned with three general areas; land values,[1] the decision

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[1]For example, Alonso, W. "A Theory of the Urban Land Market." Papers and Proceedings of the Regional Science Association, 1960, 6, 149-158; Alonso, W. Location and Land Use, Toward a General Theory of Land Rent. Cambridge: Harvard University Press, 1964; Casetti, E. "Equilibrium Land Values and Population Densities in an Urban Setting." Economic Geography, 1971, 47, 15-20; Casetti, E. "Urban Land Value Functions; Equilibrium Versus Optimality." Economic Geography, 1973, 49, 357-365; Muth, R. F. "Economic Change

making process,[2] and socioeconomic characteristics of fringe residents.[3]

In addition to these three areas, another aspect has been urban policies that contribute to the extension of political limits. Continued urban sprawl[4] has commonly

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and Rural-Urban Land Use Conversions." Econometrica, 1961, 29, 1-24; Muth, R. F. "The Spatial Structure of the Housing Market." Papers and Proceedings of the Regional Science Association, 1961a, 7, 207-220; Muth, R. F. Cities and Housing, the Spatial Pattern of Urban Residential Land Use. Chicago: The University of Chicago Press, 1969; Wingo, L., Jr. Transportation and Urban Land. Washington, D.C.: Resources for the Future, Inc., 1961.

[2]For example, Chapin, F. S., Jr., and Weiss, S. F. Factors Influencing Land Development. Chapel Hill: University of North Carolina, 1962; Chapin, F. S., Jr., Donnelly, T. G., and Weiss, S. F. "A Model for Simulating Residential Development." Journal of the American Institute of Planners, 1965, 21, 120-125; Donnelly, T. G., Chapin, F. S., Jr., and Weiss, S. F. A Probabilistic Model for Residential Growth. Chapel Hill: University of North Carolina, 1964.

[3]For example, Beegle, J. A. "Characteristics of Michigan's Fringe Population." Rural Sociology, 1947, 12, 254-263; Blizzard, S. W. "Research on the Rural-Urban Fringe." Sociology and Social Research, 1954, 38, 143-149; Duncan, O. D. and Reiss, A. J. "Suburbs and Urban Fringe," and "Rural Urban Fringe" in Social Characteristics of Urban and Rural Communities, 1950. New York: John Wiley and Sons, 1956; Gist, N. P. "Ecological Decentralization and Rural-Urban Relationships." Rural Sociology, 1952, 17, 328-335; Jaco, E. G. and Belknap, I. "Is a New Family Emerging in the Urban Fringe?" American Sociological Review, 1953, 18, 551-557; Johnston, R. F. "The Population Characteristics of the Urban Fringe; A Review and Example." Australian and New Zealand Journal of Sociology, 1966, 2, 70-93; Martin, W. T. "A Consideration of Differences in the Extent and Location of the Formal Associational Activities of Rural-Urban Fringe Residents." American Sociological Review, 1952, 17, 687-694; Martin, W. T. "Some Socio-Psychological Aspects of Adjustment to Residential Location in the Rural-Urban Fringe." American Sociological Review, 1953, 18, 248-253.

[4]See Appendix A for a definition of this term.

created a situation where the geographic city[5] extends beyond the political city.[6] However, in other areas, predominately in the South and West, urban governments have attempted to eliminate sprawl by continually extending their boundaries through annexation. Extensive annexation predominates in the West and South where cities are few and scattered; whereas in the older, more densely settled Northeast the distance between cities is smaller and there is little room for expansion. In addition, Southern and Western cities are generally not encircled by incorporated municipalities, and consequently, political barriers to expansion are absent. Lenient annexation statutes have also contributed to the common practice of annexing to extend political boundaries in the South and West (Bromley & Smith, 1973).

The spatial aspects of annexation may appear constant; however, two functional types of urban political boundary expansion can be identified. The first occurs where an urban government extends its borders to incorporate growth that has extended beyond established political limits. The second type occurs in cities where political limits are extended to include rural land, providing room for expansion and consequently influencing the direction of growth. This latter type creates overbounded cities.[7]

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[5]See Appendix A for a definition of this term.

[6]See Appendix A for a definition of this term.

[7]See Appendix A for a definition of this term.

The first annexation type is an *ex post facto* action, whereas the second provides a method of establishing rigorous control over growth using building codes and zoning. The state where the study sample cities were selected (Texas) permits extraterritorial jurisdiction[8] for all contiguous unincorporated areas (not a part of another city) within five miles of the urban corporate limits. The building codes in areas beyond the corporate limits, however, are not as stringent as those inside the political boundary, and the municipal government lacks zoning authority there.

The major hypothesis of this work is that the extension of a city's political limits to encompass large tracts of rural land (herein termed overboundedness) influences the form and process of residential development around the urban core.

The validity of the research hypothesis is examined by testing a series of supportive hypotheses concerned with density (form) and slope (process). These supportive hypotheses are tested with t-tests and least squares procedures. Differences in density are examined with t-tests to determine statistical difference in the form of residential development between overbounded and non-overbounded city study areas. Differences in slope are examined as indicators of the differing process of development between the two city categories. These slope coefficients are obtained from three different least squares procedures.

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[8]See Appendix A for a definition of this term.

The research hypothesis presumes an understanding on the part of the developer of cost factors associated with the development process. It is assumed that developers will always attempt to maximize profit. Political boundaries are significant to this behavior because they can influence the cost of the development process. The cost of providing services will be lower to the developer and subsequently the home purchaser inside the city's political boundaries. The developer is encouraged to reduce these added costs without impairing the product's marketability because a portion of the cost is passed along to the developer and subsequently the consumer.

Developers interviewed indicated they consider the decision making process of the potential homeowner in the selection of a site for residential development. This decision making process has been analyzed by several scholars, with the conclusion being that economic considerations are weighed heavily in the process of selecting a satisfactory location. The potential home buyer is not only concerned with accessibility and the ethnic and social characteristics of a neighborhood, but also considers home price, transportation costs, public utility services, and fire and police protection available (Brown & Moore, 1970; Kain, 1962; Rossi, 1955; Simmons, 1968; Wolpert, 1964).

The cost of utility services and homeowner insurance is greater beyond than within the incorporated political limits. This cost differential results from a dual set of expenses. First, the residential land developer operating beyond the urban political limits must absorb the cost of utility extensions, a cost which is subsequently passed to the consumer. Additionally, the homeowner who lives beyond the political boundary is assessed proportionately larger rates for the continuous use of utilities. This homeowner also pays a higher annual insurance rate because volunteer fire departments are considered less effective by insurance companies.

If the above assumptions are valid, residential growth variables can be anticipated to be dissimilar for overbounded and non-overbounded city[9] samples located equidistant from the periphery of the geographic city. The data describing these variables represent the end result of the above described decision making process, and will reflect growth in areas where the home purchaser is content with social and economic considerations.

Based on these results, judicious approval of annexations can be used as a planning tool in regulating the future direction and celerity of urban residential growth. Since control is exerted through building codes and zoning, particular sections of a city can be planned for development while others will remain undeveloped and will serve as buffer zones (Proudfoot, 1954; Natoli, 1971). The provision of city services in distant locations beyond the geographic city encourages development in these peripheral areas, while

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[9]See Appendix A for a definition of this term.

higher land cost nearer the geographic city creates semi-geenbelts between residential construction.

CHAPTER II

THEORIES OF RESIDENTIAL DEVELOPMENT

The exponential distance decay function has been used by several social scientists to approximate the distribution of urban population around the city core. Though not implied in previous literary efforts, this function is postulated to generally fit the residential distribution of population beyond the built-up city in cases where the political boundary is coincident with the geographic city.

Since the residential land developer's goal is the maximization of profit, he will attempt to develop land parcels in areas within the aspiration levels of most potential home buyers. Most non-overbounded city development has been adjacent to the geographic city because only the small population in the highest socio-economic category is financially capable of moving to distant areas beyond the geographic city and absorbing the cost of commuting. Most development has also been adjacent to the geographic city in overbounded cities. Because of different total development cost functions, however, more families can balance commuting costs against substantially lower priced homes. Therefore, the premise of this research is that proportionately more development can occur in the distant locations of the overbounded city study area.[10]

Many urbanology terms are ambiguous. The generally accepted conceptual definitions of many of these terms are applicable to the present study; however, there is need to formulate operational definitions of others specifically to fit this study. The concept of the political city, for example, usually refers to that portion of the urban area enclosed by the city limits, a definition in complete consonance with the definition employed herein. Conversely, definitions for overbounded and non-overbounded cities or the geographic city are inadequate for this research. For example, geographic city is a term generally applied to the built-up area of the city; however, for this work it is defined specifically as that portion of the political city where square mile samples contain less than 50 percent rural land use. Consequently, a number of terms are defined precisely prior to their inclusion in subsequent discussions. For the benefit of the reader, therefore, a compendium of terms is provided in Appendix A. The reader is advised to consult this compendium to prevent semantic misunderstandings.

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[10]The extent of the study area for each category of cities is provided in illustration form in figure 11 in the methodology chapter, but one should note that the study areas for overbounded cities are outside the geographic cities but completely within the cities' political limits. For non-overbounded cities the study areas are again outside the geographic cities, but for this case also outside the political cities.

Prior Theories of Urban Settlement Zonation

The relationship between urban densities and distance from urban nodal points, specifically the CBD, has been the topic for numerous investigations. The purpose of these analyses was often similar to the objective of this research, that is, to examine the effect of distance from the urban core on settlement density. This research, however, focuses on densities beyond the built-up portion of the city whereas most of the previous research has examined density functions within the geographic city.

Much prior work on urban densities traces to an idea originally formulated by Bleicher (1892), and later utilized by Clark (1951), that is, the population exponential distance decay function.[11] This function assumes that accessibility to the city center decreases with distance, and that the study area consists of a flat isotropic plain. The distance decay function is a generality which fits no specific urban area perfectly, but has been shown to have general applicability to many cities (Berry & Horton, 1970, pp. 276-277; Berry, Simmons, & Tennant, 1963; Muth, 1961a; Newling, 1966; Stewart & Warntz, 1958).

The exponential distance decay function describes the residential location of the urban populace. Since population

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[11]The equation expressing this distance decay function is $D_d = D_o e^{-bd}$, where D_d is the population density at distance d from the center of the city, D_o is the density at the center of the city, e is the base of the natural logarithms, and b is a model parameter (the density gradient).

and dwelling density are highly interrelated, the latter variable can be substituted into the equation without altering the theoretical association. Whereas in previous research efforts the distance decay function has been equated to the location of population everywhere around the urban core, in this work that function is used to describe residential growth occurring over the past decade in only those areas beyond the geographic city.

The author could locate no research in which a mathematical function was applied to population or residential growth beyond the geographic city. In all probability mathematical functions have not been applied to distributions in these areas because aggregate large scale data is lacking beyond the geographic city. Where census tracts do exist, they usually cover large areas when compared to those in the built-up portion of the city.

Several sources indicate descriptively that the exponential distance decay function may generally apply beyond the geographic city also. They note that more affluent families tend to move beyond the edge of the geographic city, but the majority of movers advance no more than a mile or so farther from the city center on each move (Abu-Lughod & Foley, 1966; Brown & Moore, 1970; Simmons, 1968).

Empirical evidence collected for this study from cities that do not have political boundary extensions supports this notion. The major assertion of this research is that a different configuration of density with distance will be found in overbounded cities because of differing cost with distance relationships.

Density Projection - Overbounded City Samples

While standard population density functions are acceptable where overextensions of political boundaries have not occurred, the author contends that in cases of overboundedness the relationship between distance and density is significantly modified, particularly in the outer distance bands. The relationship and logic for such a premise is derived from examining the process of urban residential development with some emphasis on relating this process to decisions developers make in converting fringe land[12] to residential use. The logic underlying the research premise is based on prior studies and theory, plus the author has also utilized interview information obtained from developers in two cities under study.[13]

Several important assumptions must be clarified prior to stating specific relationships in the model used here. Unless statements to the contrary are made in later sections, the following assumptions are held to be constant throughout:

1. Assume that the developer is attempting to maximize his profit.
    a. For any planned development the developer will choose the tract of land he feels will provide the greatest return on his investment.

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[12]See Appendix A for a definition of this term.

[13]Interviews were obtained in Lubbock, the most overbounded, and Austin, the least overbounded of Texas cities surveyed.

b. The developer attempts to develop residential land to meet the aspiration levels of a sizeable segment of the urban population.

2. Assume that most new development will occur in locations beyond the present edge of the built-up urban area.[14]

3. Assume that the home purchaser will select the location most satisfactory for his socio-economic aspirations.[15]

User Preferences and Development Demand Functions

To maximize profit the developer should understand variation in demand for residential units at various points along the distance spectrum, and should funnel his activities where the aspiration levels of most home purchasers will be met.

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[14]Support for this assumption is provided in several literary works including: Blumenfeld, H. "Are Land Use Patterns Predictable." Journal of the American Institute of Planners, 1959, 25, 51-66; Downs, A. "Alternative Forms of Future Urban Growth in the U.S." Journal of the American Institute of Planners, 1970, 36, 3-11; Nelson, H. J. "The Form and Structure of Cities: Urban Growth Patterns." Journal of Geography, 68, 1969, 198-207; and Schnore, L. F. "Metropolitan Growth and Decentralization." American Journal of Sociology, 63, 1957, 171-180.

[15]Support for this assumption is provided in several literary works including: Brown, L. A. and Moore, E. G. "The Intra-Urban Migration Process: A Perspective." Geographiska Annalar, Ser. B, 52, 1970, 1-13; Hoyt, H. The Structure and Growth of Residential Neighborhoods in American Cities. Washington, D.C.: U.S. Government Printing Office, 1939; Johnston, R. J. "Activity Spaces and Residential Preferences: Some Tests of the Hypothesis of Sectorial Mental Maps." Economic Geography, 48, 1972, 199-211; Wolpert, J. "The Decision Process in Spatial Context. Annals of the Association of American Geographers, 54, 1964, 537-558; Wolpert, J. "Behavioral Aspects of the Decision to Migrate." Papers and Proceedings of the Regional Science Association, 15, 1965, 159-169.

User Preferences

Potential home buyers considering a move to the fringe are often in search of more space for a growing family, more privacy, a cheaper house or land, better conditions for the children, and/or vista (Pryor, 1969; Simmons, 1968). Each factor functions as a centrifugal force (Colby, 1931) drawing population outward from the geographic city. There are, in contrast, centripetal forces functioning as adhesive factors in channeling the expanding population to areas nearest the geographic city. The paramount centripetal factor is accessibility which acquires increased temporal and monetary costs with distance. Additionally, certain groups of people are not content living in distant areas beyond the geographic city. For example, the fringe residence is not considered as satisfactory for the young or the old as for those in their thirties or forties and the female who is often without transportation during the day is generally not as content as the male living distant from the geographic city (Beegle, 1947; Jaco & Belknap, 1953; Johnston, 1966; Kurtz & Smith, 1961; and Martin, 1953).

The Developer Within the Preference Demand Structure

Land costs alone suggest that parcels of land located farther from the geographic city than others will be more lucrative for development. Accessibility, however, is a real factor in the developability of a land parcel. Since fringe residents are highly conscious of this variable, and remembering that it is the stated goal of residential land developers to maximize profit, most residential growth predictably occurs adjacent to the geographic city in both city categories.

As previously mentioned, the potential homeowners attracted to distant locations would generally be few because they must absorb daily commuting costs. Without additional incentives (other than cheap land which is offset by increased service cost) to attract the lower and middle socio-economic classes to the distant areas, the developer building there attracts only the few people in the highest socio-economic category; thus, development in this area would be on a small scale (Johnston, 1966; Martin, 1953; Simmons, 1968; Wolforth, 1971).

This author contends that accessibility decreases at a constant rate for some distance beyond the geographic city, but levels off after reaching a particular point. Nearly everyone considers a location one mile distant from the geographic city more accessible than two miles distant. For the person who can afford the temporal and monetary accessibility cost of a distant home, however, it is probable that he would not consider a home located for example, seven miles from the geographic city to be more inaccessible than one located six miles distant. This contention has been supported by Wolforth who has shown that London workers commute from as far away as fifty miles, indicating they do not consider their landholdings significantly more inaccessible than those closer in

(1971). Pryor has shown that accessibility ceases to operate as a major constraint in the selection of a dwelling when other advantages, such as the semi-rural environment of the fringe, outweigh physical distance (1971). Clark and Peters have supported the idea that opportunities can override distance when the homeowner considers a plot of land to represent a good opportunity while not being inaccessible to his needs (1965).

If the developer can provide incentives for the lower and middle socio-economic class potential homeowner that offset commuting costs, the developer will probably alter demand and additional home purchasers will be drawn to distant locations. Beyond the moderating point in the increase of accessibility cost, a decrease in land cost combined with other necessary incentives will attract homeowners.

Development Cost

The residential land developer is confronted with three major costs in land development:

1. Variable cost (materials and labor)
2. Land cost
3. Service cost

Variable cost is not significantly different from one locale to another and, therefore, is not considered a determinant of the location of residential development. Land and service costs may vary between different locales with each cost factor having the potential to influence development location. The role of land cost has been adequately discussed in other research. Most urban theory is predicated on accessibility and land cost interactions. No attempt is made in this research to develop a new land cost model. Rather the objective is to examine development cost as a reflection of the interaction between land and service costs.

The political boundary in the rural fringe area influences the service cost differential between overbounded and non-overbounded city study areas. This differentiation in service costs is a key variable in the development cost of this model, and explains differing residential development patterns in the two study areas.

Land Cost Function

Land cost in both the geographic city and the rural-urban fringe is related to accessibility.[16] Awareness that a parcel of land has a relatively accessible location and, therefore, is in demand, is reflected in the land cost. The concept of an equilibrium distribution of users and uses of land for residential purposes in the geographic city has been supported by several economists and geographers, noting land rent decreases with distance from the city center but as distance increases transportation costs also rise (Alonso,

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[16]For the purpose of this study, accessibility is defined as "the savings in time and cost attendant upon location near major points of population confluence" (Firey, 1946, pp. 411-412). Location of a dwelling relative to shopping, work, and other residential areas can, therefore, be incorporated within the term accessibility (Clawson, 1962; Czamanski, 1964, 1965; Gist, 1952; Martin, 1952, 1953; Pryor, 1969).

1964; Muth, 1961a; Wingo, 1961). Because peripheral accessibility is less desirable, land values for close in sites sometimes approximate ten fold that for outlying land (Lansing & Barth, 1964; Martin, 1952; Vernon, 1961; Wissinik, 1962).

The decrease in land cost with distance beyond the geographic city is less well known. Unlike geographic city land that is used almost exclusively for urban purposes, the cost of fringe land results from a multi-variate set of factors. Here the developer, the speculator, and the agriculturist are all competing for the same land parcels. Based on Sinclair's model (1967), Boal has indicated that beyond the edge of the geographic city, "Total land value declines with distance from the growing urban area. Speculative value declines likewise, until at (a particular) distance . . . from the urban area there is no speculative value . . ." (1970, p. 79).

The land rent theories of Alonso (1964), Muth (1961a), Wingo (1961) and others are applicable to the areas both within and beyond the geographic city. Each, however, treats land rent in peripheral areas only as a portion of a continuing cost curve emanating at the city center.

There is no generally accepted land cost curve applicable only to areas beyond the city's built-up portion. For that reason, empirical data in the form of developer interviews were collected in the field by this researcher in an effort to construct such a curve. The developers interviewed were unanimous in their opinion that land cost was highest near the edge of the geographic city where land holders were speculating that development would soon encompass their land parcel. They noted a sharp drop in this cost a few miles beyond the built-up area of the city where a lesser degree of speculation was occurring, and the relatively cheap land beyond was almost exclusively used for agricultural purposes.

The formal curve most closely approximating these relationships is an inverted logistic type (figure 1). Specifically, the curve is of the form:

$$LC_d = U - \left(\frac{U}{1 + e^{(a-bd)}} \right) \qquad (1)$$

where:

LC_d = land cost at distance d from the edge of the geographic city

U = upper limit equilibrium point

d = distance from the edge of the geographic city

b = model parameter

a = model parameter

e = log constant

When d = 0, e is raised to the power a, and if this is large LC_d will be large. When d increases, (a-bd) becomes smaller, decreasing the value of LC_d.

The analyses referenced above depicting land cost inside the geographic city are based on accessibility, and do not incorporate the service factor in the cost curve. The postulated land cost curve for fringe areas presented above is also based only on accessibility, and is therefore applicable to both the overbounded and non-overbounded city study areas.

Service Cost Function

Development costs for services such as water and sewage are passed to the consumer if originally incurred by the developer (Golledge, 1959; Harvey & Clark, 1965; Ullman, 1962). Texas developers noted that FHA, VA, and similar home appraisers contact developers before arriving at an assessed home valuation to determine expenses the developer necessarily incurred in preparing tracts of land for residential construction. Because service costs vary that are passed to the purchaser, identical houses were assessed differently at separate locations.

Developers noted significant differences in service costs depending upon the location of the land parcel relative to the political boundary. Beyond the corporation boundary there is usually a lack of city water and sewage services, curbs, sidewalks, and paved streets. Fringe residents often have to rely on rural governments to provide these services, and these rural towns and counties commonly do not possess the necessary legal powers (Blizzard, 1954; Wehrwein, 1942). Although public works services enhance the desirability of land (Margolis, 1968), a survey of the public works offices by this researcher revealed that none of the eleven cities comprising the study areas provide city installed water and sewage services outside their political boundaries.

In Austin, for example, city water supplies are generally available to residents located inside or outside the political boundary, but at greatly differing costs. Inside the city a developer may tie into city mains at a 10 percent cost of the tie-in expense. Outside the political boundary a developer connecting to city water lines incurs a one-hundred percent cost which is subsequently passed to the home buyer.

The postulated cost curve reflects political influences on developer service expenses, generating a curve with two forms depending upon city type. For non-overbounded cities the expense is incurred totally by the developer and finally the home purchaser with no financial aid from the municipal government. The expense of extending services to unserviced areas by the city adds a linear cost to the developer. Developers in Austin, for example, indicated that because they had to provide services to houses beyond the city boundary, their service cost per unit increased at a per unit distance. Conversely, the cost of services in the overbounded city study area would be minimal and would consist of a standard services entry fee which is the same for all areas within the political boundary. Here the connection to city utility services would be largely incurred by the municipal government (figures 2 & 3).

Specifically, these service cost curves would be of the form:

$$SC_d = a + (cb)d \qquad (2)$$

Figure 1

Land Costs

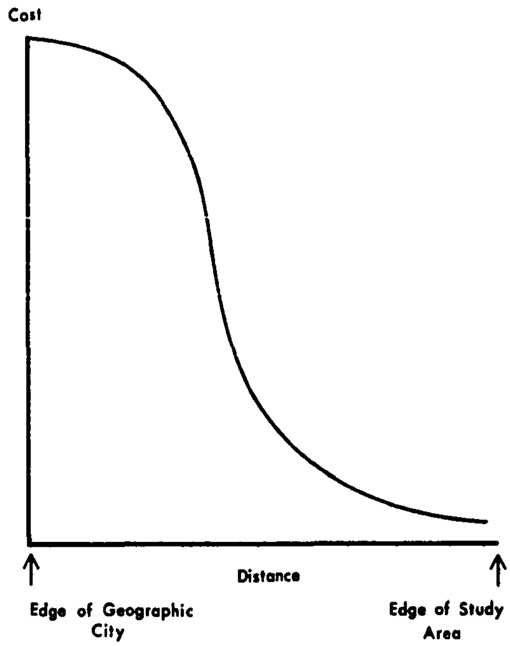


Figure 2

Service Costs

Non-Overbounded Cities

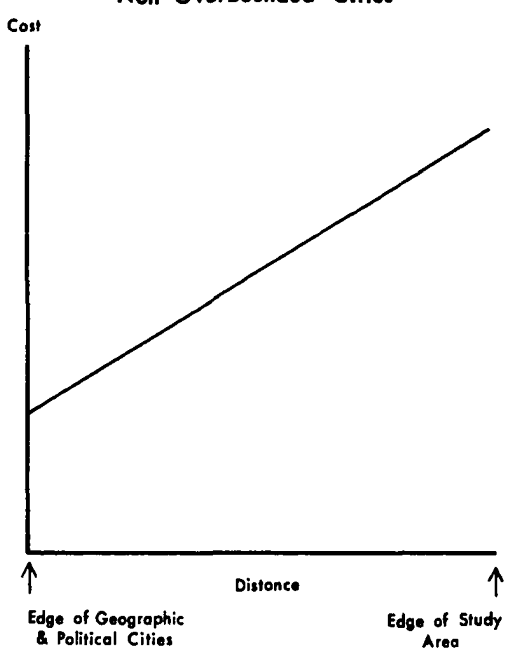
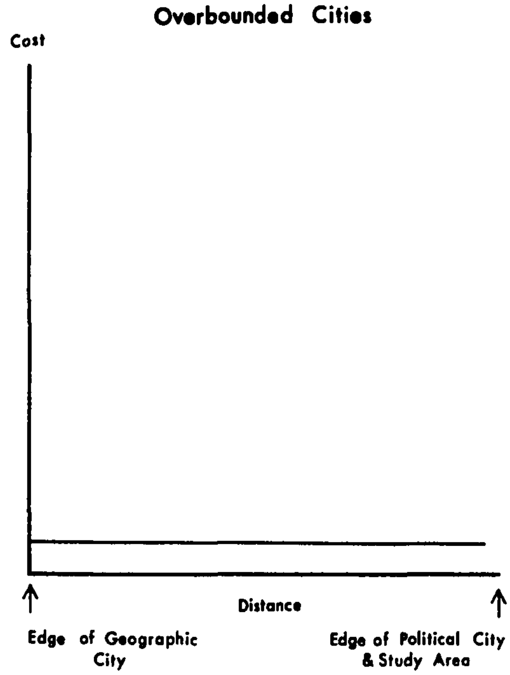


Figure 3

Service Costs

Overbounded Cities



where:

SC_d = the services cost at distance d from the edge of the geographic city

a = services entry fee

c = 0 if the curve is for an overbounded city

c = 1 if the curve is for a non-overbounded city

b = slope - the cost gradient - the cost increase for each additional distance unit extension of services

d = distance

The equation for the service cost curve for overbounded city samples is the same as that for non-overbounded cities, except that in this case the value of c will constantly equal zero, and the service cost will consist only of the entry fee.

In addition to service costs incurred by the developer, it was noted in the survey of the eleven cities that none provide invisible services such as fire and police protection beyond the city limits. While the absence of these services may not appear to represent a cost to the home purchaser, it actually does. Fire and theft insurance rates, for example, are based on the comparative availability of protection inside and outside a city's political limits, and were consistently higher beyond the political borders of the eleven cities.[17]

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[17]A representative of an Independent Insurance Agency was contacted in each city to ascertain the annual homeowner premium for a $20,000 brick veneer home ($200 deductable). For each of the cities the premium was more expensive outside than inside the political boundary, with an average difference of 14.35 percent.

Total Development Cost

Recall the developer absorbs three costs. First, materials and labor are relatively constant everywhere for both study areas; second, land varies with distance in both study areas; and, third, service is constant in the overbounded city study area but varies with distance for non-overbounded city samples.

Total development cost curves reflect a combination of land and service cost at each point throughout the distance spectrum of the study areas. Two different sets of total cost curves can be postulated because of different service costs incurred. Since service costs for overbounded cities consist only of the constant entry fee, adding this relatively low cost to the land cost curve does not alter the structure but merely the position of that curve. Therefore the total development cost curve for overbounded cities is similar in form to the land cost curve previously postulated in figure one (figure 4).

The total cost curve for samples located outside non-overbounded cities is likewise formed by meshing service and land cost throughout the distance spectrum. Because of the service cost that increases linearly with distance in these samples, both the position and the form of this development cost curve are markedly different from the land cost curve postulated in figure one.

The empirical data collected by this researcher from non-overbounded city samples supports a distance decay function of residential development outward from the edge of the geographic city. The total development cost curve ascends for a short distance beyond the edge of the geographic and political city because of increasing service cost and slowly decreasing land prices. The curve descends as land cost drops sharply, but ascends again as the rising service cost replaces the stabilizing land cost (figure 5).

As the beta value of the service cost slope is increased, the power of the linear function begins to supersede the power of the inverted logistic function of the land cost curve, therefore, this slope is an important determinant of the total development cost curve for non-overbounded cities.

This curve can be altered with a change in the beta value of the service cost curve. The author reasons, however, that the total development cost curve presented for non-overbounded cities is representative of reality because of the distance decay nature of the residential development data and the influence of the inverted logistic form of the land cost curve.

Postulated Residential Development Curves

Residential development in rural areas adjacent to geographic cities can logically be postulated to have occurred in two different forms given the demand and cost functions presented above, depending whether the samples were obtained

Figure 4

Total Development Costs
Overbounded Cities

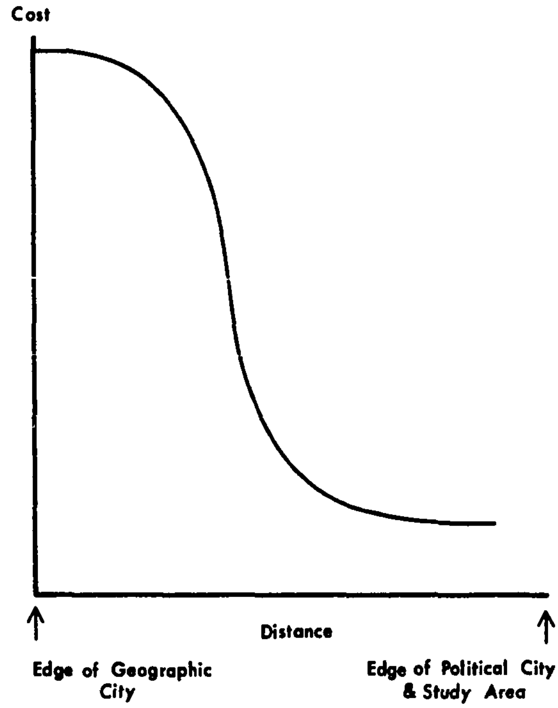
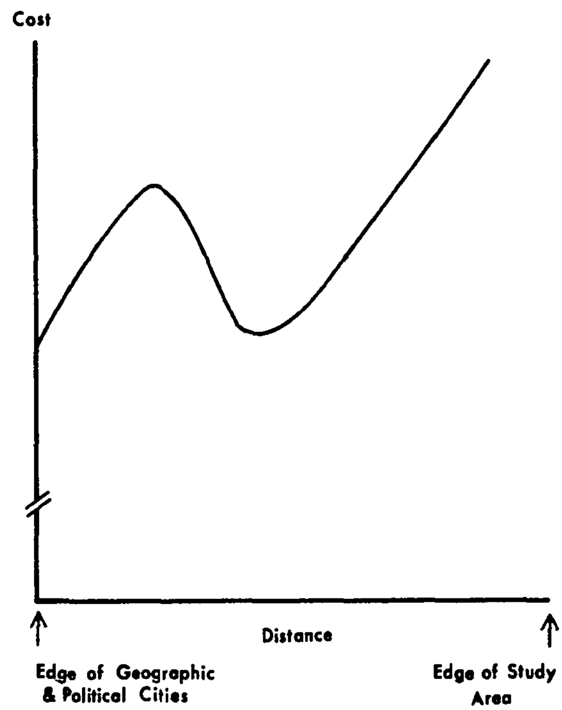


Figure 5

Total Development Costs
Non-Overbounded Cities



from overbounded or non-overbounded cities. A combination of demand to live in the most accessible areas and increasing development cost with distance indicates that when geographic and political boundaries of a city coincide, residential growth beyond the geographic city would then adhere closely to an exponential distance decay function (figure 6) of the form:

$$Y = ab^x \tag{3}$$

where:

Y = residential density at distance x from the edge of the geographic city

a = model parameter

b = model parameter

x = distance

Cost follows a continual decline with distance in overbounded cities in contrast with the generally increasing development cost with distance for the non-overbounded city study area.

Recall the user preference section indicated that because most people cannot afford the monetary cost of commuting, families in the highest socio-economic category are the ones who most often migrate to distant fringe areas. The fringe would appeal to more potential homeowners where city financed services are combined with relatively low land cost.

Recall there is a point beyond the geographic city where perceived user accessibility ceases to decrease at a constant rate. Beyond this point proportionately more families in the overbounded than in the non-overbounded study area would be able to achieve satisfaction from a distant fringe residence. The postulated residential development curve for the overbounded city approximates an exponential distance decay function to a point beyond the geographic city because developers perceive that most potential homeowners desire to live in the most accessible locations. But unlike the curve for non-overbounded city samples, this curve has an additional quadratic function at the outer reaches of the distance spectrum because of the relatively low development costs in the periphery of the study area (figure 7).

Formally, this curve is represented by the equation:

$$Y = a + b_1X + b_2X^2 + b_3X^3 + e \qquad (4)$$

where:

Y = residential density at distance X from the edge of the geographic city

a = model parameter

b = model parameter

X = distance

The existence of a curve such as this is supported in several literary works describing "leap-frog" growth where the settlement of discontinuous land plots is common. Residential density waves out from the city center have been shown to rise relatively steeply to a peak, decline and flatten out, and rise again. This processional wave beyond the geographic city creates speculative land holdings, paper land plats, farms falling into disuse, and a plethora of

Figure 6

Residential Development
Non-Overbounded Cities

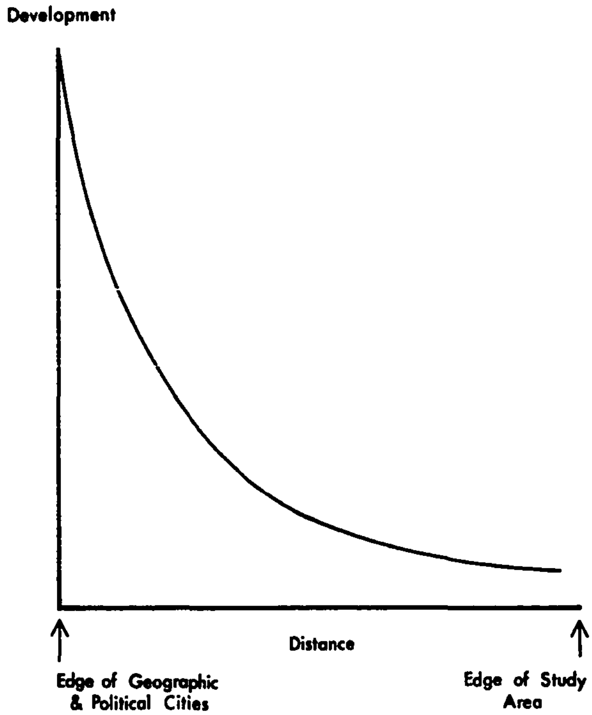


Figure 7

Residential Development
Overbounded Cities

realtors. The next logical development step in this zone is the construction of dwellings (Blumenfeld, 1954; Boyce, 1966; Harvey & Clark, 1965).

The residential development curves postulated above are anticipated for the aggregate of samples in each category of cities - not necessarily for any specific city. Site factors, for example, such as poor physical terrain, an inadequate transportation network, or the inability of developers to acquire large tracts of land (Brodsky, 1973) in any particular overbounded city may render a portion of that city's outer extremity undevelopable. Investigation of development in the outer distance limits for all overbounded cities overshadows specific site factors. The postulated growth for all overbounded city samples taken as one group, therefore, is expected to be omnidirectional, reflects dense growth near the geographic city, less dense growth near the periphery of the study area, and a relative growth void between these two locations. The postulated growth outside non-overbounded cities is likewise omnidirectional for all non-overbounded city samples combined, but is restricted to the areas near the geographic city (Hudson, 1973; Morrill, 1965).

Summary

User preferences perceived by the residential land developer are paramount in the development/non-development of land parcels for both overbounded or non-overbounded cities.

Introducing contrary service costs for the overbounded compared to the non-overbounded city generates a completely new set of economic relationships. Whether or not these differing relationships will be reflected by different residential growth patterns in the two dichotomous sample areas is discussed in the analysis chapter.

CHAPTER III

METHODOLOGY

Cities sampled in this research were chosen for their location within the United States and city size. Rural mile square samples for each city type (overbounded and non-overbounded) were selected from aerial photographs. Dwelling density data were analyzed in a series of models to determine their fit with the conceptual models presented in the previous chapter. Ordinary least squares procedures and t-tests were used to examine the research and supportive hypotheses dealing with slope and density variations around the city fringe.

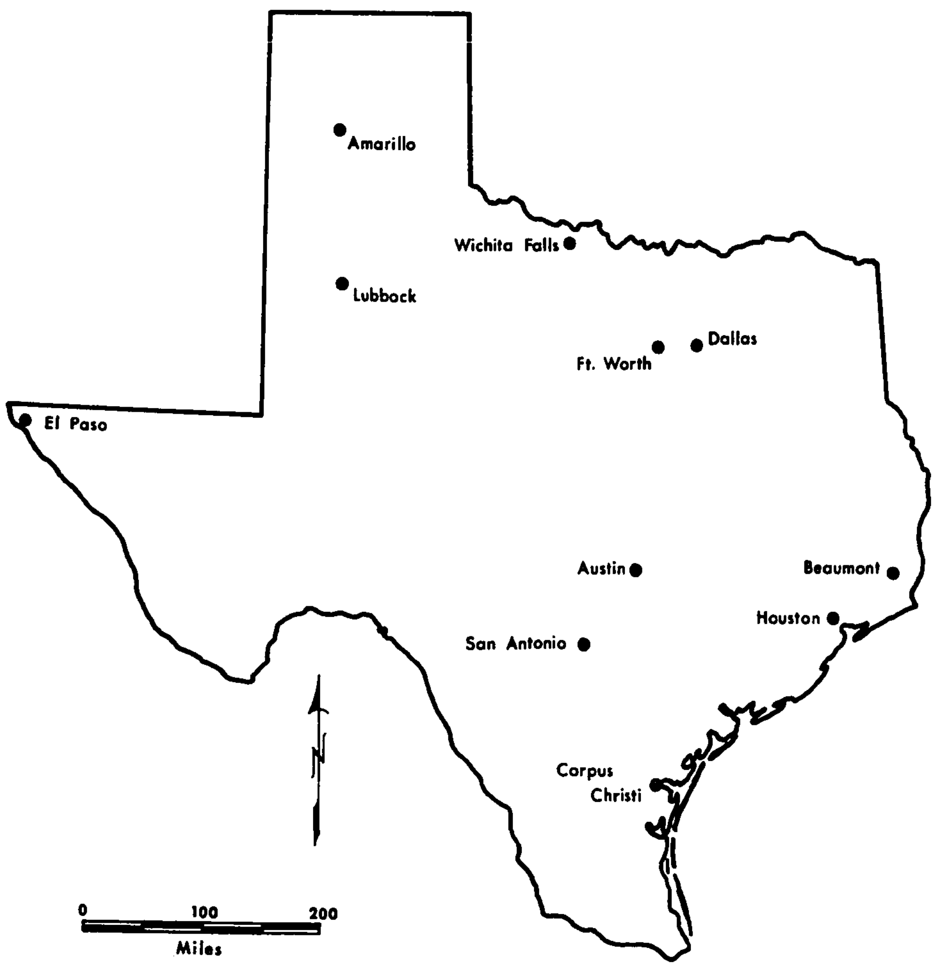
Research Area

Land immediately peripheral to eleven Texas cities which had 1960 populations of 100,000 or more (figure 8) was sampled to determine its residential character. These eleven cities exhibited urban growth patterns, that is, comprised a large enough population to sustain residential growth in several directions around the geographic city.

Large Southwestern cities were selected because they were widely spaced, generally lack juxtaposed small incorporated municipalities, were settled after Northeast cities

Figure 8

Sample Cities



(indicating lower densities), and were located in a state with lenient annexation laws.

A single state was sampled to control for heterogeneous state annexation laws. Local annexation laws in Texas are uniform throughout the state. Texas laws are uniformly applied and they also facilitate the annexation process. On its own initiative a Texas city may increase its area by almost one-third within twenty days. Additionally, the city area can increase by a relatively unlimited percentage in a matter of days through annexation requested by specified voters and land owners, or through acquisition of government owned property.

A city may annex in any one calendar year territory equivalent to 10 percent of the total corporate area of the city as of the first day of that calendar year, according to the Texas Municipal Annexation Act. In addition, if a city fails to annex the total quantity of territory for which it is authorized during a calendar year, the unused allocation may be carried over and used in subsequent years to a maximum annexation of 30 percent of the city's total area in one year.

The above figures seem excessively lenient, but in actuality the annexations that occur under these percentage guidelines may represent only a fraction of the land ultimately annexed in one calendar year. The above limitations apply only to private land that is annexed through city initiative. In addition, land may be taken into the city and excluded from the above percentage figures if it is:

> (1) territory caused to be annexed by a request of the majority of the qualified resident voters in the territory and the owners of fifty per cent (50%) or more of the land in the territory, (2) territory annexed which is owned by the city, the county, the State, or the Federal Government which is used for a public purpose . . . (Municipal Annexation Act and Amendments, 1972, p. 57).

Each incorporated city in Texas is empowered to accomplish annexations under this law. The only action required by the city governments is to publish notification of impending annexations in a newspaper having circulation in the city and the territory proposed to be annexed not more than twenty or less than ten days prior to a public hearing on the matter, and to complete any annexations within ninety days of the date the city initiates annexation proceedings.

Lenient annexation laws were an important consideration in the sample state selection. City officials are unable to use annexation as a planning strategy where laws restrict it.

Overboundedness as a Relative Concept

Traditional definitions of overboundedness are based on the degree to which political boundaries extend beyond the city's built-up area. Despite basic agreement with the concept, no standard extension distance exists, and little has been done to standardize measurement. Rather than a distance criterion, cities in this study are classified as overbounded or non-overbounded based on the percent of rural land[18] in

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[18]See Appendix A for a definition of this term.

any one city when compared to a similar percentage for each of the other cities under study. The intention of the methodology is not to formulate a universal definition for overboundedness, but to operationalize the concept so the eleven cities can be classified. To categorize overboundedness in cities based on the percent of rural land in each requires a definition of rurality.

Identification of Rurality

For the purpose of this study, rural areas include agricultural land, idle land, and land in forest. All other areas, with the exception of land permanently covered by water or government property is termed non-rural. Land covered by water or government property is not subject to future residential growth because of physical limitations or Texas annexation laws and for this study is considered non-existent.

Land use was categorized on observable use rather than its functional classification. Consequently idle land[19] on the periphery of cities was classified as rural even if occupied by residents employed in the central city. Unfortunately this does not permit identification of speculative land. The distribution of this land is significant, because the distance and direction of residential growth around any one geographic city is closely associated with speculative land. Since the samples from all cities within one study

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[19]See Appendix A for a definition of this term.

area are combined, however, it has been assumed that speculative holdings in any one section of a city are balanced by similar holdings in other areas of other cities.

It was imperative that the 1973 square mile samples in each city were in rural land use in 1963, and it was necessary to identify land that could be termed rural in 1963 by the aforementioned criteria. An accurate method of identifying land that was rural in 1963 was to use ten year old aerial photography[20] and topographic maps for each city. The percentage of rural land in each square mile sample of a political city was determined from these approaches.

Sample areas containing land more than 50 percent in agricultural use, forests, or idle were classified as rural in 1963. This figure was used as the break between rural and non-rural land use. A lower percentage figure would have been more useful for assessing the exact amount of residential growth in each sample that was attributable to 1963-1973 growth; unfortunately, lowering the percentage figure eliminates many samples located in areas near geographic cities. Fifty percent was also used for samples from both city categories to balance pre-1963 growth between the two study areas.

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[20]A combination of U.S. Department of Agriculture, U.S. Geological Survey, and U.S. Air Force photos were used in an effort to obtain 1963 photography. In some cases, however, photography of that exact date was not available, and the nearest date photos were used. When these photos varied by several years from the 1963 target date, photos before and after that date were used with an interpolation made to approximate 1963 development

Others have used different criteria for delineating rural land from the geographic city, but for various reasons these procedures do not apply to this work. For example, Myers and Beegle (1947) established rural land around Detroit to exist in square mile townships where less than 25 percent of the population was non-village-rural-non-farm (NV-RNF). Early in the 1950's, Blizzard and Anderson determined rural land around Williamsport, Pennsylvania to begin at the point where agricultural land uses (including waste lands and wooded areas) predominate, and where full city services terminate (1952).

The Myers and Beegle method is not applicable here because the goal of the present effort is to identify open rural land that can support future residential growth. A square mile sample using their method may be less than 25 percent NV-RNF, and thus be classified as rural, yet contain so many dwellings that residential growth could not occur on the scale desired by a residential developer. Blizzard's method is not applicable here because city services are available in rural samples inside overbounded cities.

City Classification

A single linkage clustering algorithm was used to classify cities based on the percent of rural land within each political limit. These percentages ranged from zero to thirty-three. In the algorithm, cities were grouped by distance to nearest neighbor. Those with the smallest separation on the distance vector were joined to form the initial group. San Antonio contained 3 percent less rural land than Houston. Corpus Christi and Amarillo both contained 25 percent rural land and were separated from Ft. Worth also by only 3 percent. Therefore, two groups of cities were formed on the first cycle (figure 9).[21] During subsequent cycles additional cities were added to the nearest groups until all were classified into the two dichotomous categories. The first group (overbounded) included seven cities; the other contained four (figure 10) (Abler, Adams, and Gould, 1971, p. 160).

Population Characteristics of Sample Cities

Diverse ends of the population spectrum are represented in the two city categories. The non-overbounded group contains the largest (in terms of 1970 population) as well as the smallest Texas cities surveyed (Houston and Wichita Falls), while the overbounded group has the second largest and smallest cities under study (Dallas and Beaumont). More specifically, using the 1970 population rank within 1960 political limits, the non-overbounded cities were the first, third, sixth, and eleventh largest cities of the eleven cities studied.

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[21]Theoretically, two groups of cities were formed before these described above. But the distance separation is zero in both cases (Corpus Christi and Amarillo; Lubbock, El Paso, and Beaumont) and the first actual grouping of cities based on different percentages of rural land is as described above.

Figure 9

CLUSTERING SEQUENCE

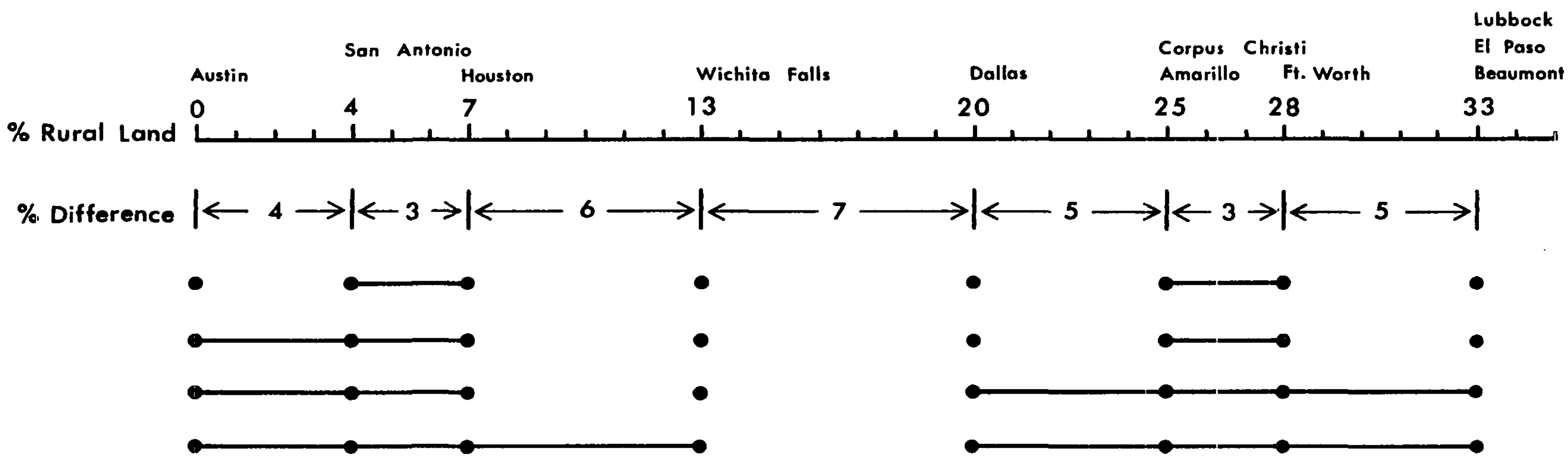
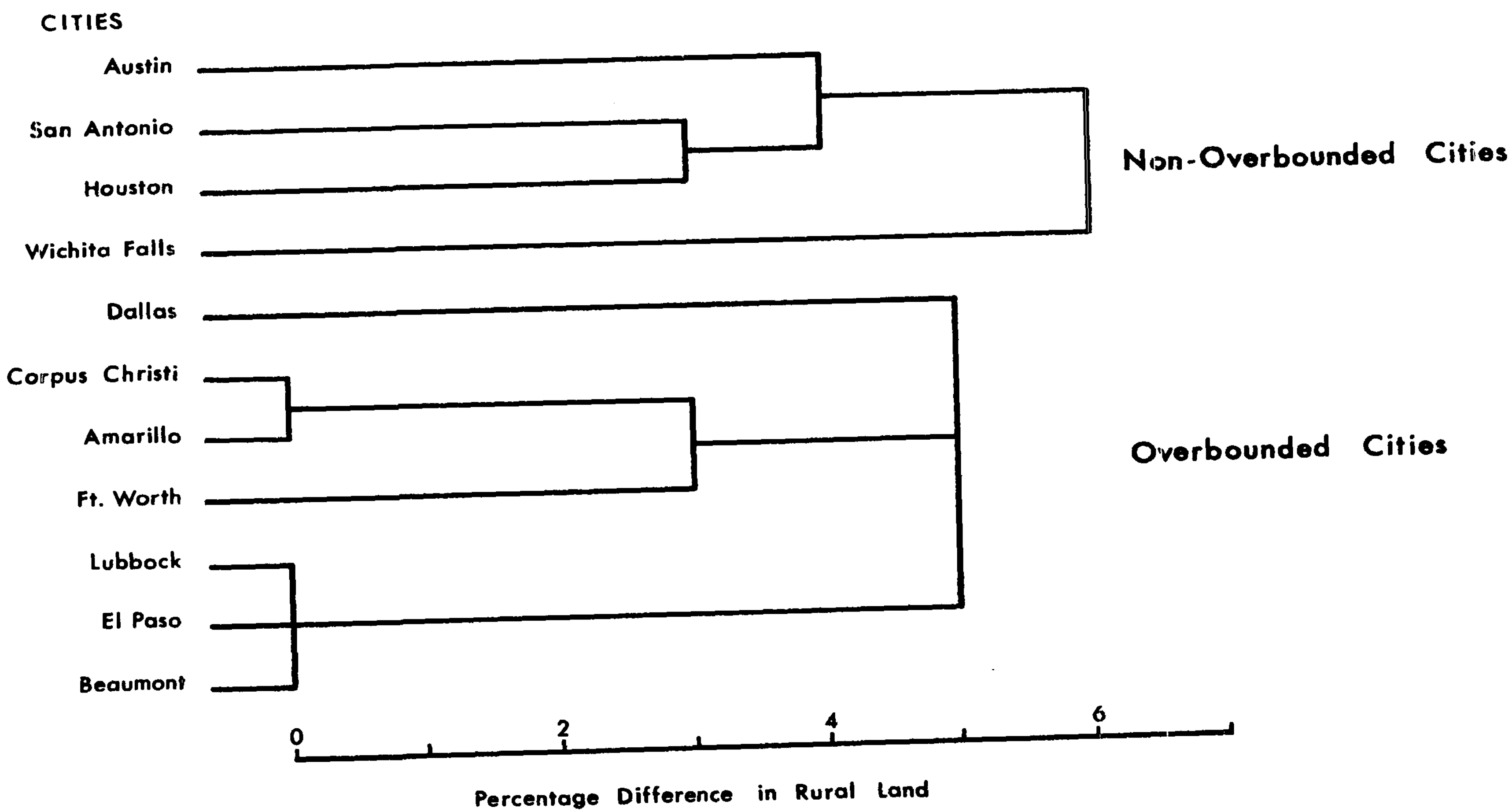


Figure 10

CLASSIFICATION MATRIX



Each category (overbounded and non-overbounded) contains cities of varying sizes with differing growth rates (table 1). It is not possible to compare samples between categories without first demonstrating there has been no significant difference in the mean growth of overbounded and non-overbounded cities or considering in later statistical analyses the differing means, if they exist. Using this type control, a significant residential growth difference between 1963 and 1973 in the periphery of overbounded and non-overbounded cities can be attributed to the overbounded nature (and therefore extended amenities) of some cities.

TABLE 1

CHANGES IN SAMPLE CITY POPULATIONS, 1960 - 1970

Overbounded Cities				Non-Overbounded Cities			
City	1960 Pop	1970 Pop in 1960 Area	% Change	City	1960 Pop	1970 Pop in 1960 Area	% Change
Amarillo....	137,969	123,735	-11.4	Austin......	186,545	207,159	11.0
Beaumont....	119,175	117,548	- .1	Houston.....	938,219	1,197,278	27.6
Corpus Christi....	167,690	179,218	6.8	San Antonio....	587,718	639,687	8.8
Dallas......	679,684	833,065	22.5	Wichita Falls......	101,724	95,901	-6.0
El Paso.....	276,687	321,945	16.3				
Ft. Worth...	356,268	382,431	7.3				
Lubbock.....	128,691	149,101	15.9	Mean Percentage Change = 10.35			
Mean Percentage Change = 8.19				Standard Deviation = 11.91			
Standard Deviation = 10.59				t = -.2816325			

Source: 1970 U.S. Census of Population, Number of Inhabitants, Texas. Statistical Test Calculated by Author (See Appendix B)

Percentage changes in population (1960 to 1970, in 1960 area) varied within both city categories. For overbounded cities it ranged from a 22.5 percent increase in Dallas to an 11.4 percent decrease in Amarillo. In the non-overbounded cities the largest single rise in population (27.6 percent in Houston) was greater than that for Dallas, but the maximum decline was less (6 percent in Wichita Falls). Thus, extremes indicate that cities in the non-overbounded class grew faster. The averages for the two groups, however, were found to be statistically similar (table 1).

Study Areas and Samples

The study areas for the two city categories consist of square mile samples that were identified as being rural in 1963. For non-overbounded cities these samples are located between the political and geographic city and an established eleven mile limit. Overbounded city samples are located between the geographic city and a similar eleven mile limit, which coincides with the political city (figure 11).

The eleven mile limit was selected because it is the average radii of the political limits of Houston, the largest city, in 1973. Since neither the geographic nor the political cities of the other urban areas under study approached the eleven mile diameter, this radius was the maximum extent for each study area. No samples were closer to the city center[22] than three miles in either category; therefore, the study area for each city category was eight miles wide.

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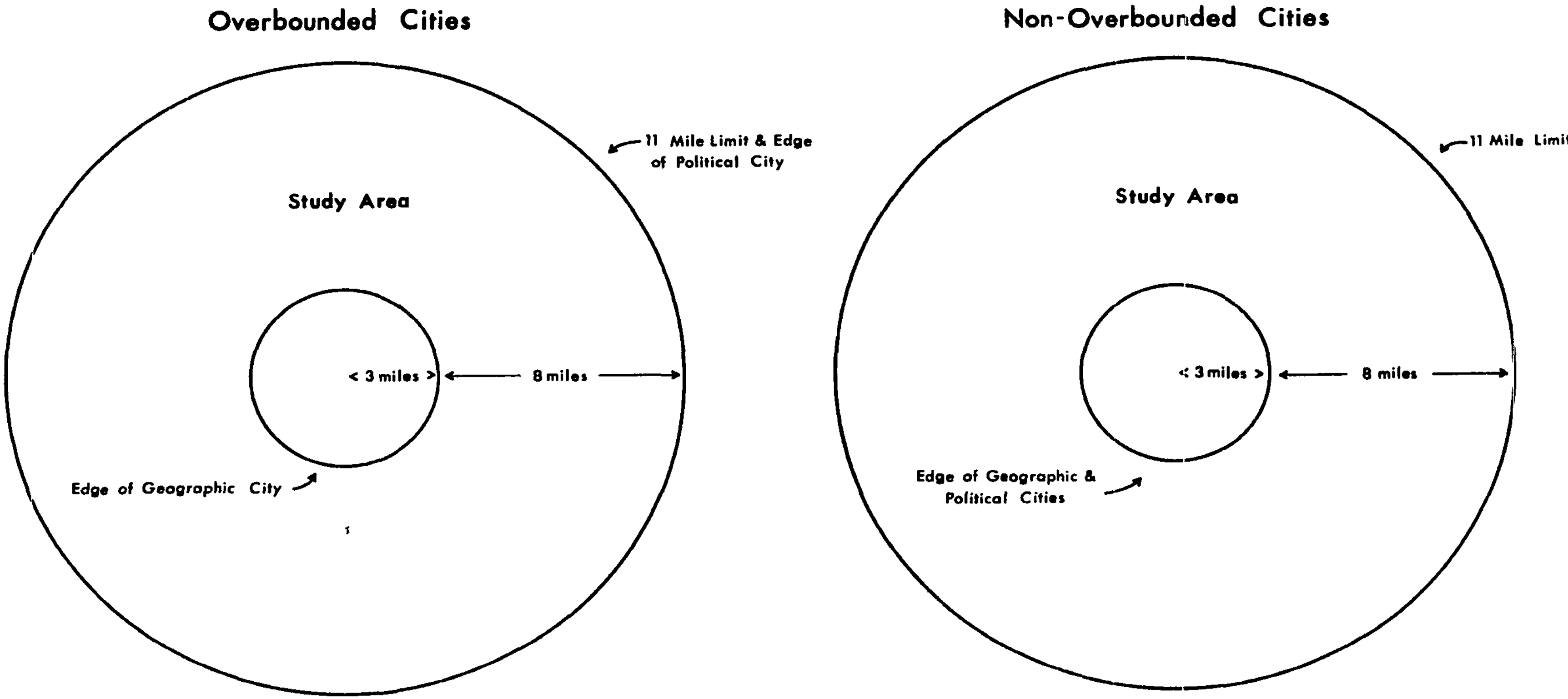
[22]See Appendix A for a definition of this term.

Figure 11

Study Areas



Comparing residential density between any one overbounded and non-overbounded city could be strongly altered by speculative land holdings, topographic variability, transportation patterns and the like in a particular area of one of the cities. To control for these problems, the comparison of residential density in this model was to be between data taken from samples from all overbounded cities as one group and data taken from samples from all non-overbounded cities as the other. Therefore, a statistically adequate sample size was randomly selected for each mile distant from the city center, grouping all overbounded city samples into one category and all non-overbounded city samples into the other.

Measurement of Residential Development

Residential development in this research is identified as the construction of dwellings, associated appurtenant structures, and paved roads. The extraction of data defined as residential development *per se* from aerial photography and in the field, however, is not possible. Surrogate variable data that were capable of being extracted, therefore, served as an indicator of this development.

Dwelling density is probably the single best indicator of this residential development. The percentage of residential land would not serve as adequately as an indicator because of the presence of apartment and trailer dwellings. The addition of one-hundred single family dwellings to a square mile sample would appreciably increase the percentage of residential land; however, the addition of one-hundred apartment or trailer dwellings would not. Miles of paved roads would serve as a precise indicator of residential development if it were not for roads that were built separately from residential construction, or in conjunction with apartment and trailer growth. Many more miles of paved roads would be needed to serve one-hundred single family dwellings than one-hundred closely spaced dwelling units, as would be found with apartments and trailers.

Data for density of dwellings per square mile sample was, therefore, used as the indicator variable of residential development.[23] Its facilitation for accurate extraction from aerial photography[24] and in the field, as well as its close association with development, assured it of providing the most reliable residential growth information.[25]

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[23]The data pertaining to the density of dwellings were found to be non-normal in an exponential fashion within each mileage band. Square root and log transformations were performed on this data, with the latter being a greater normalizing factor. Therefore, all subsequent calculations were performed on the log transformed data.

[24]In each of the eleven cities visited the most recent U.S. Department of Agriculture aerial photos were used, and the data pertaining to density of dwellings were extracted and superimposed on cultural maps of the samples. These data were subsequently field checked for changes that occurred since the photo date.

[25]An analysis of the relationship of data for percentage of residential land and miles of paved roads to the density of dwellings data was performed in conjunction with this research to establish the validity of these two variables as surrogates of residential development. The results were essentially as anticipated above. In this analysis least squares procedures were used. Percentage and mileage data were used as independent variables and density of dwellings

Hypotheses

The major hypothesis of this work is that the extension of a city's political limits to encompass large tracts of rural land (herein termed overboundedness) influences the form and process of residential development beyond the geographic city. Residential development in overbounded and non-overbounded cities is measured by the surrogate variable referenced above. Using this measure, a series of supportive hypotheses were tested. Each of these hypotheses is predicated on the postulated residential development curves presented in chapter two:

<u>Hypothesis 1</u>: The mean density of dwellings for all samples combined throughout the distance spectrum will be significantly greater in overbounded cities.

<u>Hypothesis 2</u>: The mean density of dwellings will be significantly greater by mileage band in overbounded city samples only in the outer reaches of the distance spectrum.

<u>Hypothesis 3</u>: The slopes obtained from plotting the data for the density of dwellings on X (distance)

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data as the dependent variable in two separate procedures. Slope coefficients from each procedure were subsequently examined for value changes throughout the study areas. The percentage of residential land data were found to be more closely associated with the density of dwellings data, with each of the three variables related throughout the study area. Since each variable was providing relatively similar information about residential development, and the density of dwellings data provided the most useful for this research, only data for dwelling density were used in later analyses.

Y (density) axes for the entire distance spectrum will be significantly different between city categories, with the slope for non-overbounded cities more nearly fitting the exponential distance decay function.

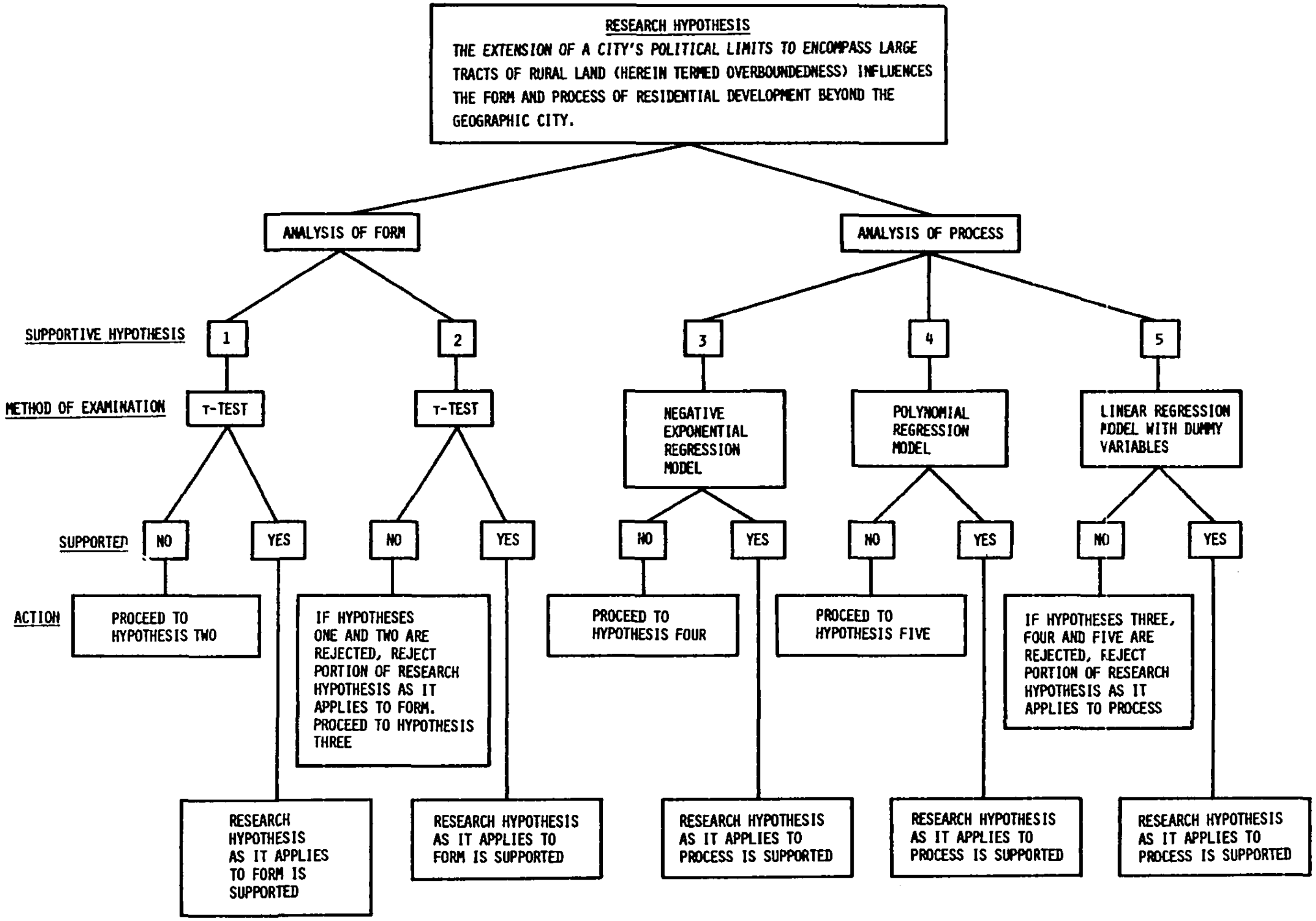
Hypothesis 4: The slopes obtained from plotting the overbounded city data for the density of dwellings on X (distance) Y (density) axes for the entire distance spectrum will best be fit by a cubic equation, whereas the slopes for this variable for non-overbounded cities will not.

Hypothesis 5: The slopes for the density of dwellings data will be significantly different by mileage band between city categories only in the outer reaches of the distance spectrum.

These hypotheses are based on the residential development process as presented in the conceptual model. The expected growth near the outer extremity of the overbounded but not the non-overbounded study area is anticipated to increase the relative density there and to affect the slope of overbounded city samples. As the two city categories are later shown to have increased in population at a similar rate over the past decade, it is obvious that the residential growth in the non-overbounded cities must have occurred inside their political boundaries. Recall that cities were classified relatively in a linkage analysis. Three of the four cities ultimately classified as non-overbounded contained rural sections within their borders in 1963. The developers

FIGURE 12

HYPOTHESES FLOW DIAGRAM



operating in these cities were aware of the advantages of developing within the political border, and much residential growth has been in those rural areas.

Analysis of Density

Two procedures were used to test variation in density of dwellings between overbounded and non-overbounded cities. These are related to hypotheses one and two.

Concerning hypothesis one, the mean values for the entire distance spectrum for density of dwellings for overbounded and non-overbounded cities were tested for a significant difference with a t-test. The null hypothesis being:

$$\bar{x}_1 = \bar{x}_2$$

where:

$\bar{x}_1$ = the mean density of dwellings for the entire distance spectrum of overbounded cities

$\bar{x}_2$ = the mean density of dwellings for the entire distance spectrum of non-overbounded cities

To test the second hypothesis, the mean density values for each mileage band for the two city categories were tested for significant differences with t-tests. The null hypothesis being:

$$\bar{x}_1 = \bar{x}_2$$

where:

$\bar{x}_1$ = the mean density of dwellings for a particular mileage band of overbounded cities

$\bar{x}_2$ = the mean density of dwellings for the same mileage band of non-overbounded cities

Since the original data were non-normal in an exponential form within each mileage band, a good probability exists for a significant difference in the variance also. There is, in fact, a chance of statistical difference even after transgeneration in the case of extreme variance. A variation of the Analysis of Variance (ANOVA) test[26] (Runyon & Haber, 1971, p. 199) was applied to the log transformed data before subjecting it to a t-test. Two varieties of t-tests were used to determine significant density differences by mileage bands.[27]

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[26] $$F = \frac{S^2 \text{ (larger variance)}}{S^2 \text{ (smaller variance)}} \qquad (5)$$

[27] When the variance in the two samples of transformed data was not significantly different, the following t-test was used (Crow, Davis, & Maxfield, 1960, p. 57):

$$t = \frac{\bar{x}_1 - \bar{x}_2 - d}{S_o \left(\frac{1}{n_1} + \frac{1}{n_2}\right)^{\frac{1}{2}}}$$

where: (6)

$$S_o^2 = \frac{\sum(x_{1j} - \bar{x}_1)^2 + \sum(x_{2j} - \bar{x}_2)^2}{n_1 + n_2 - 2}$$

and where the variation was statistically different, the following t-test variation was utilized (Crow, et al., 1960, p. 60):

$$u_i = x_{1i} - x_{2i}\sqrt{\frac{n_1}{n_2}} \qquad (i = 1, 2, \ldots, n_1)$$

$$\bar{u} = \frac{1}{n_1} u_i$$

$$Q = n_1 \sum(u_i - \bar{u})^2 = n_1 \sum u_i^2 - (\sum u_i)^2$$

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{Q}{n_1^2 (n_1 - 1)}}} \qquad (7)$$

These analyses of density provide the information needed to accept or reject the first and second hypotheses testing residential form, and therefore the position of the postulated residential development curves on the Y axis.

Analysis of Slope

In addition to tests of absolute differences, this research is also concerned with differences in slope as an indicator of the residential development process. Hypotheses number three and four deal with slope configuration for the entire distance spectrum. To test hypothesis three, density of dwellings data were plotted on X (distance) Y (density) axes for each city category. A negative exponential regression model was used to construct a best fit regression line for each plotting, with slope coefficients subsequently examined for differences between city categories.[28]

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where:

$$\bar{x}_1 = \frac{1}{n_1}\sum x_{1i} \qquad \bar{x}_2 = \frac{1}{n_2}\sum x_{2i}$$

[28]The slope coefficients were tested using a t-test (Crow, et al., 1960, p. 161), in which the best estimate of the common variance ($S'^2_{y/x}$) is computed:

$$S'^2_{y/x} = \frac{(n_1 - 2)S^2_{y_1/x} + (n_2 - 2)S^2_{y_2/x}}{n_1 + n_2 - 4}$$

where: $S^2_{y_n/x}$ = standard error of the estimate squared

Based on the pooled information from both samples, the estimate of the regression coefficient b_1 is:

This model is identified as:

$$Y = ab^{x} \tag{8}$$

where:

Y = density of dwellings data

a = model parameter

x = distance

b = model parameter

And by taking the log of the dependent variable, the linear form becomes:

$$\log Y = \log a + X \log b \tag{9}$$

A null hypothesis was established that:

$b_1 = b_2$

where:

b_1 = the slope coefficient of density of dwellings data for the entire distance spectrum of overbounded cities

b_2 = the slope coefficient of density of dwellings data for the entire distance spectrum of non-overbounded cities

In testing hypothesis four, data for density of dwellings were again plotted on X (distance) Y (density) axes for each city category. A best fit regression line was constructed for each plotting using a polynomial regression

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$$S'^2_{b_i} = \frac{S'^2_{y/x}}{(n_i - 1)S^2_{x_i}}$$

where: $S^2_{x_i}$ = standard deviation of x squared

and the standard deviation of the difference $b_1 - b_2$ is estimated from:

$$S^2_{b_1-b_2} = S'^2_{b_1} + S'^2_{b_2} \quad \text{and:} \quad t = \frac{b_1 - b_2}{S_{b_1-b_2}} \tag{10}$$

model of the third degree. The relative goodness of fits for each degree were subsequently examined using F scores as fit indicators. This cubic regression model is of the form:[29]

$$Y = a + b_1X + b_2X^2 + b_3X^3 + e \qquad (11)$$

where:

Y = density of dwellings data

a = model parameter

b = model parameter

X = distance

Hypothesis three states that slopes for the entire distance spectrum will differ significantly between city categories. This difference, however, as stated in hypothesis five is anticipated to result from significant differences only in the mileage bands located in the outer reaches of the distance spectrum. This expectation is consonant with the fourth hypothesis that the cubic equation best fits overbounded but not non-overbounded city data.

The procedure best suited to examine the fifth hypothesis is a least squares procedure using dummy variables.[30] This procedure segments the distance spectrum into eight separate parts, and constructs a best fit line for each segment. Using this method, significant mileage band differences

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[29]The dependent variable was transformed to logs in a normalization procedure.

[30]For a description of dummy variables, see Blalock (1972, pp. 498-503), Suits (1957, pp. 548-551), and Draper and Smith (1966, pp. 134-141).

may emerge that were obscured when one best fit line was constructed for the entire data set.

The procedure utilizes two dummy variables. The first is active and is set up as follows:

Z_1 = 1 if the data were collected from overbounded city samples

Z_1 = 0 if otherwise

With dummy variables, an estimating equation is formed:[31]

$$Y = a + b X + c Z \qquad (12)$$

where:

Y = density of dwellings data

a = intercept

b = slope

X = first independent variable (distance)

Z = a dummy variable indicating whether the data were extracted from an overbounded or non-overbounded city

When the interaction term, d X z is introduced into equation twelve, it becomes:

$$Y = a + b X + c Z + d X z \qquad (13)$$

With data taken from the non-overbounded city, $Z_1 = 0$, and the equation reduces to:

$$Y = a + b X \qquad (14)$$

and with data obtained from the overbounded city, $Z_1 = 1$, and the equation becomes:

$$Y = a + b X + c Z + d X z =$$

$$(a + c) + (b + d) X \qquad (15)$$

---

[31]The dependent variable data were transformed to logs in a normalization procedure.

This least squares procedure was applied to the data for density of dwellings. When the slope coefficient for the overbounded city samples was compared to the same parameter for non-overbounded city samples, the desired difference in slope emerged.

The postulated residential development curves indicate continuous similarity in mean development (slope--process) throughout the distance spectrum until the advantage of peripheral development of the overbounded study area takes effect. The above procedure provides a means of testing this relationship. The least squares solution presents a method of constructing a best fit line for each mileage band through the mean of the data plotted on X (distance) Y (density) axes, and is in essence a lateral portrayal of residential development for each band. Where these emerging slope coefficient differences for a mileage band are not statistically significant between overbounded and non-overbounded city data, the mean lateral residential development (process) can be considered similar between the two city categories. The converse is true when significant differences in slope emerge; therefore, a null hypothesis was established for each mileage band that:

$$b_1 = b_2$$

where:

b_1 = the slope of density of dwellings data for a particular mileage band of overbounded cities (b + d in equation 15)

b_2 = the slope of density of dwellings data for the same mileage band of non-overbounded cities (b in equation 14)

These analyses of slope provide the necessary information to accept or reject the third, fourth, and fifth hypotheses concerning the process of residential development, and therefore the structure of the postulated residential development curves.

Summary

Sample cities were selected from a region of the United States where the overbounded city is prevalent. The relative nature of the overbounded city definition facilitated the selection of sample cities from one state, while the presence of many large urban areas combined with the absence of local annexation laws there, rendered Texas an ideal study location.

Least squares procedures and t-tests were used to examine the research and supportive hypotheses and the structure and position of the postulated residential development curves. The statistical procedures outlined above allow one to assess the relationship between the extension of the political limits of a city to encompass rural land and the urbanization of settlement patterns located in the previously rural area.

CHAPTER IV

DATA ANALYSIS

Density of dwellings was used as an indicator of residential development. Data pertaining to this variable were utilized to examine density differences between overbounded and non-overbounded cities. T-tests were used for this. Since it is possible for the mean densities of all samples within each group to differ because of extreme variation in only one area, however, densities were analyzed by mileage band. These results provide support/non-support for the similar and different positions of the conceptual model residential development curves with respect to the density axis at various points along the distance spectrum.

Studies of density comparisons provide information concerning the form of residential development at any one time period. The development process, however, cannot be assessed by such a method. A measure that provides information on the growth intensity as it varies with distance presents a picture of this development process. Slope coefficients from several least squares procedures provide this measure. Three procedures with density-distance data were used. In one, a negative exponential model is fitted to the dwelling density data extracted from both city categories for the entire distance spectrum. Fits are analyzed by examining correlation coefficients, and slope coefficients are examined for differences between city categories for the entire distance spectrum. In the second model a polynomial equation of the fourth degree is fitted to the same data with a subsequent examination conducted to determine the relative goodness of curve fits by city category.

One problem with comparing curves generated for both groups is that differences in density in one mileage band, that is, the outer edge, may not alter the overall curve sufficiently to cause a significant difference. This smoothing effect is important since this research asserts that development between overbounded and non-overbounded cities is similar except for variations in the outer zone. A third procedure incorporating dummy variables was used for individual mileage bands to examine density-distance associations in segments of the distance spectrum.

Analysis of Density

The first supportive hypothesis is that the mean density of dwellings will be significantly different between the two city categories. To test this hypothesis, a null hypothesis, $\bar{x}_1 = \bar{x}_2$, was established where each mean represents the data for the entire sample. When means were examined with t-tests (equations 6 & 7), there was statistical significance at the .05 alpha level, substantiating the first supportive hypothesis (table 2).[32]

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[32]Data for all 254 mile square samples obtained in the field (135 for overbounded and 119 for non-overbounded cities)

TABLE 2

DENSITY DIFFERENCES BETWEEN CITY CATEGORIES

ALL MILEAGE BANDS

City Category	n	$\overline{x}$	log $\overline{x}$	Std. Dev.	Cal. t	Table t
Overbounded.........	85	115	1.68083	.58046	3.27919	1.645
Non-Overbounded.....	85	65	1.40372	.51275		

Source: Calculated by author (see Appendix B)

These results taken alone indicate that densities of the postulated residential development curves being similar with respect to the Y axis except in the outer distance bands is in error. In actuality this may not be the case. Consequently, an additional analysis was made to determine if the difference was significant in all segments of the distance spectrum. A null hypothesis, $\overline{x}_1 = \overline{x}_2$, was established for each of the eight mileage bands.

In each band the mean for the density of dwellings was greater for the overbounded city samples. Significant differences in density, however, were not so frequent. The mean density was significantly greater (at the .05 alpha level) inside overbounded city samples when compared to data

---

were used in each of the least squares procedures. In an effort to render the t-test results as valid as possible, however, the number of samples used in these tests, plus the t-tests conducted by mileage bands was reduced in a random selection process to an equal number of samples in each mileage band. For each band this equalized number was similar to the maximum number of samples available in the city category with the fewest samples.

taken from samples located outside non-overbounded cities only in the fifth and sixth mileage bands (table 3). In the seventh band the difference was almost significant at the desired alpha level (it is significant at .07), while no differences that emerged in any of the other bands were this significant. Therefore, the null hypothesis was rejected in the fifth and sixth bands.

There is little statistical variation by mileage band between the sample data obtained inside overbounded and outside non-overbounded cities. These differences generally occur near the outer extremity of the distance spectrum. The results substantiate the second supportive hypothesis, and provide support for the postulated residential development curves.

Analysis of Slope

This research is concerned with the process and the form of development. The data for dwelling density were analyzed in three separate least squares procedures where the dependent variable was density and the independent variable distance (equations 8, 11 & 15). In each procedure density was viewed as a function of distance, and these slope parameters served as indicators of the residential growth process. Best fit lines emerged from the least squares solutions and represent continuously changing means with distance across the eight mile spectrum or any one mileage band. Thus the influence of development occurring in one portion of the

TABLE 3

DENSITY DIFFERENCES BETWEEN CITY CATEGORIES

BY MILEAGE BANDS

Mile	City Category	n	$\bar{x}$	log $\bar{x}$	Std. Dev.	Cal. t	Table t
1	Overbounded........	21	213	1.88667	.70341	.92416	1.684
	Non-Overbounded....	21	126	1.69009	.64049		
2	Overbounded........	15	94	1.60960	.58173	1.47228	1.701
	Non-Overbounded....	15	82	1.30627	.50584		
3	Overbounded........	18	107	1.68846	.59123	.74943	1.697
	Non-Overbounded....	18	63	1.49460	.46828		
4	Overbounded........	12	56	1.56539	.45674	.64959	1.717
	Non-Overbounded....	12	34	1.44568	.40613		
5	Overbounded........	4	104	1.72860	.50448	1.98297	1.943
	Non-Overbounded....	4	3	1.11018	.09854		
6	Overbounded........	5	143	2.01819	.34462	2.39450	1.860
	Non-Overbounded....	5	10	1.39093	.39461		
7	Overbounded........	8	23	1.33731	.37806	1.66881	1.761
	Non-Overbounded....	8	2	1.07295	.33853		
8	Overbounded........	2	3	1.11266	.03447	1.36245	2.920
	Non-Overbounded....	2	2	1.06029	.01889		

Source: Calculated by author (see Appendix B) spectrum or mileage band that may have been lost in the t-test is detected.

Null hypotheses, $b_1 = b_2$, were established. In the first procedure (equation 8) the validity of the third supportive hypothesis was examined. A best fit line was constructed for data for the density of dwellings for the entire distance spectrum, with correlation coefficients indicating goodness of fit. Significant differences in slope coefficients were analyzed with t-tests between city categories (equation 10). In the second procedure (equation 11) the fourth supportive hypothesis was examined. In this analysis a best fit line was again constructed for all data for each city category, with F-ratios examined for goodness of fit. In the third procedure (equation 15) a best fit line was constructed for the dwelling density data between city categories by mileage band with significant differences in slope coefficients analyzed with t-tests.

Negative Exponential Model

In this first model, least squares procedures were used to measure the relationship of the data to the exponential distance decay function. As hypothesized, the data for non-overbounded cities more closely conforms to this function than does the overbounded city data. Plotting the means of the original data by mileage band confirms this closer association with non-overbounded city data (figure 13). Neither of the correlation coefficients, however, were substantial (see table 4).

Figure 13

MEAN DENSITY OF DWELLINGS - ALL SAMPLES

ORIGINAL DATA

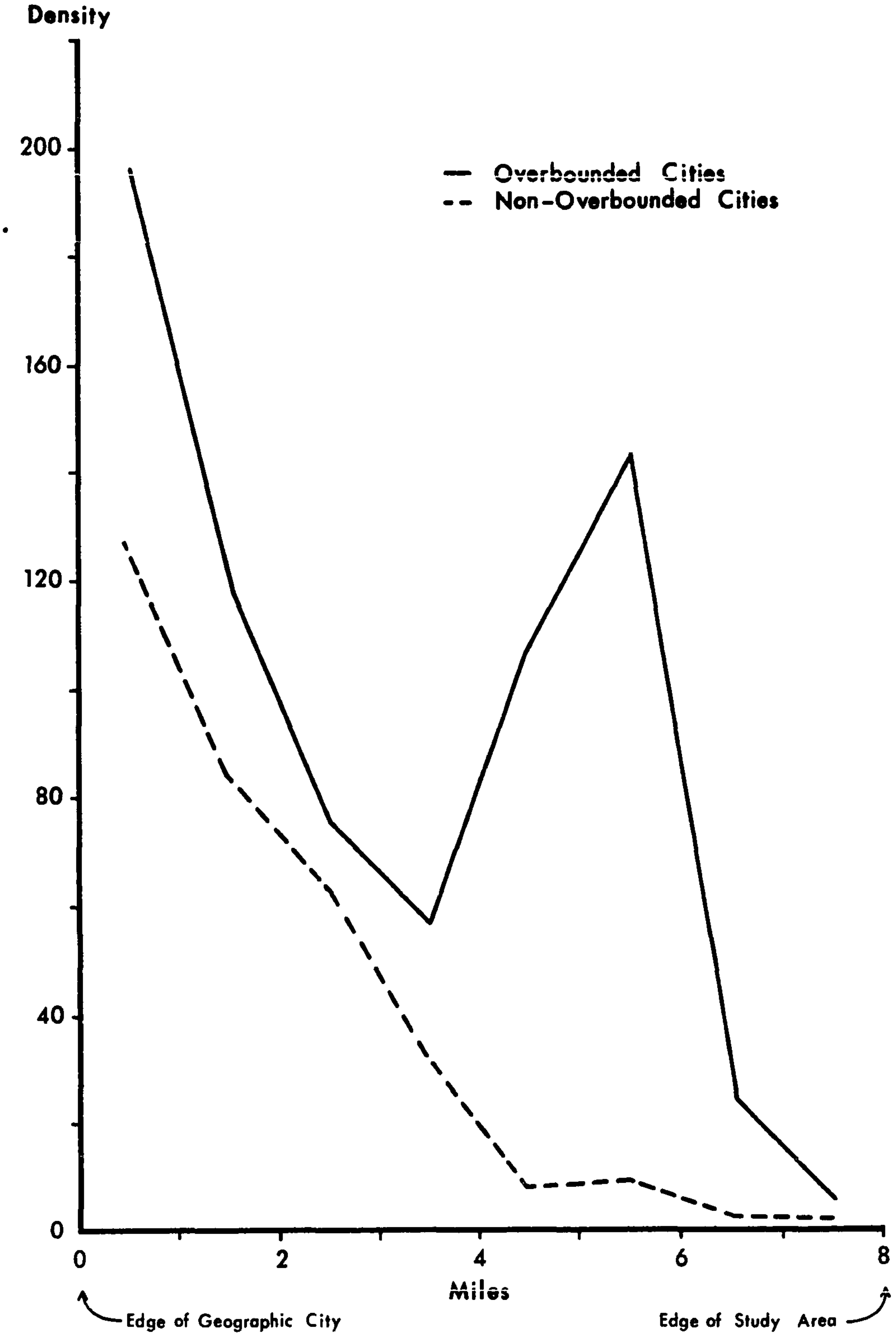


TABLE 4

CORRELATION COEFFICIENTS

ALL SAMPLES

City Category	n	Correlation Coefficient
Overbounded.............	135	-.16437
Non-Overbounded.........	119	-.44849

Source: Calculated by author

As explained earlier, the variance of the dwelling density data is quite large within many mileage bands. To eliminate the problem of variance, the mean of the data for each mileage band was used in a similar exponential model. The results (table 5) indicate the portion of the third hypothesis dealing with the better fit of the model to non-overbounded city data is supported.

TABLE 5

CORRELATION COEFFICIENTS

MEAN DATA

City Category	n	Correlation Coefficient
Overbounded.............	8	-.55625
Non-Overbounded.........	8	-.89750

Source: Calculated by author

The null hypothesis dealing with significant differences in slope parameters between city categories for all samples could not be rejected. The calculated t-value obtained when testing slope coefficient differences in density of dwelling units was 1.16815, while the table value for a sample size of 254 and an alpha level of .05 is 1.645 (table 6).

TABLE 6

SLOPE COEFFICIENT DIFFERENCES BETWEEN CITY CATEGORIES

ALL MILEAGE BANDS

City Category	n	Slope Coefficient	Cal. t	Table t
Overbounded.......	135	-.00433	1.16815	1.645
Non-Overbounded...	119	-.00731		

Source: Calculated by author

Polynomial Model

Development in overbounded cities but not in non-overbounded cities is postulated in hypothesis four to be best fit with a polynomial least squares model of the third degree because of the relative advantages that residential developers in overbounded cities have over non-overbounded city developers in the outer reaches of the distance spectrum. A fourth degree polynomial model was fitted to the dwelling density data for both city categories, with the relative goodnesses of fit determined from F-ratios of variation based on regression divided by deviation about regression.

The results were essentially as anticipated (table 7), based on changes in these F-ratios. For overbounded cities the F score was highest for density of dwellings when a linear model was applied to the data, but the scores generally increased to the third degree, and began to descend as the quartic model was used. For overbounded cities the F scores declined, as expected, with each addition in the degree of the exponent.

TABLE 7

F-RATIOS FOR POLYNOMIAL REGRESSION

ALL SAMPLES

City Category	Degree of Polynomial	F-Ratio
Overbounded	1st	3.87671
	2nd	1.95533
	3rd	2.40722
	4th	1.85273
Non-Overbounded	1st	24.32436
	2nd	12.14429
	3rd	8.08558
	4th	6.54442

Source: Calculated by author

The data variance for the density of dwellings for each mileage band is predominately less for non-overbounded cities. The lesser degree of variance is evident in the higher F scores obtained for that city category. Additionally, the high correlation coefficients obtained from non-overbounded city data in the negative exponential model indicates they fit that function well. These data would also fit slopes of the first, second, third and fourth degrees that are best fit lines approximating the distance decay function at each degree. What is important, however, is that the goodness of fit decreases as the exponent is increased for non-overbounded cities.

Mean data by mileage band better fit the negative exponential function than the data for all samples within each band; therefore, the polynomial model was also applied to the data in that form. The results were essentially the same as those explained above, with the cubic model again fitting best the overbounded but not the non-overbounded city data.

Perhaps the most important contribution of the polynomial regression model was to present support for the postulated residential development curves. As can be observed from the predicted Y values for density of dwellings in figures 14 and 15, the structure of these postulated curves is essentially correct.

Based on the trends evident from the F ratios in table 7, the fourth hypothesis that the entire distance spectrum slopes for overbounded and not for non-overbounded cities will be best fit by a cubic equation is supported.

Least Squares Procedure by Mileage Band

Application of the negative exponential model to data from both city categories revealed, as hypothesized, that the

Figure 14

PREDICTED Y VALUES - CUBIC POLYNOMIAL REGRESSION MODEL - MEAN DATA BY MILEAGE BAND - OVERBOUNDED CITIES

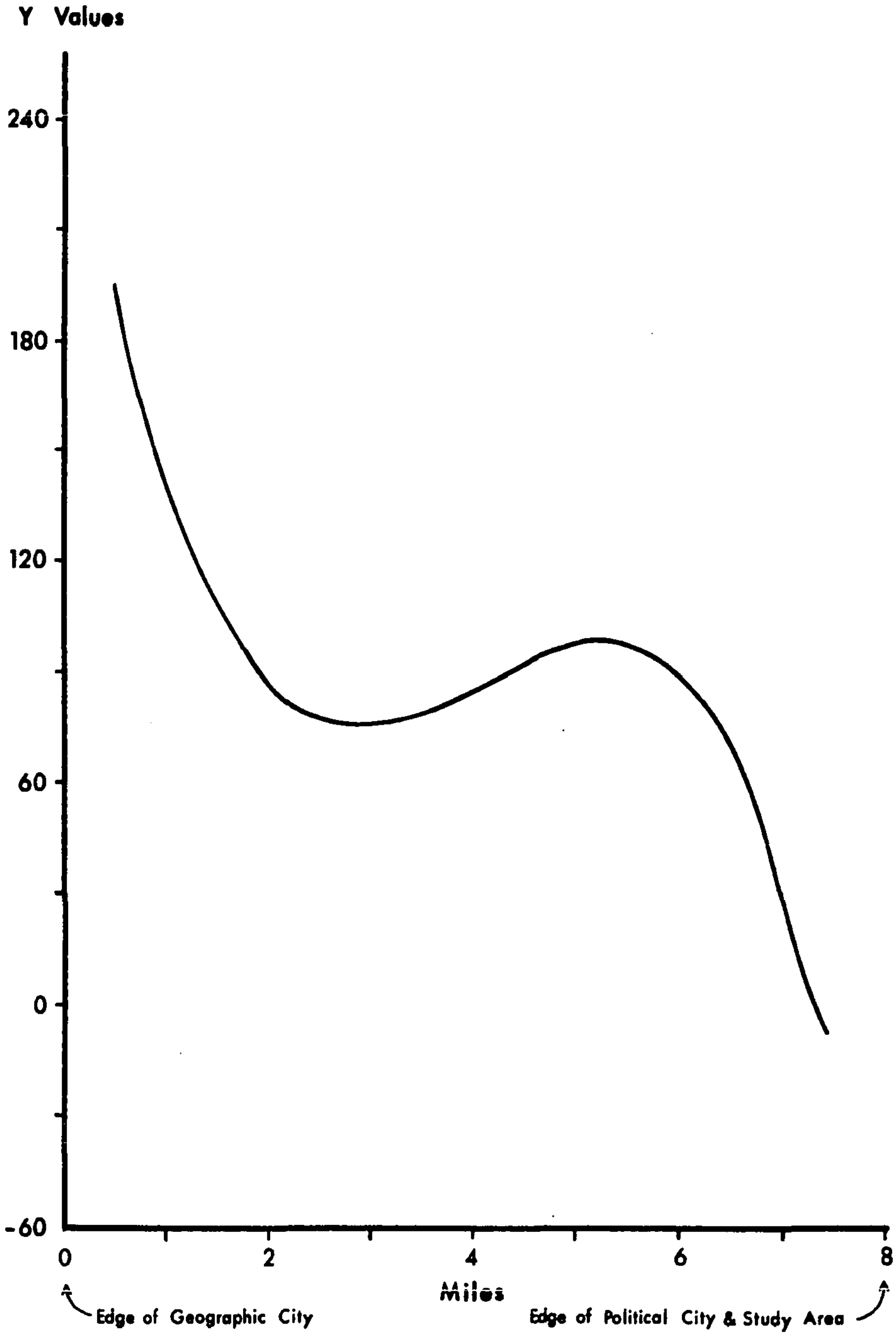
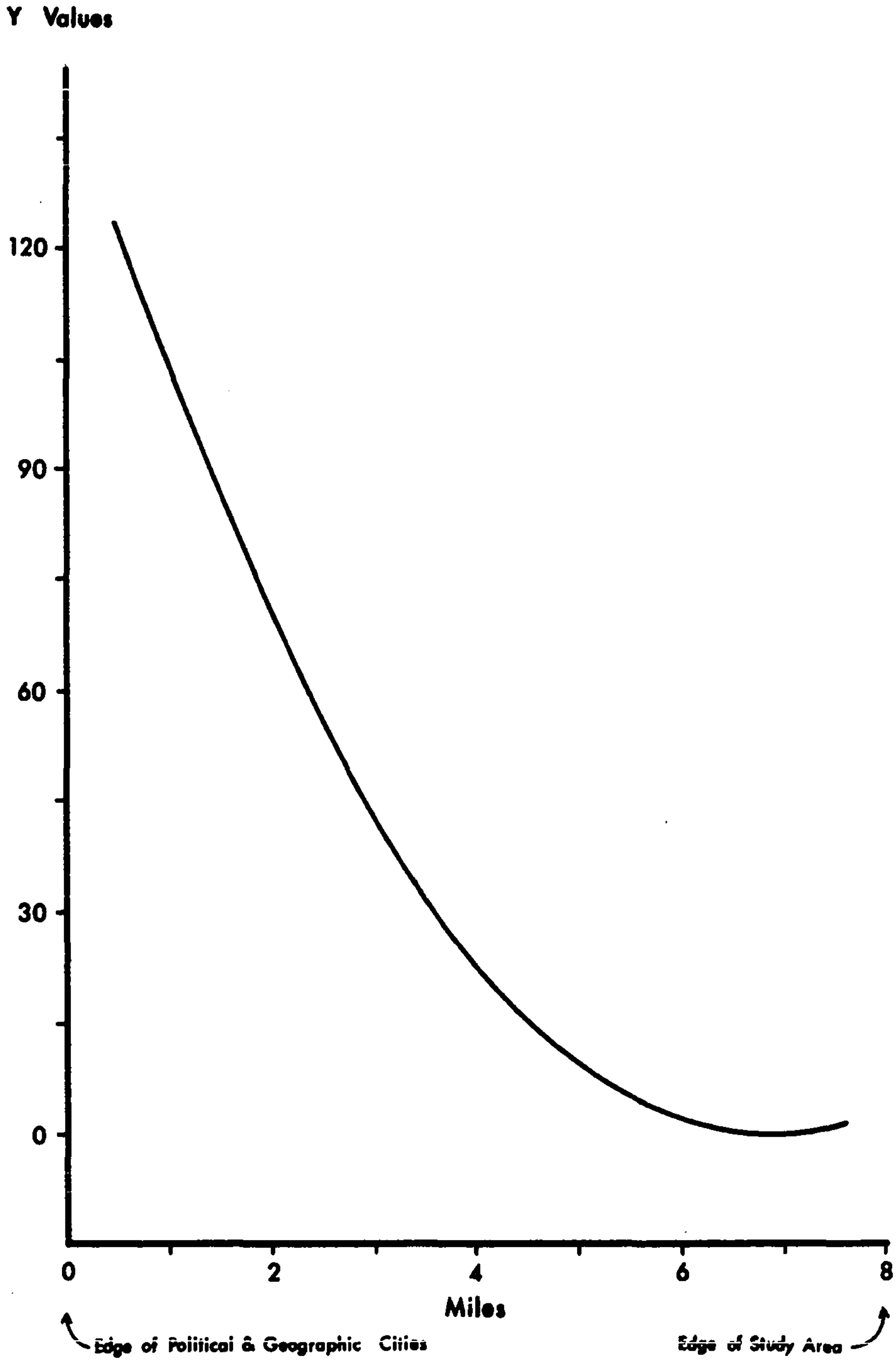


Figure 15

PREDICTED Y VALUES - CUBIC POLYNOMIAL REGRESSION MODEL - MEAN DATA BY MILEAGE BAND - NON-OVERBOUNDED CITIES



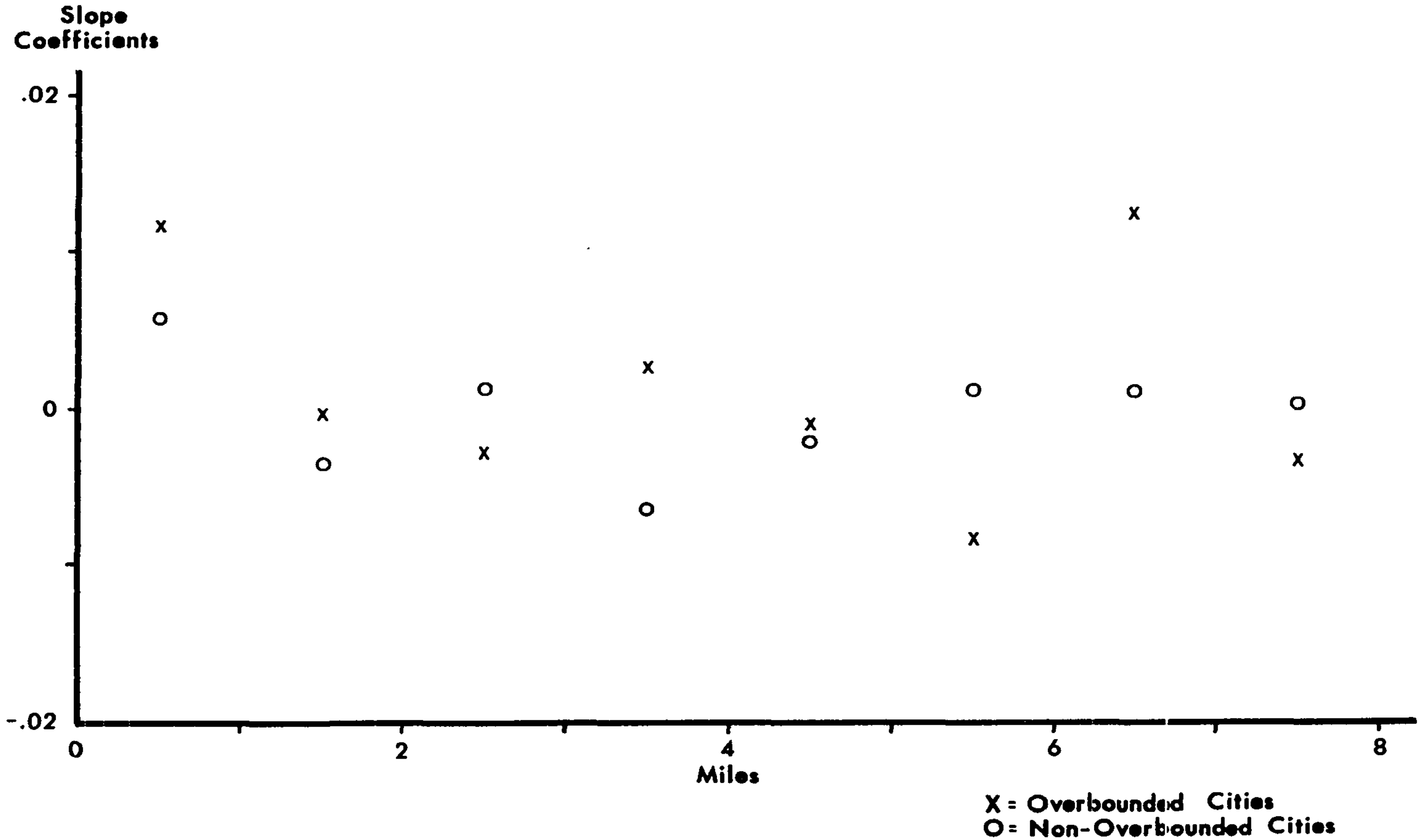
model best fits the data for non-overbounded cities. Recall, however, that significant differences in the slopes between city categories could not be substantiated. Plots of predicted Y values for each variable by city category generated from the polynomial regression model indicated difference in the development process in the outer reaches of the distance spectrum. Hypothesis five is examined in this section with a least squares procedure by mileage band (equation 15) to determine if differences also exist within individual mileage bands in the outer but not the inner reaches of the distance spectrum.

To examine development process in individual bands, slope parameters obtained from this procedure were plotted by mileage band for each category of cities (figure 16). These coefficients for the dwelling density data for non-overbounded city samples vary little from zero throughout the distance spectrum, indicating the dwelling density variance is similar to the variance in dwelling location throughout the band. The only locations where the slope parameters for the samples from this city category differ noticeably from zero are in the first and fourth mileage bands. The proportionately large variance in the density of dwellings in the first band combined with the positive nature of the slope is responsible for the relatively high positive coefficient there.

The negative value in the fourth mileage band results from the large density data variance and the fact that most development has occurred in the portion of the mileage band

Figure 16

SLOPE COEFFICIENT VARIATION
ALL SAMPLES - DENSITY OF DWELLINGS



nearest the geographic city, causing a low variance of the independent variable and a negative correlation coefficient. In figure 13 the mean density of dwellings drops noticeably between the fourth and fifth mileage bands of non-overbounded cities, from thirty-two to seven. The present analysis indicates that change in the development process actually begins before the outer limits of the fourth mileage band are reached.

Slope parameters of the dwelling densities for overbounded cities deviates from zero only in the first, sixth, and seventh mileage bands. Again the large dwelling density variance in the first mileage band explains the relatively high slope coefficient there, and again, for the same reason cited above, the correlation coefficient is positive.

Recall that in the t-test to determine differences in dwelling density by mileage bands, significant differences emerge in the fifth and sixth bands, with the data for the seventh band approaching significance. The slope coefficient for the fifth mileage band is near zero, whereas that value for the sixth band is a relatively large negative value. This is an indication that the high development density in the fifth band is spread relatively evenly across the mileage band, whereas this density in the sixth band is concentrated in the portion of the band nearest the geographic city. This is a significant finding because it indicates developing inside the overbounded city has a profound influence on the residential growth process from four to approximately five and one-half miles out from the geographic city, but the development process tapers off at that point.

A relative development void occurs between about five and one-half and approximately six and one-half miles distant. A concentration of development near the outer extremity of the seventh mileage band is responsible for the only significant difference in slope coefficients between the two city categories (see table 8).

As mentioned before, the density differences as measured with t-tests were not significant between the two city categories at this seventh mileage band; therefore, the form of development is similar. This significant difference in the slope coefficients is important because it indicates the development process, and only in this mileage band has the process significantly differed over the last decade.

The predicted Y values from the polynomial regression model (presented in figures 14 & 15) indicate process throughout the distance spectrum. Because of the low density in the seventh mileage band when compared to the fifth and sixth, and the smoothing nature of the third degree fit for the entire distance spectrum, however, this significant difference in the development process in the seventh band was not obtained.

The null hypothesis, $b_1 = b_2$, was rejected in the seventh mileage band. Although it may appear that the results concerning development process obtained from the polynomial regression model and the least squares procedure

TABLE 8

SLOPE COEFFICIENT DIFFERENCES BETWEEN CITY CATEGORIES

INDIVIDUAL MILEAGE BANDS

Mile	Overbounded City Slope	Non-Overbounded City Slope	Diff. in Slope Coeff.	Cal. t	Table t
1	.01169	.00515	.00654	1.11104	2.010
2	.00063	-.00307	.00370	- .56062	2.010
3	-.00221	.00062	-.00283	- .50271	2.010
4	.00299	-.00668	.00967	1.66174	2.069
5	-.00025	-.00190	.00165	.30605	2.110
6	-.00845	.00128	-.00973	- .71948	2.080
7	.01447	.00169	.01278	3.85838	2.131
8	.00223	.00036	.00187	.66846	2.228

Source: Calculated by author

applied by mileage band are providing contradictory information, this is not the case. The significant difference from the least squares procedure applied to each mileage band was not effected by densities in any other band, and consequently a smaller scale difference in density with distance can emerge as being significant. This occurred in the present analysis. The best fit regression line that was constructed in the polynomial model dismissed the importance of the significant differences noted above, but highlighted the general difference in the growth process in the outer distance spectrum between city categories. An important finding was that both procedures revealed differences in the outer portion of the distance spectrum, while indicating a general similarity in process nearer the edge of the geographic city.

Summary

In this chapter the mean densities of dwellings were found to be significantly different throughout the distance spectrum between city categories. A later analysis of densities by mileage bands, however, revealed significant differences only near the outer limits of the distance spectrum.

Data for non-overbounded cities were found to more closely approximate an exponential distance decay function, while a polynomial regression model of the third degree provided the best fit slope for overbounded city data. Plottings of predicted Y values from the polynomial regression model provided support for the postulated residential development curves. A best fit slope was constructed for data from each mileage band in an ordinary least squares procedure. This analysis also supported the postulated development curves. These results all support the major hypothesis of the work that extending a city's political limits to encompass large tracts of rural land influences the form and process of residential development beyond the geographic city.

Residential development within an urban context is a complex process. Decisions as to when and where to develop are concentrated in the hands of a few. Correct decisions are essential to this group to maintain their market position. Consequently, they are sensitive to a number of development factors. In its simplest form these factors can be viewed as cost and market variables. This simple framework, however, obfuscates the myriad of variables to be analyzed before development decisions are made. Topography, accessibility, neighborhood quality, landscape aesthetics, and service costs are only a handful of the factors to be considered. These in turn are influenced by Federal policy, local environment, business cycles, and political climate to mention a few.

From this myriad of variables the author has selected one factor -- limits of political jurisdiction -- and attempted to determine whether this factor influences the spatial pattern of residential development. Geographers and others have often ignored the significance of political boundaries in metropolitan studies in favor of "functional" boundaries. Yet, political boundaries can and do represent meaningful limits for certain activities or perceptions. The premise of this study was that political boundaries were meaningful to the residential development process because they influence the cost of development through service cost. The nexus is thus: political limits $\longrightarrow$ service costs $\longrightarrow$ development patterns.

A cross-sectional analysis of two groups of cities -- overbounded and non-overbounded -- was used to examine the hypothesized linkages. Results of the analysis are encouraging. Development between the two groups does differ in a pattern consistent with service cost patterns. The author concludes, then, that the location of the political boundary with respect to the built-up area of the city does influence development patterns.

The author, however, wishes to emphasize that the political boundary is only one of a number of factors that influence the course of development. Many are operative, and local conditions might change relationships found to exist at the aggregate level. For example, the rough topography around El Paso alters the service costs pattern found to exist at the more general, aggregate level. In contrast, the flat topography of Lubbock entices that city government to extend some city services, like sewage, beyond the legal limits of the city. These effects would alter somewhat the residential densities found to exist at the group level.

The impact of these local effects can be understood only by disaggregating the development process by the individual city. The results from this study suggest that further work in this area would not be fruitless. Differences do exist, and appear to be in part a function of the location of political boundaries.

CHAPTER V

CONCLUSIONS

Overextension of urban political boundaries functions positively in influencing the spatial configuration of rural land development. The significant differences in form and process of residential development at the outer reaches of the study areas of overbounded and non-overbounded cities is evidence that judicious approval of annexations can be used to control the direction, location, and intensity of residential growth.

In his search for a home man aspires for satisfaction in seeking out a neighborhood with acceptable ethnic and social characteristics, and he also weighs economic considerations such as accessibility cost, land cost, public utility services, and fire and police protection.

As illustrated by von Thünen (1826), Alonso (1964), Muth (1961a), and Wingo (1961), the awareness that a parcel of land is in a relatively accessible location is reflected in the land cost. Although land adjacent to the geographic city is more expensive than land in more distant locations, land developers have determined accessibility to be the dominant factor considered by the home purchaser. Developers, therefore, have generally concentrated residential development in accessible locations. Because of this reaction by land developers, the density of dwellings generally conforms to an exponential distance decay function just beyond the edge of the geographic city for both city categories.

The relationship of land cost to accessibility breaks down at some point beyond the geographic city, as land costs decrease according to a negative logistic function while accessibility costs increase at a constant rate to some point at which the increase begins to level off. Beyond this moderating point in accessibility costs (where land costs continue to decline) home prices are appealing to purchasers. Without considering higher utility service costs and home insurance rates as a reflection of fire and police protection, the lower complete home costs in these distant areas is a reality.

In overbounded city samples these services are provided by the municipal government, and are similar in cost to the homeowner both adjacent to and distant from the geographic city. Thus, a home constructed, for example, six miles distant from the geographic city would be considerably cheaper because of land cost than one built, for example, four miles distant; yet the difference in temporal and monetary accessibility costs would probably not be considered significant by the home purchaser. Conversely, a home built six miles distant from the geographic city in the non-overbounded samples would be more expensive than one constructed at four miles distant because differing service costs increase according to a linear function beyond the geographic and political city, combined with increased commuting costs.

The monetary benefit of developing at distant points inside the politically overbounded city has caused developers to construct dwellings there in hopes of attracting potential home buyers to these locations. As the financial benefits do not exist in the outer limits of the non-overbounded city samples, residential construction there has been almost non-existent. This variation in the construction patterns between the two city categories has had the effect of altering the exponential distance decay function of overbounded city sample data near the outer extremity of the distance spectrum.

As hypothesized, the expansion of a city's political border to encompass large tracts of rural land does influence the form and process of residential development beyond the geographic city. Development is similar in density and distribution for several miles distant from the edge of the geographic city, but near the outer limits of the eight mile distance spectrum significant differences begin to emerge, illustrating not only the form of growth over the past ten years has been dissimilar, but the present process as well.

This researcher feels these conclusions are significant from a geographical standpoint since they reveal a significant difference in residential development patterns of the two city categories. While other researchers such as Blumenfeld (1954) and Boyce (1966) have noted the increase of residential activity at a distance beyond the geographic city in some urban areas, to the knowledge of this researcher there have been no published reports with the purpose of relating this growth to the city's political boundary.

The purpose of this research work was not to present an argument for residential growth in relatively isolated areas, as, for example, Lessinger (1962) has done. Rather, the purpose was to analyze the precise location of growth and to analyze its relative location with respect to the political boundaries and city amenities. The study area was limited to Texas cities because of temporal and economic restrictions, and, therefore, the results cannot be strictly inferred to other locales. If one accepts the findings of the two sociologists referenced in the first chapter (Bromley & Smith, 1973), however, the results may be applicable to all the South and West of the United States.

Subsequent to the data collection, an additional economic factor (the energy crisis) has emerged that may affect development patterns inside overbounded cities in the future. In the past, developers in this type city have speculated that potential homeowners will be willing to move to more distant locations to acquire lower home purchase prices. This cost benefit will not diminish. Should the energy crisis continue, however, it is soon to have a profound effect on accessibility costs, and thus total costs of home ownership in distant locations.

This researcher hopes the results will inspire other research ventures in similar areas of urban geography.

Although the overbounded city is a widespread phenomenon in the United States today it has received proportionately little attention from geographers. With a more complete understanding of emerging residential growth patterns, the geographer would find himself with an information base for implementing policy decisions to control the direction and rate of future urban residential growth.

APPENDIX A

Definitions

City Center - The original city center as identified from maps and aerial photography. The original courthouse or post office is situated on this block. It is not necessarily the geometric city center.

Political City - The legal area of the city as encompassed by its political boundary (city limits).

Rural Land - Land in agricultural use, idle land, and land in forest. Excluded is land permanently covered by water and U.S. Government property. An area is classified as rural or non-rural based on the observable land use and not necessarily its functional classification.

Geographic City - ". . . the built up area extending in all directions until significantly interrupted by farms, forest, or other non-urban land, or by water bodies" (Murphy, 1966, p. 13). As an operational definition for this research work, the geographic city is defined as that portion of a political city in which the square mile sections of land contain less than 50 percent rural land use.

Overbounded and Non-Overbounded Cities - For the purpose of this study, all surveyed cities fall into one of these two dichotomous classes. Cities are classified into natural categories with a linkage analysis, with any city classified as overbounded or non-overbounded based on the percentage of rural land in that city when compared to the percentage of this type land within the borders of each city studied.

<u>Rural-Urban Fringe</u> - That portion of land on the periphery of a geographic city where the settlement pattern is discontinuous. Wehrwein described it as an area in transition between well recognized urban land uses and the area devoted to agriculture (1942).

<u>Urban Sprawl</u> - Discontinuous urban development that occurs on the periphery of many cities. Developed land may be located more distant from the geographic city than are other plots that have experienced no residential growth.

<u>Extraterritorial Jurisdiction</u> - As defined in the Municipal Annexation Act, <u>Legal Statutes of Texas</u>, an incorporated city maintains jurisdiction over the platting and subdivision of land beyond its political borders to a specified distance depending upon city population size. Violations of the platting and subdivision regulations cannot, however, be considered a misdemeanor or subject the violator to a fine, as is the case within political boundaries.

<u>Idle Land</u> - Land observed to be inactive, and therefore capable of supporting residential growth.

APPENDIX B

Statistical Calculations

Percentage Change in City Population 1960 - 1970, in 1960 Area

$$t = \frac{\bar{x}_1 - \bar{x}_2 - d}{S_o\sqrt{\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

where:

$$S_o^2 = \frac{\sum(x_{1j} - \bar{x}_1)^2 + \sum(x_{2j} - \bar{x}_2)^2}{n_1 + n_2 - 2}$$

$$S_o^2 = \frac{785.208540 + 567.710000}{9}$$

$$S_o = 12.260679$$

$$t = \frac{8.1857142 - 10.3500000}{12.260679\sqrt{\left(\frac{1}{7} + \frac{1}{4}\right)}} \qquad (16)$$

$$t = -.2816325$$

Density Differences Between City Categories

All Mileage Bands - Density of Dwellings

$$t = \frac{\bar{x}_1 - \bar{x}_2 - d}{S_o\sqrt{\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

where:

$$S_o^2 = \frac{\sum(x_{1j} - \bar{x}_1)^2 + \sum(x_{2j} - \bar{x}_2)^2}{n_1 + n_2 - 2}$$

$$S_o^2 = \frac{28.639024 + 22.347641}{168}$$

$$S_o = .550901$$

$$t = \frac{1.6808271 - 1.4037214}{.550901\sqrt{\left(\frac{1}{85} + \frac{1}{85}\right)}} \qquad (17)$$

$$t = 3.2791905$$

Density Differences Between City Categories

by Mileage Bands - Density of Dwellings

1st Mileage Band

$$t = \frac{\bar{x}_1 - \bar{x}_2 - d}{S_o\sqrt{\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

where:

$$S_o^2 = \frac{\sum(x_{1j} - \bar{x}_1)^2 + \sum(x_{2j} - \bar{x}_2)^2}{n_1 + n_2 - 2}$$

$$S_o^2 = \frac{10.390555 + 8.6146494}{40}$$

$$S_o = .6892968$$

$$t = \frac{1.8866728 - 1.6900852}{.6892968\sqrt{\left(\frac{1}{21} + \frac{1}{21}\right)}} \qquad (18)$$

$$t = .9241552$$

2nd Mileage Band

$$S_o^2 = \frac{5.076104 + 3.8380427}{28}$$

$$S_o = .564236$$

$$t = \frac{1.6095993 - 1.3062666}{.564236\sqrt{\left(\frac{1}{15} + \frac{1}{15}\right)}} \qquad (19)$$

$$t = 1.4722765$$

3rd Mileage Band

$$S_o^2 = \frac{6.2919768 + 3.9472221}{34}$$

$$S_o = .5487739$$

$$t = \frac{1.6884677 - 1.4945955}{.5487739\sqrt{\left(\frac{1}{18} + \frac{1}{18}\right)}} \qquad (20)$$

$$t = .7494258$$

4th Mileage Band

$$S_O^2 = \frac{2.5033442 + 1.9792892}{22}$$

$$S_O = .4513933$$

$$t = \frac{1.5653866 - 1.44568}{.4513933\sqrt{\left(\frac{1}{12} + \frac{1}{12}\right)}} \qquad (21)$$

$$t = .649589$$

5th Mileage Band

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{Q}{n^2{}_1(n_1-1)}}}$$

where:

$$\bar{x}_1 = \frac{1}{n_1} \sum x_{1i}$$

$$\bar{x}_2 = \frac{1}{n_2} \sum x_{2i}$$

$$u_i = x_{1i} - x_{2i}\sqrt{\frac{n_1}{n_2}} \qquad (i = 1, 2 \ldots, n_1)$$

$$\bar{u} = \frac{1}{n_1} \sum u_i$$

$$Q = n_1 \sum (u_i - \bar{u})^2 = n_1 \sum u_i^2 - (\sum u_i)^2$$

$$u_i = 2.47368$$

$$u_i^2 = 2.69690$$

$$Q = 4\ (2.69690) - (2.47368)^2$$

$$Q = 4.668508$$

$$t = \frac{1.7285975 - 1.1101775}{\sqrt{\frac{4.668508}{48}}} \qquad (22)$$

$$t = 1.9829664$$

6th Mileage Band

$$S_o^2 = \frac{.593829 + .7785922}{8}$$

$$S_o = .414189$$

$$t = \frac{2.018188 - 1.390934}{.414189\sqrt{\left(\frac{1}{5} + \frac{1}{5}\right)}} \qquad (23)$$

$$t = 2.3945004$$

7th Mileage Band

$$Q = 8\ (1.96447) - (2.11493)^2$$

$$Q = 11.242832$$

$$t = \frac{1.3373112 - 1.072945}{\sqrt{\frac{11.242832}{448}}} \qquad (24)$$

$$t = 1.668811$$

8th Mileage Band

$$S_o^2 = \frac{.002241 + .000714}{2}$$

$$S_o = .0384382$$

$$t = \frac{1.112655 - 1.060285}{.0384382\sqrt{\left(\frac{1}{2} + \frac{1}{2}\right)}} \qquad (25)$$

$$t = 1.3624467$$

Slope Coefficient Differences Between City Categories

All Mileage Bands - Density of Dwellings

The best estimate of the common variance ($S'^2_{y/x}$) is computed:

$$S'^2_{y/x} = \frac{(n_1 - 2)S^2_{y_1/x} + (n_2 - 2)S^2_{y_2/x}}{n_1 + n_2 - 4}$$

where: $S^2_{y_n/x}$ = standard error of the estimate squared

Based on the pooled information from both samples, the estimate of the regression coefficient b_i is:

$$S'^2_{b_i} = \frac{S'^2_{y/x}}{(n_i - 1)\ S^2_{x_i}}$$

where: $S^2_{x_i}$ = standard deveiation of x squared

and the standard deviation of the difference $b_1 - b_2$ is estimated from:

$$S^2_{b_1 - b_2} = S'^2_{b_1} + S'^2_{b_2}$$

and

$$t = \frac{b_1 - b_2}{S_{b_1 - b_2}}$$

therefore:

$$S'^2_{y/x} = \frac{(133)\quad .3249467 + (117)\quad .1723158}{250} =$$

$$\frac{43.217911 + 20.160948}{250} = .2535154$$

$$S'^2_{b_i} = \frac{.2535154}{64408.965} \quad \text{and} \quad \frac{.2535154}{95784.846}$$

$$S^2_{b_1 - b_2} = .0000065$$

and:

$$t = \frac{-.0043326\ (-)\ -.0073108}{.0025495} \qquad (26)$$

$$t = 1.1681506$$

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