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Simulating Suburban Development
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1950 through 1990

presented by

Ralph J. De Vitto

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Stanley D. Brunn
Major professor
by Lawrence M. Sommers
Chairman

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SIMULATING SUBURBAN DEVELOPMENT FROM 1950-1990 IN SUFFOLK COUNTY, NEW YORK

By

Ralph Joseph De Vitto

A THESIS

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ABSTRACT

SIMULATING SUBURBAN DEVELOPMENT FROM 1950-1990
IN SUFFOLK COUNTY, NEW YORK

By

Ralph Joseph De Vitto

Suburban sectors within major metropolitan regions of the United States have been growing more rapidly than their urban cores in both population and area since World War Two. The population dynamics of the New York Metropolitan Region are analyzed from 1940-1970. Through time urbanization is found to be dependent primarily upon distance from the New York City CBD and the areas of highest population density. Both past and present population trends in Suffolk County, a low-density outer suburban county, are examined in detail. Several factors including adjacency to existing development and distance from urbanized Nassau County are found to be significant. Two Monte Carlo simulation runs are constructed to measure the spatial patterns of development across Suffolk County from 1949-1969. A third simulation is also presented depicting probable development situations in the county's semi-rural eastern townships through 1990.

To My Parents

For Their Encouragement and Support

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I gratefully acknowledge the conscientious advisement received throughout my program from Professors Stanley Brunn and Deiter Brunnschweiler of the Geography Department at Michigan State University. Their guidance, assistance and academic stimulation have helped me to realize an academic goal of which I am very proud. I also wish to thank the Department of Geography for the financial assistance awarded during most of my attendance. Gratitude is extended to Sandy Briggs for a typing job well done, and since nothing is possible without the inspiration of friends and loved ones, to my sister and Anne, thank you.

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CHAPTER I

INTRODUCTION

Urbanization is the dominant theme of twentieth century population dynamics in both the United States and the entire world. Geographer Clyde Browning (1974:1) has stated that, "urban growth is one of the central facts of the twentieth century," and considering recent urban population growth figures recorded in the United States, this statement is well qualified. The nation's urban population, for instance, increased by 66 million persons from 1900-1950 (Gottmann, 1961:21) a value roughly comparable to three times the estimated 1976 population of Canada.

Rugg, in Spatial Foundations of Urbanism (1972), estimates that one-third of the entire world's population lives in cities. In describing the urban population growth characteristics of the United States, Rugg notes that the rural population was first exceeded by the urban population as early as 1920, and "in the half-century since then the proportion of urban population to total has become three-fourths, having grown from two-thirds in only one decade, the 1960's" (Rugg, 1972:xii). In a later chapter Rugg conclusively asserts, "we truly live in an age of urban explosion" (Rugg, 1972:72).

Yeates and Garner have also acknowledged the volatility of contemporary urban growth in their text, The North American City (1971). Concerning the topic of increasing urbanization they state:

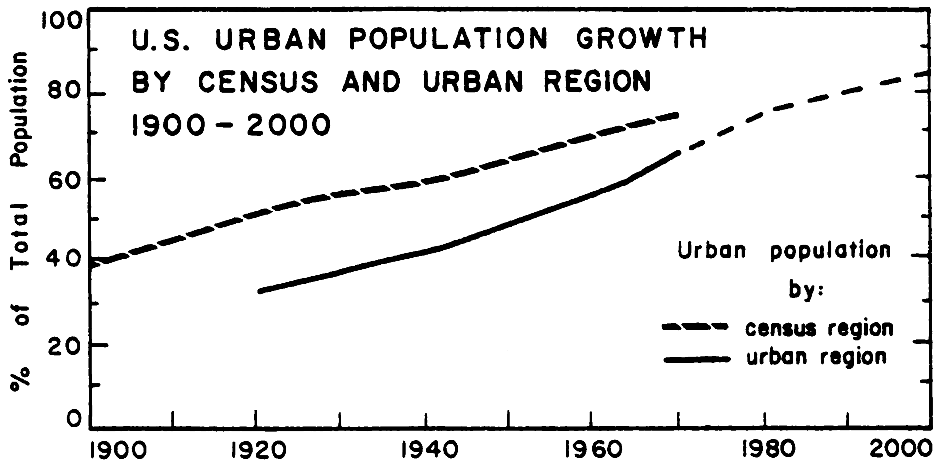
> Our first assumption, therefore, with respect to North America is that the urban explosion over the next few decades will be of dramatic proportions (Yeates and Garner, 1971:472).

These viewpoints of Browning, Rugg, Yeates and Garner suggest that urbanization has been and will continue to be a dominant feature of contemporary population dynamics. More specifically, the increase of urban populations, and the subsequent expansion of built-up areas in the United States, identify a significantly critical problem worthy of scientific research (Figures 1 and 2).

Urbanization in the United States

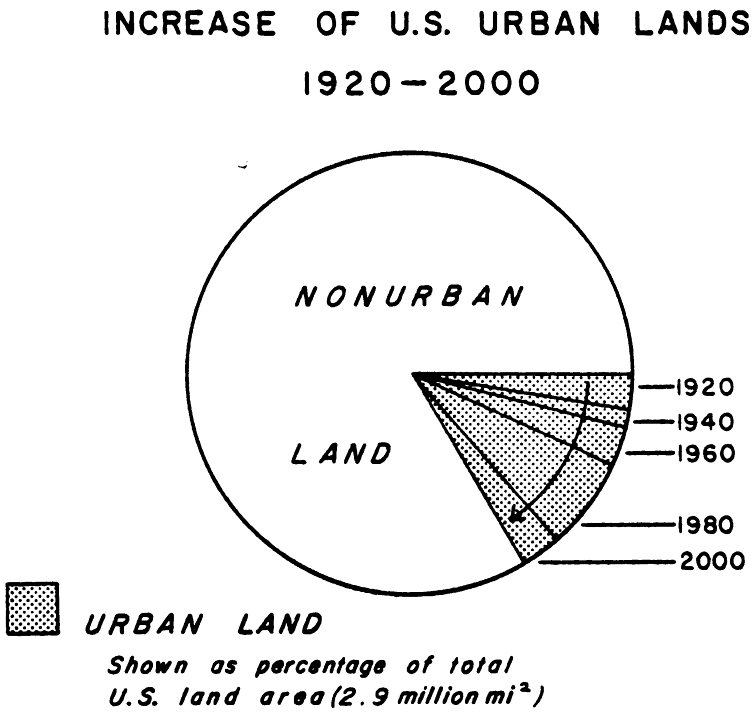
By far the most significant changes in the urban and rural proportions of the United States population have taken place since 1950. Approximately 74 percent of the nation's total population was classified as urban by the Bureau of the Census in 1970. When compared to the urban population percentage recorded for 1950 and 1960, the overall 15 percent increase between 1950-1970 indicates

FIGURE 1



Source: Yeates & Garner, 1971, p. 30.
Reilly, 1973, p. 84.

FIGURE 2



Source: Reilly, 1973, p. 84.

an unprecedented shift in the nation's basic population structure.

Simple percentage increase figures, however, fail to identify the various dimensions of recent urbanization processes. Suburban areas, for instance, have been growing more rapidly than urban areas since World War Two in both population and area. Since that time, the percentage of the nation's total population residing outside of these urban areas has been increasing. Correspondingly, the percentage of the total population located in nonmetropolitan areas (areas away from cities and their associated suburban regions) decreased from 38 percent in 1950 to 31 percent in 1970 (Reilly, 1973:85). And during the same two decades, a 10 percent increase in persons residing outside of central cities, from 27 percent to 37 percent, was matched by a 6 percent decrease in persons residing outside of nonmetropolitan areas. Increases in suburban populations have therefore accounted for the major portion of urban growth between 1950-1970.

During the 1970s, a new demographic shift is evident as nonmetropolitan populations have increased both absolutely and relatively. Roseman recently noted, "Now there is a tendency toward movements down the size hierarchy of urban centers and movements from urban areas to rural areas..." (Roseman, 1977:iv). These more recent patterns and the reasons behind them, however, are beyond the scope of this study.

Numerous factors have been identified which account for the rapid increase in suburbanization since World War Two. These factors affecting the growth of suburban populations and the areal expansion of suburban lands to meet residential, commercial and industrial needs are varied and complex. The major stimuli have been cited in the report compiled by the Task Force on Land Use and Urban Growth (1973).

> More people, with more money, following their expressed preference for low density living in a metropolitan area can mean only one thing--bigger metropolitan areas. If past trends continue, 36 million of the 54 million population increase expected by the year 2000 will live in suburbs, more than moved there between 1950 and 1970 (Reilly, 1973:82).

In essence, many of the metrpolitan regions in the United States have experienced significant population increases and associated expansion in outer-lying suburban areas. These areas will also continue to accommodate a major portion of future population growth. The processes of suburbanization will transform existing suburban lands into urban areas and existing rural lands into suburban areas.

Geographers and other social scientists have identified this "explosive" nature of post World War Two suburbanization as urban sprawl. The term itself as defined by Northam indicates more precisely the pace at which the conversion of land from nonurban to urban uses is presently occurring rather than the mere physical expansion of urban areas, a process that has been taking place for several thousand years (Northam, 1975:378). As urban sprawl occurs, it gives rise to a number of problems that suggest the use of geographic research for their solutions. One such problem is that contemporary suburbia, an outgrowth of urban sprawl, is unique in terms of its rate of development and internal patterns and processes. Only recently, however, have geographers and others attempted to investigate suburbia as a subsystem functioning both independently and interdependently within a larger urban system.

Muller's recent publication, The Outer City (1976), is perhaps the most current and rigorous investigation into the modern suburban spatial system. Although the paper is a general survey of "only the major dimensions of suburban social and economic spatial organization," it does provide some valuable information concerning the diversities and dynamics of the suburban environment (Muller, 1976:3). Muller begins his thesis by identifying the various suburbanization processes which have transformed "the tightly focused single-core urban region of the past to the widely dispersed multinodal metropolis of today" (Muller, 1976:1). He goes on to suggest that, "suburbia in the late 1970s is emerging as the outer city," a direct result of various intrametropolitan socioeconomic decentralization and deconcentration trends occurring since the early 1950s. Indicating that both the causes and consequences of the "urbanization of the suburbs are multifaceted and far reaching," Muller asserts that there is a clear "need for geographers to conduct more research on contemporary suburbia, particularly on regional variations in suburbanization processes and patterns" (Muller, 1976:3).

Present Objectives

In an attempt to elucidate some of the major factors influencing the internal and external spatial morphology of modern suburbia, this study has three main objectives. The first, found in Chapter II, is a general descriptive analysis of the population growth and development patterns which have taken place since the end of World War Two in the largest metropolitan region in the United States: the New York-Northeastern New Jersey urbanized area. The second objective is a detailed analysis of the changing population and land use patterns occurring within one suburban county of the New York Metropolitan Region: Suffolk County. Chapter III therefore provides such an investigation into the recent trends of suburban growth in this county. The third objective is found in Chapter IV and involves the formulation and application of a simple Monte Carlo simulation model to measure recent and future population and development patterns within rapidly urbanizing Suffolk County. Chapter V provides a summary of this study's findings along with some recommendations for further investigations. The completion of the above stated objectives will provide a comprehensive understanding of some of the major dimensions of suburbanization in the New York area and yield greater insight into the dynamic spatial aspects of contemporary suburban processes.

CHAPTER II

THE NEW YORK METROPOLITAN REGION

In 1959 Hoover and Vernon formally delineated the New York Metropolitan Region (NYMR) in their classic research monograph, Anatomy of a Metropolis (1959). Their region included twelve counties from New York, nine from New Jersey, and one from Connecticut. They asserted that, "No other metropolitan region in the United States approaches it in population, employment, or wealth" (Hoover and Vernon, 1959:3). For instance, in 1956 an estimated 15 million people resided in the NYMR, accounting for 48 percent of the total 1950 population of Gottman's Megalopolis[1] in only 13 percent of its total area. The NYMR was divided into three zones based upon the level of land development found within each of its twenty-two counties in the 1950s. Counties grouped into the Core, for example, demonstrated the highest percentages of developed land to total developable land, while the

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[1]Megalopolis encompassed 54,000 square miles stretching 600 miles along the northeastern seaboard from southern New Hampshire to northern Virginia. Its population grew from 32 million in 1950 to 37 million in 1960 (Gottmann, 1961:26).

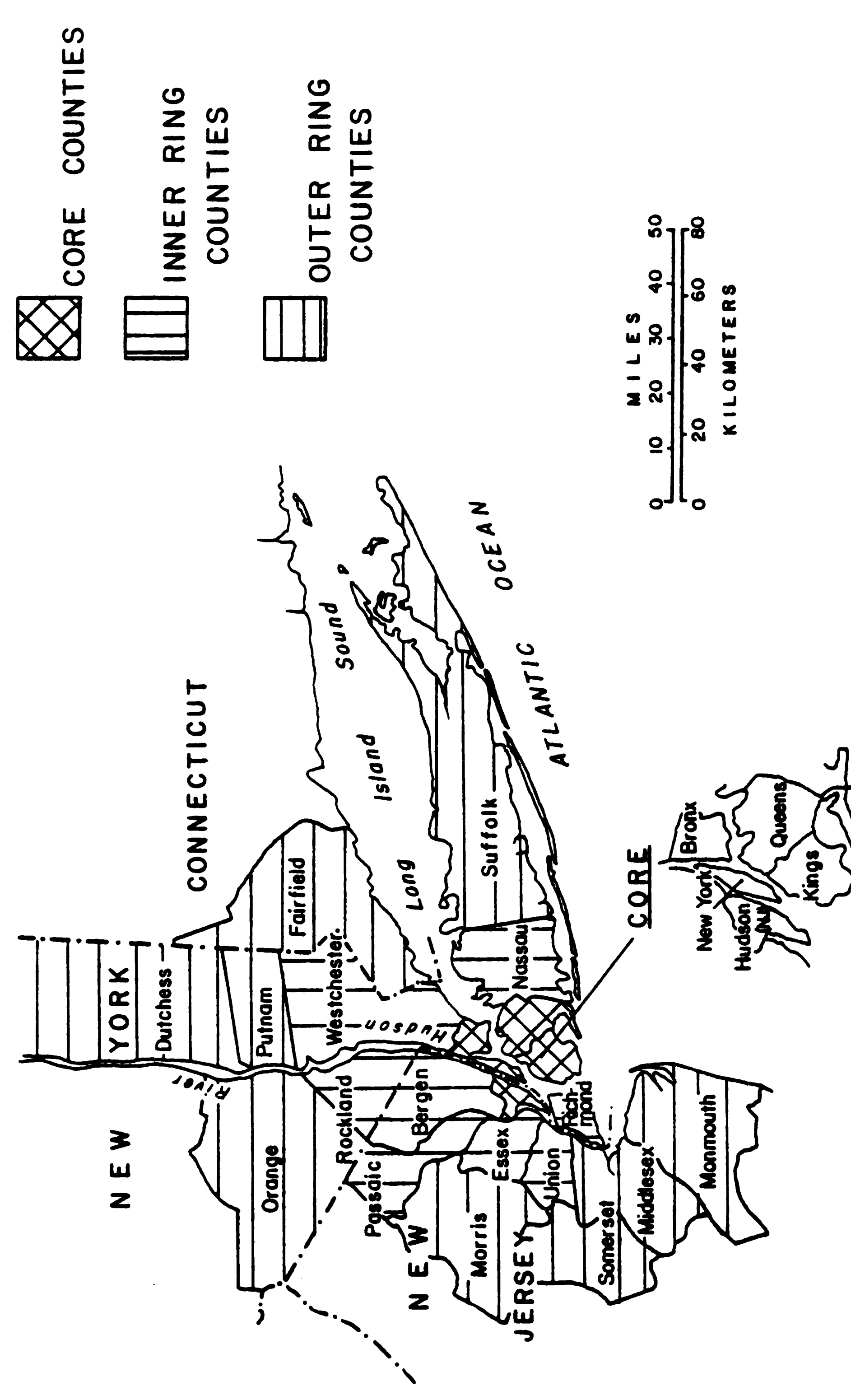
Inner Ring and Outer Ring Counties exhibited successively lower percentages (Figure 3).

During the last thirty years the NYMR has experienced the most dramatic population changes nationwide. Between 1950-1960, the region increased its population by 16 percent, adding 2.2 million persons to its base population of nearly 14 million (Nassau-Suffolk Regional Planning Board, 1968:1). The outlying suburban counties of New York City, that is, those located in the Outer Ring accounted for the major portion of this increase. In contrast, all but one county located in the Core (Queens County) recorded population decreases during the 1950s. As New York City proper experienced a population decline (losing over 100,000 residents), both the Inner and Outer Rings grew by 48 and 56 percent respectively.

If taken individually, the population changes evidenced by each county since 1940, identify an intraregional trend towards a decreasing urban and increasing suburban population which parallels the national trends previously discussed. These changes are summarized in Table 1 and illustrated in Figures 4-6 to provide a temporal perspective of the NYMR's overall population dynamics. From an examination of these population changes occurring between 1940-1970, several generalizations hold. Prior to 1950 the region's population growth took place primarily to the east and west of New York City, specifically in the

FIGURE 3

THE NEW YORK METROPOLITAN REGION



After Hoover & Vernon, 1959.

suburban counties on Long Island and in northeastern New Jersey. The northernmost counties in the Lower Hudson Valley and eastern Connecticut at the same time remained relatively stable, experiencing very minimal population increases. Immediately after World War Two and continuing into the 1950s, however, explosive increases occurred throughout the NYMR; the most dramatic changes took place in the previously stable counties of the Lower Hudson Valley. In the ten years from 1960-1970, three of these counties (Rockland, Putnam and Dutchess) along with Suffolk County and all of New Jersey's Outer Ring counties maintained relatively high growth rates while the majority of Inner Ring counties declined sharply.

Based upon these changes, it is hypothesized that through time intraregional growth will vary locally in response to the three following factors: 1) the size of the base populations; 2) the existing level of urban development; and 3) the distance from the region's urban center. It follows from the first hypothesis that higher growth rates are characteristically exhibited by those areas with small base populations since even relatively low increases in the number of inhabitants represent high percentage increases. Hence, no further discussion of this relationship is necessary. The second and third hypotheses concerning growth rates in relation to the amount of existing development and distance from the

Table 1.

NYMR Population Summary Table

County Population Change: 1940-1970

(By Thousands)

	1940	% Change	1950	% Change	1960	% Change	1970
The Core	8944	5.6	9447	-1.4	9316	1.3	9434
Manhattan (New York)	1890	3.7	1960	-13.4	1698	-9.4	1539
Brooklyn (Kings)	2698	1.5	2738	-4.1	2627	-1.0	2602
Bronx	1395	4.1	1451	-1.8	1425	3.3	1472
Queens	1298	19.5	1551	16.7	1810	9.8	1987
Hudson	652	-.7	647	-5.7	611	-.2	609
Inner Ring	2028	26.9	2573	47.7	3800	11.2	4224
Richmond	174	9.9	192	15.9	222	33.1	295
Essex	837	8.2	906	1.9	924	.7	930
Bergen	410	31.6	539	44.7	780	15.1	898
Nassau	407	65.4	673	93.3	1300	9.8	1428

Table 1. (cont'd.)

	1940	% Change	1950	% Change	1960	% Change	1970
Passaic	309	9.0	337	20.6	407	13.3	461
Union	328	21.3	398	26.7	504	7.7	543
Westchester	574	9.1	626	29.3	809	10.5	894
Outer Ring	1546	25.0	1933	56.4	3022	41.4	4274
Dutchess	121	13.5	137	28.7	176	26.3	222
Fairfield	418	20.5	504	29.6	654	21.3	793
Middlesex	217	22.0	265	63.8	434	34.5	584
Monmouth	161	39.8	225	48.4	334	37.4	460
Morris	126	30.8	164	59.1	262	46.6	384
Orange	140	8.7	152	20.6	184	20.7	222
Putnam	17	22.3	20	56.2	32	78.9	57
Rockland	74	20.2	89	53.2	139	68.1	230

Table 1. (cont'd.)

	1940	% Change	1950	% Change	1960	% Change	1970
Somerset	74	33.1	99	45.4	144	37.9	198
Suffolk	197	39.9	276	141.5	667	68.7	1125
Total	12518	11.5	13953	15.7	16139	11.1	17932

Source: Bergman and Pohl, 1975, P. 67.

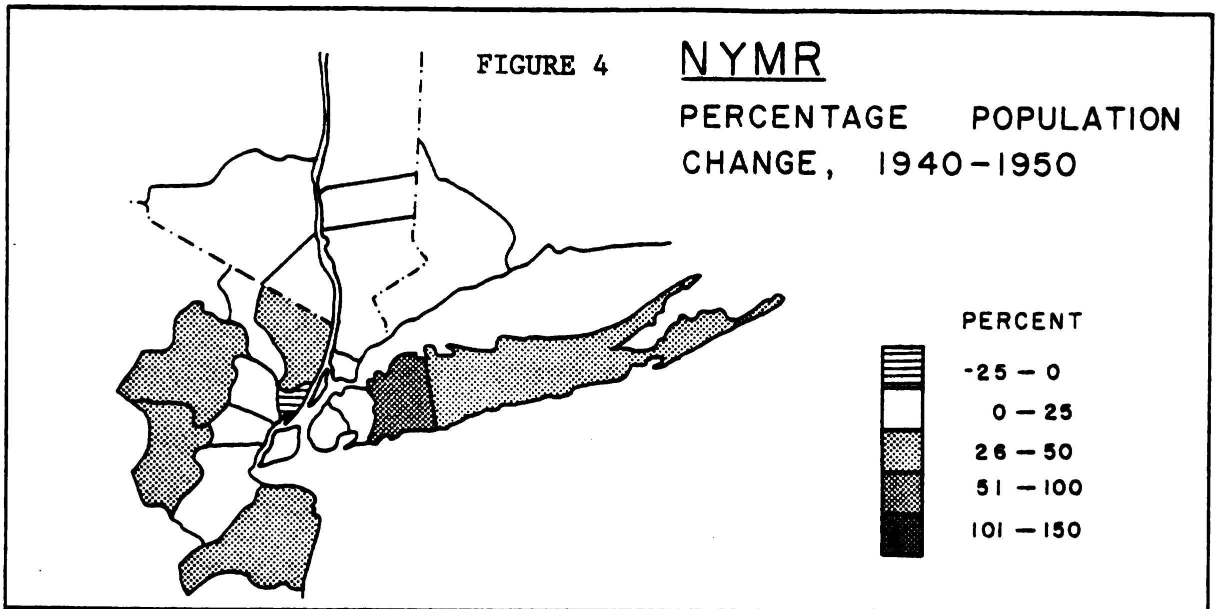


FIGURE 4 NYMR PERCENTAGE POPULATION CHANGE, 1940-1950

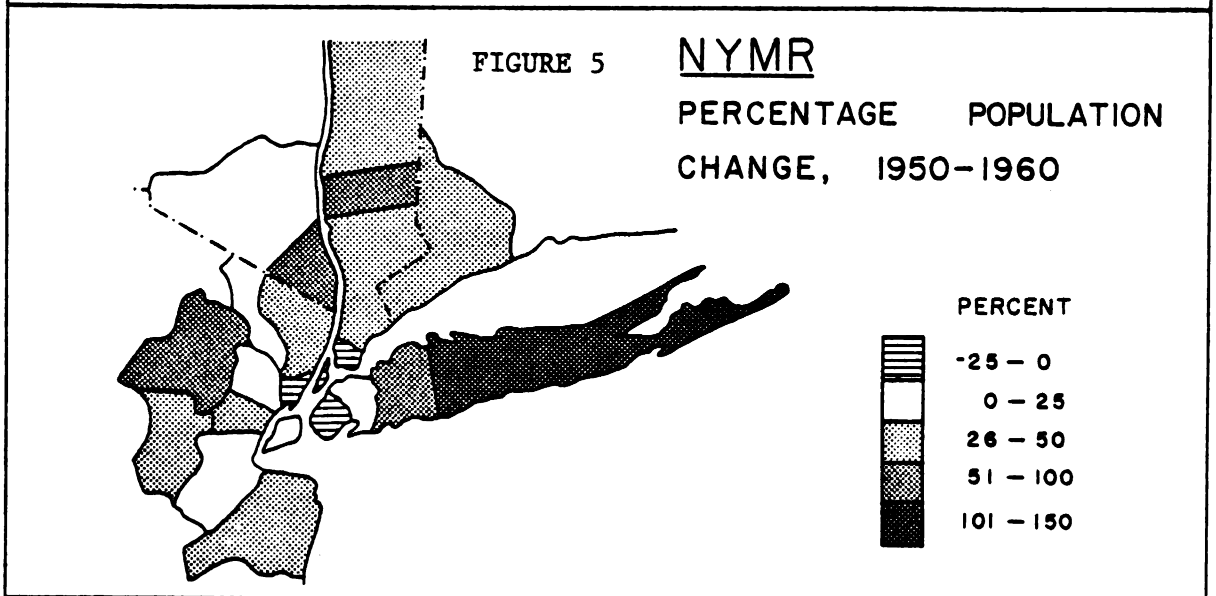


FIGURE 5 NYMR PERCENTAGE POPULATION CHANGE, 1950-1960

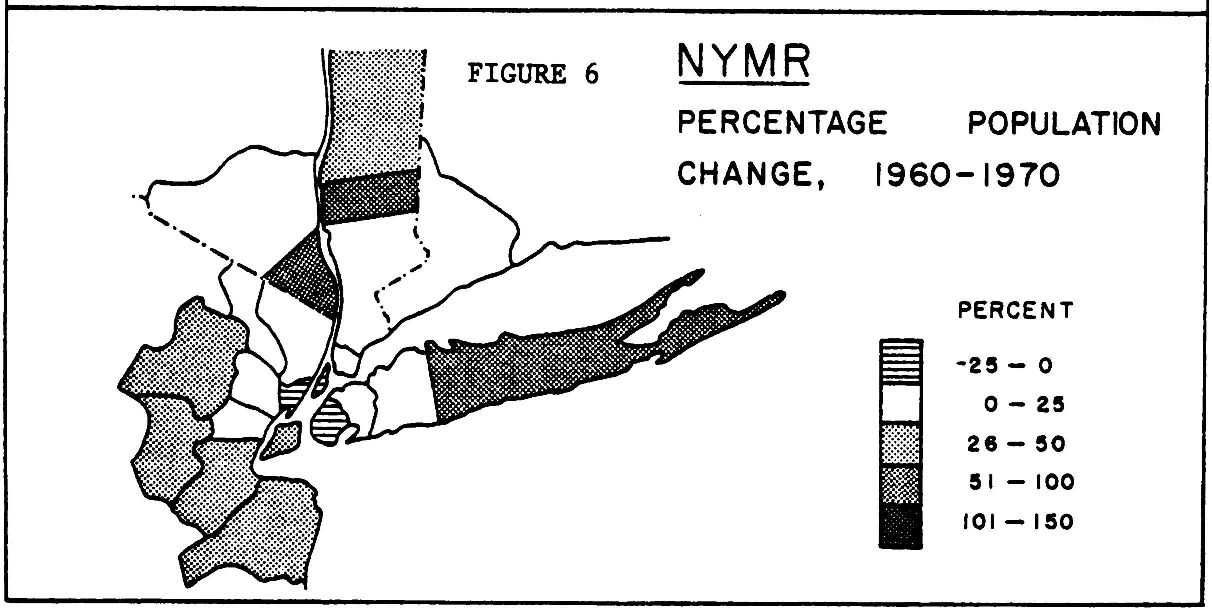


FIGURE 6 NYMR PERCENTAGE POPULATION CHANGE, 1960-1970

region's center, however, need to be more fully investigated.

Newling's Model

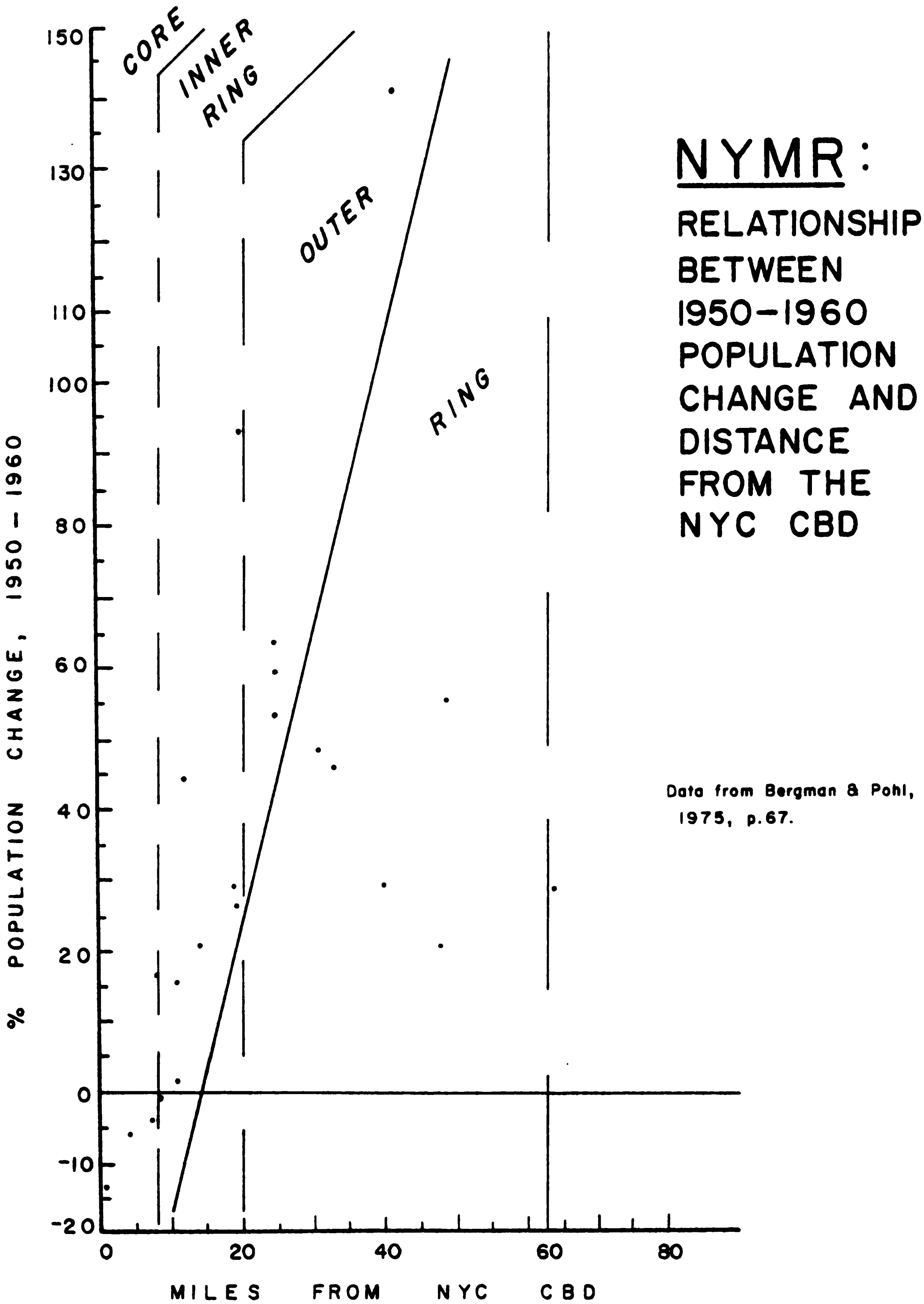
Newling (1966) developed a mathematical model of intraurban growth suggesting that a systematic relationship exists between a population's rate of growth and its distance from the center of the urban area. Newling's hypothesized relationship indicates that the two variables (distance and growth rate) are positively related: as distance from the urban center increases, population growth rates also increase. The majority of his research that tested this model was carried out on the internal spatial structures of several cities. In his Pittsburgh study, population growth rates were analyzed for each of the city's thirty-two wards and showed a significant positive relationship outward from the central business district (CBD). Newling's model probably has applicability in a larger dimension. To illustrate, when the conceptual basis of the model is applied to the NYMR's population growth patterns for 1950-1960 (the decade exhibiting the most dynamic changes), the hypothesized relationship conforms with the empirical situation. Population growth rates were highest in the Outer Ring and relatively lower in the Inner Ring; the Core recorded population declines

(Figure 7).

Newling has also determined that although a relationship exists between a population's distance from the urban center and its rate of growth, a third variable, population density (persons per square mile) must also be considered. He suggests that in cities where "topographic controls and the development of the city through the coalescence of several primary settlement nodes have produced a highly complicated spatial structure," simple linear distance from the urban center does not adequately explain the resultant patterns (Newling, 1966:220). Assuming, therefore, that the spatial structure of the NYMR is highly complex as a result of various topographic and developmental factors, county growth rates also require analysis with respect to their population densities. Employing Spearman's rank-order correlation technique to measure the relationship between the 1950-1960 percentage population change and the 1956 population density for each of the region's twenty-two counties, a coefficient of -.44 is obtained indicating that a moderate inverse relationship exists between the two variables; it was significant when tested at the .05 level.

It is concluded that the population changes experienced by the counties of the NYMR have been dependent upon two primary factors: 1) distance from the New York City CBD;

FIGURE 7


CORE
INNER RING
OUTER RING
150
130
110
100
80
60
40
20
0
-10
-20
% POPULATION CHANGE, 1950 - 1960
0
20
40
60
80
MILES FROM NYC CBD
NYMR:
RELATIONSHIP BETWEEN 1950-1960 POPULATION CHANGE AND DISTANCE FROM THE NYC CBD
Data from Bergman & Pohl, 1975, p.67.

and 2) existing population density.[2] Within the region, the counties located the greatest distances away from New York City and having the lowest population densities will experience the most significant changes in both population and development in the coming years.

The gross regional patterns discussed above are the result of local variations in suburbanization processes not able to be identified by such a large-scale analysis. Therefore, in Chapter III a more detailed investigation of one of the NYMR's low-density, outer suburban counties, Suffolk County in particular, is presented; it provides greater insight into such intraregional processes of suburban growth.

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[2]Population density is used here as a measure of the level of urban development from the second hypothesis concerning intraregional growth trends.

CHAPTER III

SUBURBANIZATION IN SUFFOLK COUNTY

The Nassau-Suffolk Standard Metropolitan Statistical Area

Nassau and Suffolk Counties, located on Long Island, have been among the fastest growing counties in the United States since the late 1940s according to the Nassau-Suffolk Regional Planning Board (NSRPB, 1968:2). This bi-county region was the scene of:

> ...one of the nation's earliest, most powerful surges to suburbia...as tens of thousands of young families poured out of New York City after World War Two (Reilly, 1973:39).

By 1970 their combined populations equaled 2.6 million persons, representing over 14 percent of the NYMR's total population and more than 1 percent of the entire country's. The federal government in 1972 designated Nassau and Suffolk Counties as the nation's first "all suburban" Standard Metropolitan Statistical Area (Muller, 1976:2). The Nassau-Suffolk SMSA today ranks ninth among the nation's 272 SMSAs with a population larger than that of Philadelphia, the country's fourth largest city. In addition, this region is expected to accommodate a major portion of the NYMR's suburban population growth through the 1980s. In a recent publication it has been projected that by 1985 over 3 million of the region's total 22 million residents will live in the bi-county area (NSRPB, 1968:1, 5).

Over the last twenty years, suburbanization has consumed almost all of the developable lands in Nassau County which has resulted in the stabilization of growth and associated development. In fact, with the county's current population density at almost five thousand people per square mile, "growth is at a virtual standstill" (Morris, 1977:17). But suburban development continues to be vigorous in Suffolk County where the population density is only 29 percent that of Nassau's and the population growth rates have been consistently higher since the latter part of the 1950s. According to population projections made by the NSRPB, this trend will continue throughout the remainder of this century as Suffolk County is expected to accommodate 93 percent of Long Island's suburban population increases (NSRPB, 1976:6). The latest available census data published by the Long Island Lighting Company (LILCO) reveal that between January 1, 1976 and January 1, 1977, Suffolk County gained over eighteen thousand residents while its western neighbor (Nassau County) gained only two thousand (LILCO, 1977:2).[3] Future development in this area will also be affected by the relocation of light industry from New York City and Nassau County, a local trend now in evidence. Overall, Suffolk County is experiencing dynamic growth and thus provides a prime area for the study of contemporary suburban development (Figure 8).

Land Use Changes in Suffolk County

Suffolk County occupies the eastern two-thirds of Long Island, encompassing approximately 900 square miles (2,331 square kilometers) of land as it extends 85 miles (136 kilometers) from its western boundary into the Atlantic Ocean. The county is elongated in shape with its maximum width of 20 miles (32 kilometers) occurring along the Nassau-Suffolk boundary line from Long Island Sound to Great South Bay. In the east the county terminates in two peninsulas or forks that represent the topographic highs of the Harbor Hill moraine on the north flank and the Ronkonkoma moraine in the south. These morainal ridges are merged at the western end of the county, but diverge towards the east as the Ronkonkoma moraine crosses from the north to the south. Moderate elevations of 100-200 feet (30-60 meters) are characteristic of both moraines

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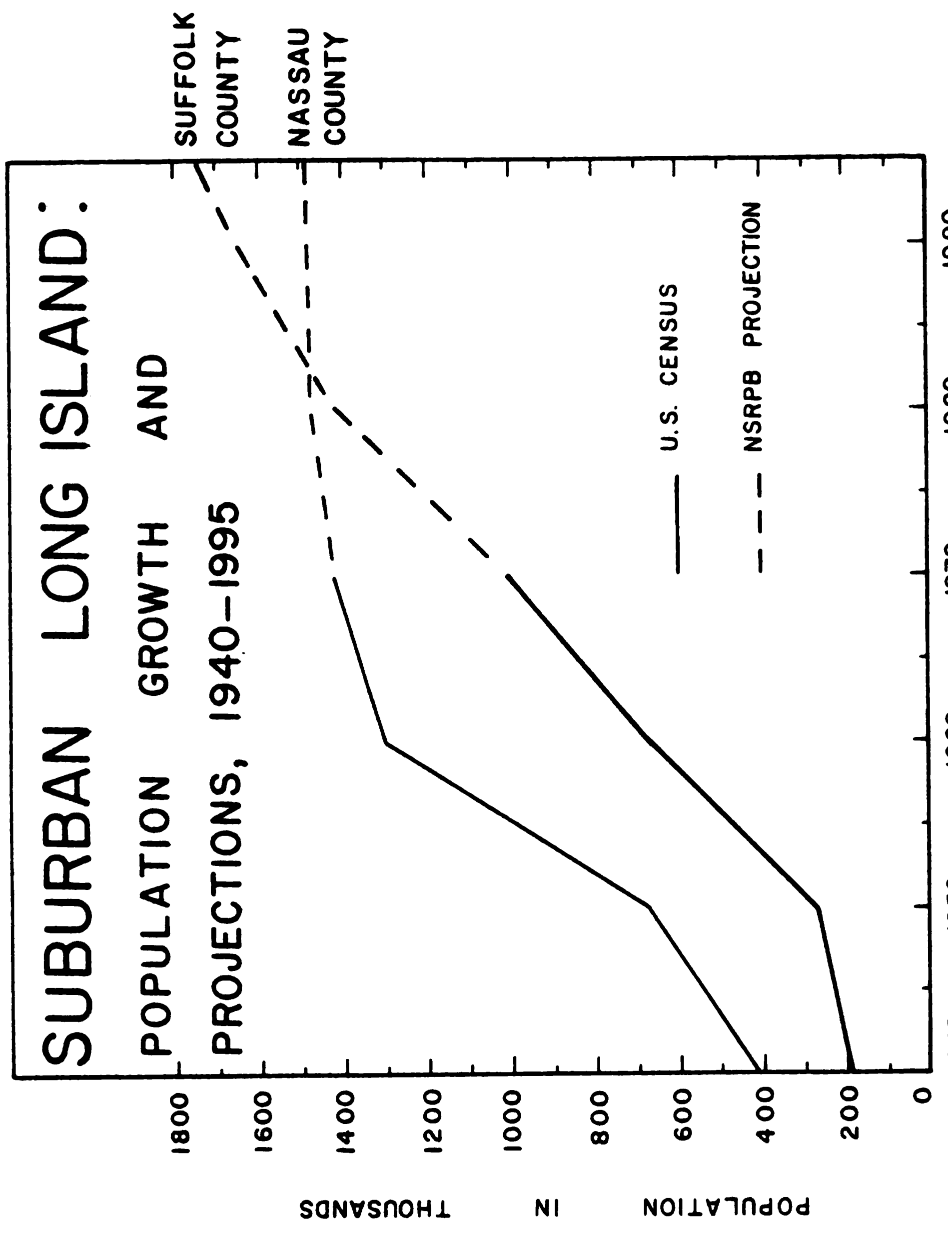
[3]An explanation of LILCO's population estimation methods is found in the Appendix.

FIGURE 8


SUBURBAN LONG ISLAND:
POPULATION GROWTH AND
PROJECTIONS, 1940–1995
SUFFOLK COUNTY
NASSAU COUNTY
U.S. CENSUS
NSRPB PROJECTION
POPULATION IN THOUSANDS
1800
1600
1400
1200
1000
800
600
400
200
0
1940
1950
1960
1970
1980
1990

(Figure 9). The remaining physiographic features of Suffolk County are the result of erosional and depositional processes occurring from the Cretaceous period to the present. Extensive outwash plains and channels are common throughout, along with several isolated pre-Pleistocene plateau remnants (Fuller, 1914:23). Physiographically, the county is basically homogeneous and is characterized predominantly by sand-gravel plains and hummocky ridges of glacial origin.

The subtlely diverse landscapes of Suffolk County--hills and plains--have influenced suburban growth both directly and indirectly. The economic costs required to develop the morainal areas, for example, are restrictive and subsequently limit their potential as building sites. As Eschman and Marcus have noted:

> ...even though in these days man's technology allows him to move mountains, the economic costs of overcoming geologic and geomorphologic factors continue to impose directional and aerial constraints on urbanization. Thus...the basic landscape on which cities are situated continues to play an important role in modern urbanization (Detwyler and Marcus, 1972:27).

Therefore, even though the moraines are prominent landforms only in the county's northwestern and northcentral parts, the roughness of the local terrain is a direct control affecting suburbanization. The plains exert a positive impact; they attract high-density development since obstacles

FIGURE 9

(a)

An exposure of the Ronkonkoma moraine(a) in western Suffolk County partly depleted by intensive sand-gravel mining(b), Long Island's major extractive industry.

(b)

such as irregular depressions and slopes are absent (Figure 10). On these sandy plains, the construction of single family detached dwellings (the predominant housing type) and low-rise, sprawling industrial buildings is easier and less expensive than on the heavily wooded, hummocky moraines.

Topography also exerts indirect controls upon intra-county development patterns, reflecting the problems associated with changing land uses. These controls are illustrated by the processes that have converted Suffolk's agricultural lands into urban lands over the last twenty years. Agriculture has been a major economic activity in the county since its early settlement in the seventeenth century. As recently as 1950 more than 120,000 acres were farmed (4,000 more than in 1940) which represented almost one-fourth of the county's total land area. But as the population grew from 276,000 in 1950 to 1.1 million in 1970, agricultural lands decreased to 73,000 acres. The suburban encroachment into agricultural lands created pressures upon the farmers who subsequently found themselves on the fringe of advancing urban lands. Hart (1976) has cited some of these pressures in a recent article where he also identifies urban encroachment onto rural lands as a serious problem in Suffolk County.

FIGURE 10

An outwash plain in Brookhaven Township, the predominant landform in eastern Suffolk County.

> City people who desire new houses, especially inexpensive new houses, can find them in quantity only in new, outlying developments. Political reality dictates that the burgeoning population of these new developments must be given city services...Taxes must be raised in order to provide the necessary services, and the farmers who remain are eventually forced to sell their land because they cannot afford to pay urban-level taxes (Hart, 1976:1).

In this instance where agricultural land uses succumb to urban land uses, topography exerts an indirect influence upon suburbanization as it determines only the original use of the respective lands but not the subsequent uses which are determined more strongly by economics (Figure 11).

Suffolk's plains and areas of moderate relief have accommodated the major portion of suburban development since the 1950s while its morainal lands have generally resisted high-density suburban development for two reasons. First, the plains are easier to develop than the moraines in both economic and labor input. Second, in the past they have accommodated the greater amount of agricultural acreage while the moraines provided relatively little arable land. It has been shown that as such land uses become economically sensitive in the suburban-rural fringe zone, development is most likely to appear on the newly acquired, defunct agricultural lands. Of the county's four western towns, for example, the two northern towns of

FIGURE 11

(a)

Remnant agricultural fields in western Suffolk County fringed by (a) residential and (b) industrial lands.

(b)

Huntington and Smithtown, dominated by moderately dissected morainal topography recorded population densities of two thousand persons per square mile in 1970. The two southern towns of Babylon and Islip, located on the outwash plains recorded higher densities closer to four thousand persons per square mile.

The overall effects of the topography upon suburban expansion in Suffolk County as a whole are only locally significant since most of the lands are characterized by plains and areas of moderate relief. Only to a limited extent have the direct and indirect controls of the geomorphic environment shaped the patterns of intracounty suburban development.

Recent Population Trends

Population growth since the late 1940s has resulted in varying levels of development throughout Suffolk County. At present, the western end of the county is heavily suburbanized, while the eastern end remains relatively undeveloped and even semi-rural in character. For example, in 1972 the county grossed over $81 million from agricultural sales making it New York State's leading county in agricultural production (Suffolk County Planning Department, 1975:296). Only 5 percent of the land area encompassed by the five western townships of Babylon, Huntington, Smithtown, Islip and Brookhaven was devoted to agriculture in 1966, while 22 percent of the land area in the remaining five townships was farmed (NSRPB, 1968:18). From the remnant seventeenth century Dutch-English international boundary line which today divides Nassau from Suffolk, the level of urban development shows a decrease from west to east across the county or conversely agriculture subsequently increases.

Similar patterns of decrease from west to east exist for population density and percentage of built-up land for each of Suffolk County's ten townships. In 1970 each of the four westernmost townships recorded population densities in excess of two thousand persons per square mile. Densities in five of the six eastern townships, however, remained well below 320 persons per square mile. Brookhaven, the single eastern unit with a relatively high density of almost one thousand persons per square mile, is presently Long Island's fastest growing township, and represents a transitional zone between the urbanized western and semi-rural eastern ends. By comparison in 1966, the percentage of built-up or developed land decreased from west to east with an average of 47 percent of the total land area in the western townships and 19 percent among the eastern ones (Figures 12 and 13).

The spatial variation of built-up lands, agricultural lands and population densities across Suffolk County is summarized in Table 2 which suggests the existence of two

FIGURE 12

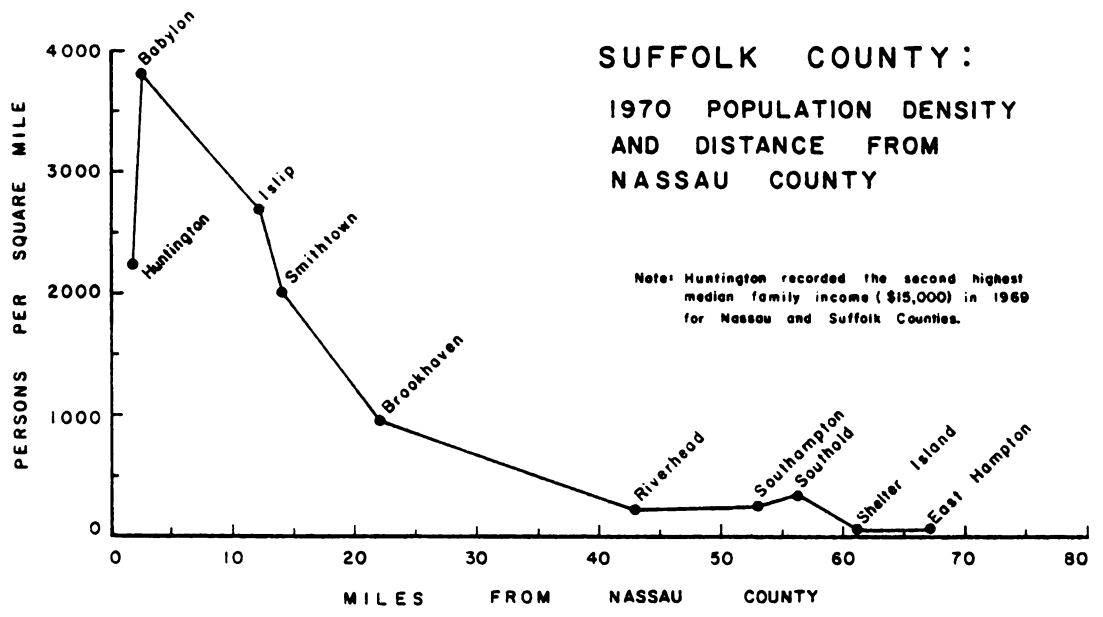


FIGURE 13

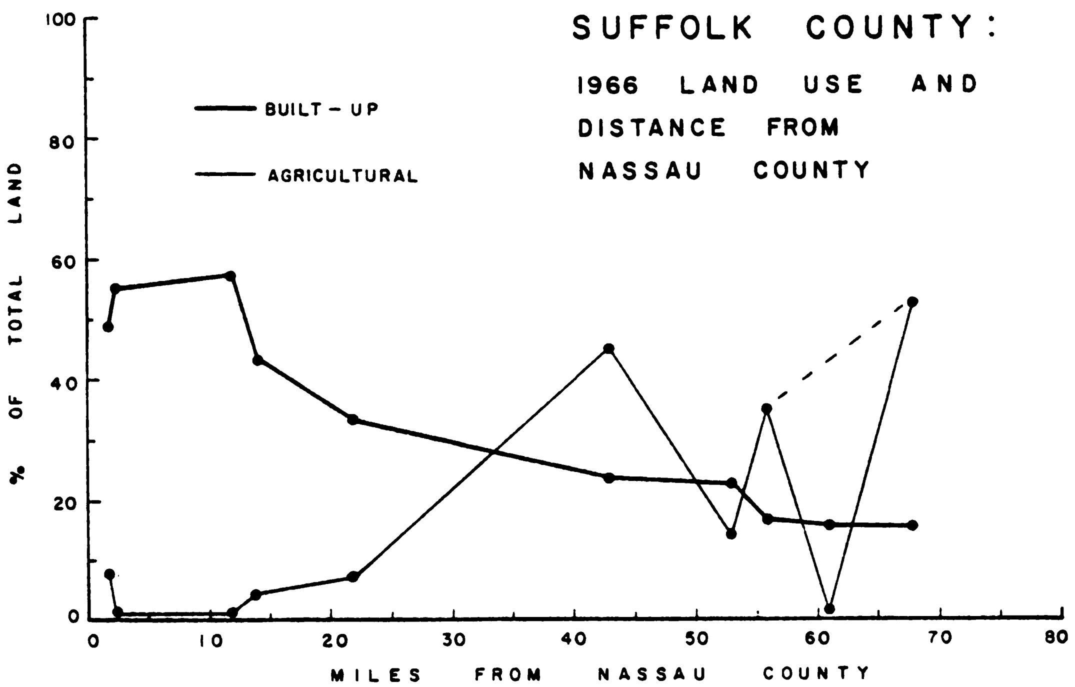


Table 2.

Township Land Use and Population Density

	Land Use (In Square Miles)					1970 Net Population Densities
	Total Land Area	Built-Up	% of Total	Agricultural	% of Total	(Persons Per Square Mile of Land)
Huntington	94	54	57	7	7	2129
Babylon	50	36	72	1	1	4071
Islip	103	64	62	1	1	2708
Smithtown	54	29	54	2	4	2123
Brookhaven	261	99	38	18	7	940
Riverhead	68	21	31	31	46	278
Southampton	140	40	29	19	14	258
Southold	53	13	25	19	36	317
East Hampton	71	19	27	4	6	155
Shelter Island	11	6	55	1	1	149
			(mean = 45)		(mean = 12)	(mean = 1312)
Suffolk County Total	905	381	42	103	11	1245

(Compiled from NSRPB, 1966, Table 6, p. 18) distinct internal zones. The townships in the Inner Zone (western zone) include Babylon, Huntington, Islip and Smithtown. Each has:

1) population densities in 1970 above the mean value for the entire county;
2) percentages of built-up lands in 1966 above the mean value for the entire county; and
3) percentages of agricultural lands in 1966 below the mean value for the entire county.

The Outer Zone (eastern zone) includes the six remaining townships, and although it displays slightly less statistical uniformity in actual land use percentages, overall similarities do tend to unify the area. The members of this zone are characterized by:

1) population densities in 1970 below the mean value for the entire county;
2) percentages of built-up lands in 1966 below the mean value for the entire county, with the single exception of Shelter Island; and
3) percentages of agricultural lands in 1966 below the mean value among the

peripheral towns of Brookhaven, Shelter Island and East Hampton, but below the mean value among the central towns of Riverhead, Southold and Southampton.

The different levels of development existing in these two zones today result from intensive countywide suburbanization that has taken place over the last quarter-century. The evolution of these present patterns is best explained by analyzing the recent population data for the county's ten townships shown in Table 3. From 1950-1960, all five western townships experienced population increases greater than 100 percent, while the eastern townships grew by less than 60 percent. During the next decade, all of the western townships exhibited decreases in their rates of increase, with only two (Smithtown and Brookhaven) maintaining rates in excess of 100 percent; the others decreased by an average 120 percent. In contrast, two eastern townships (Southold and Shelter Island) increased their populations by 11 percent and the remaining three averaged relatively modest declines (19 percent). Using LILCO's 1977 population data, current growth rates indicate significant shifts in the county's development patterns. Over the last seven years, the Inner Zone townships have experienced sharp declines recording rates of less than 13 percent. But in the Outer Zone, population increases ranged from slightly less than 15 percent

Table 3.

Township Total Population and Percent Change: 1950-1977

	1950	% Change	1960	% Change	1970	% Change	1977*
Huntington	47,506	166	126,221	59	200,172	9	217,131
Babylon	45,556	212	142,309	43	203,570	9	221,305
Islip	71,465	142	172,959	61	278,880	12	312,762
Smithtown	20,993	140	50,347	128	114,657	8	123,695
Brookhaven	44,522	147	109,900	123	245,260	38	339,183
Riverhead	9,973	46	14,519	30	18,909	15	21,684
Southampton	17,013	59	27,095	33	36,154	23	44,376
Southold	11,632	14	13,295	26	16,804	16	19,473
East Hampton	6,325	40	8,827	24	10,980	28	14,032
Shelter Island	1,144	15	1,312	25	1,644	25	2,059
Suffolk County Total	276,129	141	666,784	69	1,127,030	147	2,778,454

(Compiled From LILCO, 1977, p. 2) (*1977 = LILCO Estimates) to 38 percent. Rapidly suburbanizing Brookhaven, for example, gained over twelve thousand residents in 1976. In summary, in terms of population growth since the 1960s the previously rapid-growing Inner Zone has experienced dramatic decreases, while the Outer Zone has recorded only minor decreases and presently exceeds the western zone by 14 percent (Figure 14).

Within the individual townships of the Outer Zone, an analysis of annual population growth rates for the 1960-1970 period and the 1970-1977 period reveals significant changes in the patterns of current intrazonal suburbanization.[4] From 1960-1970, the highest annual rates were found in the northwestern parts of Brookhaven Township where eighteen of its forty-six minor civil divisions (MCD) recorded percentage increases above the zone's mean value of 13 percent. Throughout the entire township, annual rates of increase ranged widely from 2 to 25 percent, with only one MCD (South Yaphank) experiencing a population decrease. Annual rates occurring in the remaining five townships also varied widely (Figure 15).

During the first seven years of the 1970s, the MCDs recording the highest annual growth rates throughout the zone were located in the eastern half of Brookhaven Township

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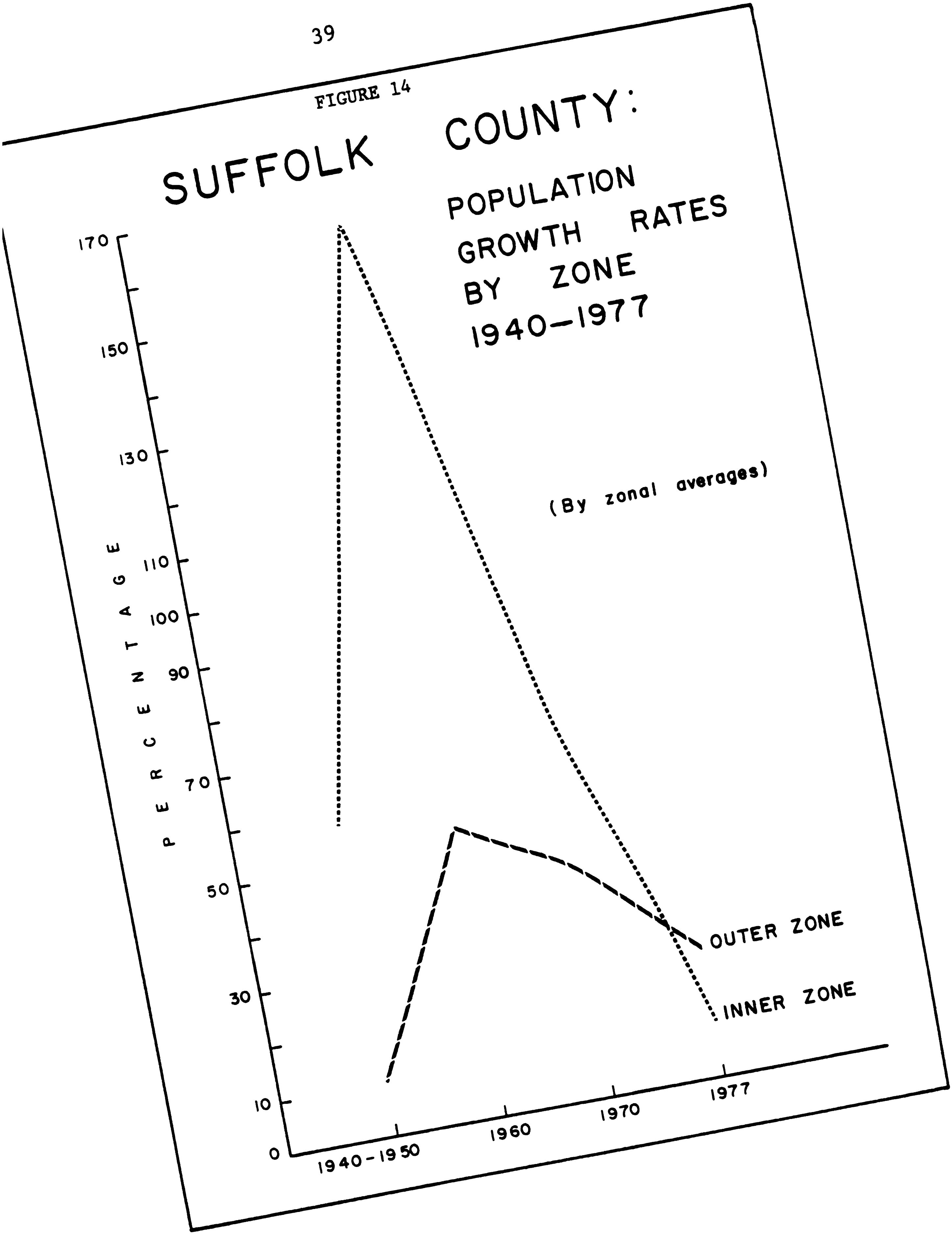
[4]Annual population growth rates have been calculated and are used here to enable direct comparison of 1960 trends with 1970 trends. The use of only the first seven years for 1970 rates is adequately representative.

FIGURE 14


SUFFOLK COUNTY:
POPULATION GROWTH RATES BY ZONE 1940–1977
(By zonal averages)
PERCENTAGE
170
150
130
110
100
90
70
50
30
10
0
1940–1950
1960
1970
1977
OUTER ZONE
INNER ZONE

which represents an eastward shifting in the cluster of high rates found in the 1960s. This shift is indicated specifically by the township's seven eastern MCDs that experienced increases in their annual population growth rates in the 1970s. More significant is the apparent spillover of high increase rates into four MCDs in western Southampton (Riverside, Remsenburg-Speonk, West Hampton and West Hampton Beach) and one MCD in central Riverhead Township (Roanoke). Relative to these population changes in the western townships, the eastern townships have experienced less significant growth rates (Figure 16).

From the percentage changes in the eastern zone's western end between the 1960s and 1970s, a spatial trend of systematic suburban expansion is evident. During the 1960s the highest rates were clustered in northwestern Brookhaven Township, adjacent to the heavily developed Inner Zone. In the 1970s, however, the formerly high-increase MCDs experienced decreases in their rates of growth while neighboring ones to the east experienced increases. Development is therefore occurring in a systematic pattern as MCDs adjacent to rapid growth areas themselves experience rapid growth in successive time periods after growth has increased, peaked, and then subsided in the rapidly growing MCDs.

In combination, the patterns of intertownship and intratownship growth indicate that suburbanization is

FIGURE 15

OUTER ZONE: PERCENTAGE ANNUAL POPULATION CHANGE, 1960 — 1970

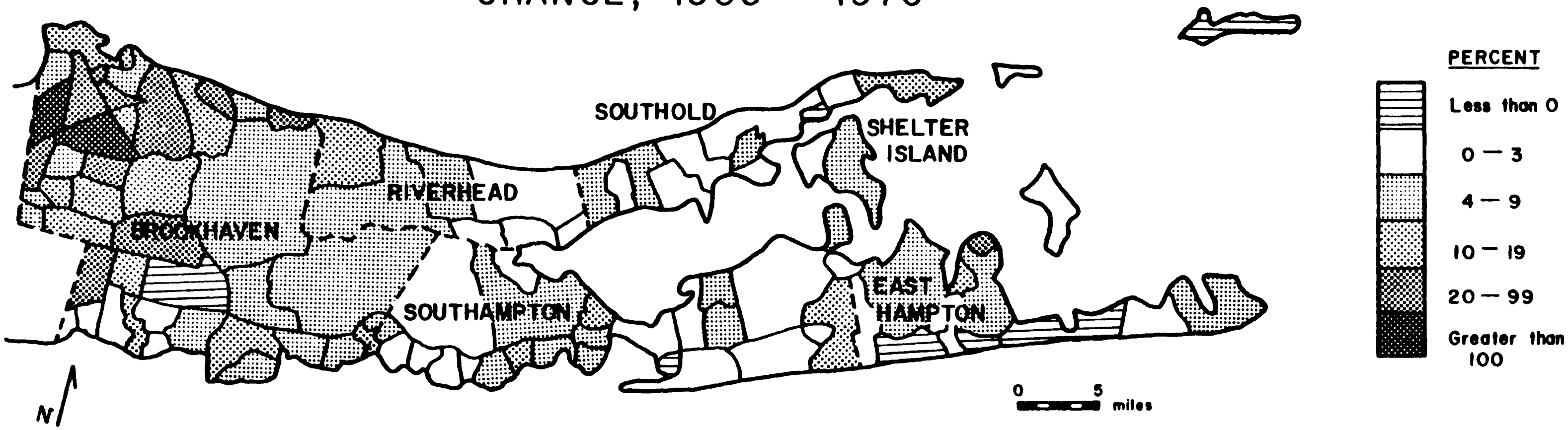
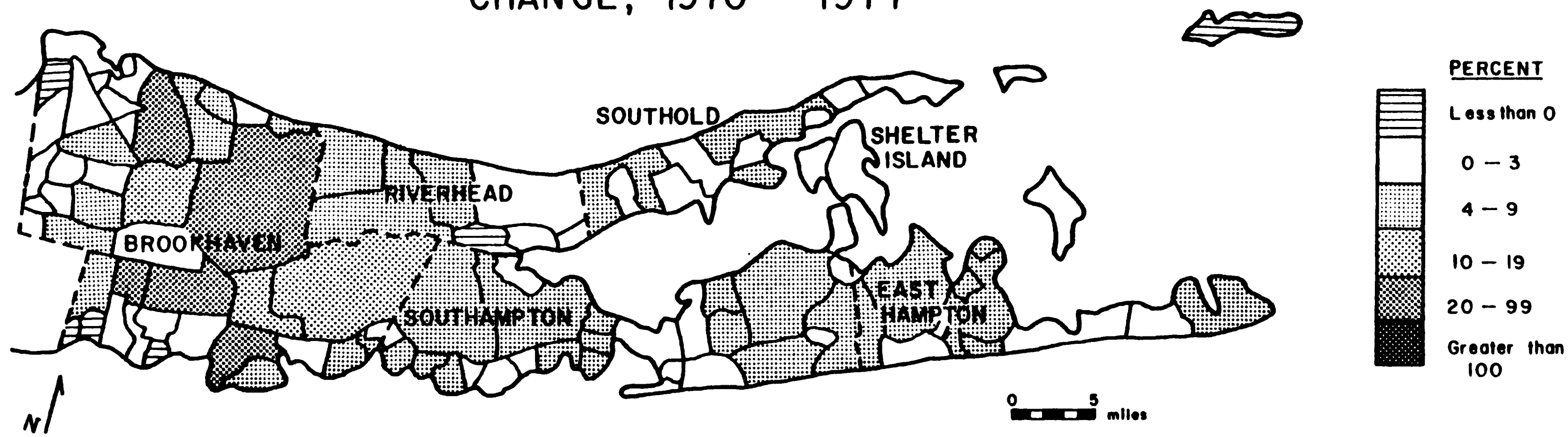


FIGURE 16

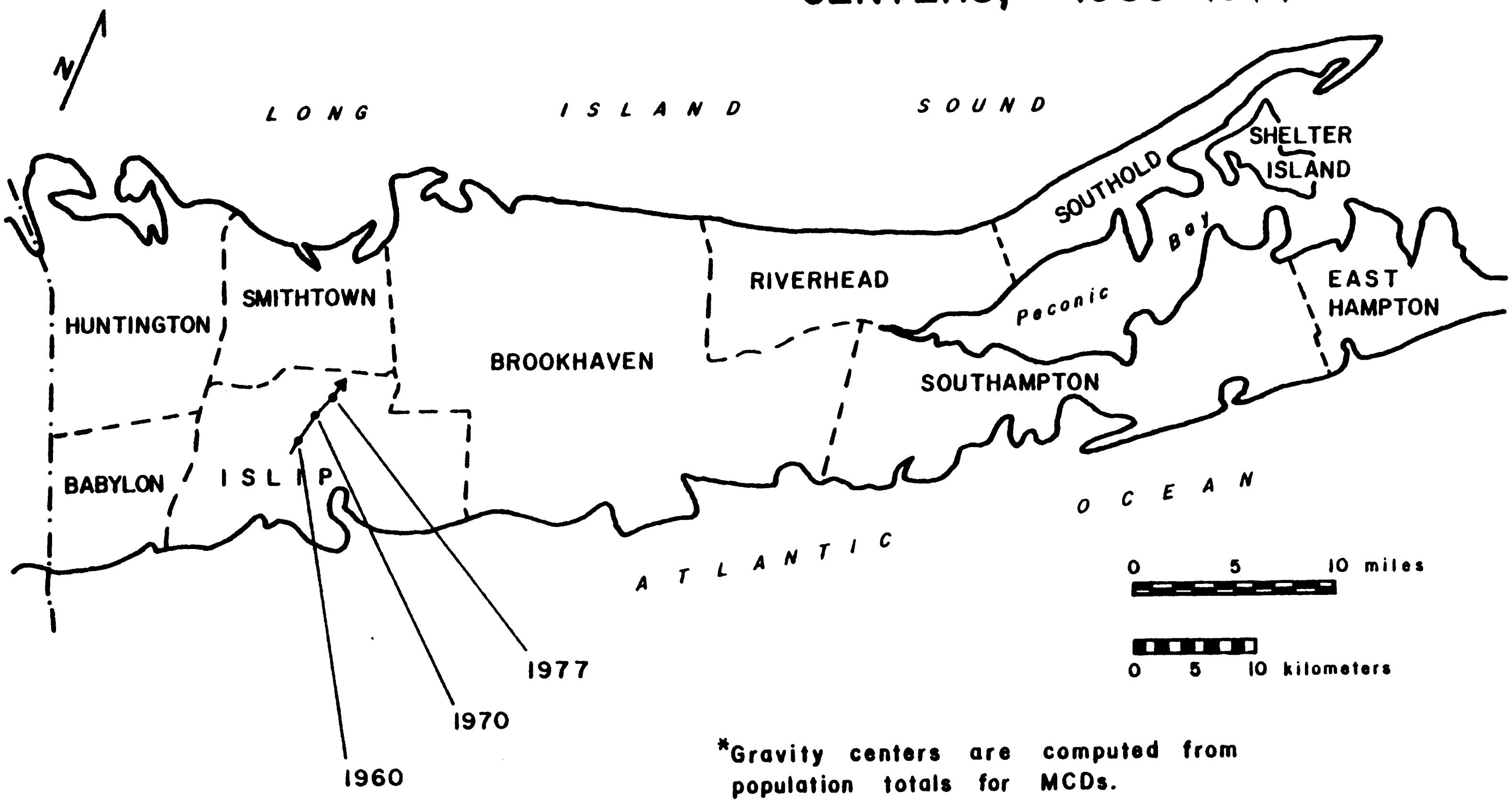
OUTER ZONE: PERCENTAGE ANNUAL POPULATION CHANGE, 1970 — 1977



diffusing eastward across Suffolk County as vacant lands are consumed in the western townships where population densities are increasing. This diffusion is illustrated in Figure 17 which depicts the center of gravity for Suffolk County's total population for three selected years: 1960, 1970 and 1977. The center of gravity of an areal distribution is statistically defined as the mean or average point of that distribution; the point at which the algebraic sum of the deviations from it is equal to zero (Hart, 1954:50). If each unit within the distribution is given equal weight and the distribution itself is located upon a rigid plane, the center of gravity is actually the fulcrum point "at which this hypothetical plane would balance..." (Hart, 1954:50). The linearity of Suffolk County conforms exceptionally well to the conceptual framework of this type of centrographic model. Assuming the county's main land mass (excluding the barrier islands, Gardiners and Fishers Islands) to be a plane of uniform weight, the three centers of gravity plotted in Figure 17 identify the mean points for the 1960, 1970 and 1977 population distributions. By connecting these points with a line, the resultant path represents the movement of the gravity center through time. It moved northward from the center of Islip toward the southeastern corner of Smithtown (or simply towards Brookhaven) covering approximately 2 miles (3.2 kilometers) for

FIGURE 17

SUFFOLK COUNTY: POPULATION GRAVITY CENTERS, 1960–1977*



the seventeen year period, and reflects a significant overall shift eastward in the county's population.

From the preceding observations concerning the spatial and temporal dimensions of recent suburban development in Suffolk County, it is hypothesized that at any given time, a township's location with respect to all others determines both its rate of growth and population density. To test this hypothesis, an analysis of these three variables (location, growth and density) is carried out for all ten townships. Assuming that the boundary line with congested Nassau County marks Suffolk's zone of maximum suburban development, a township's straight-line distance from it represents relative location to the suburban core. The measured distance from Nassau County is then used to determine the strength of its relationship to the respective 1977 population density and the percentage population change from 1970-1977 for each township. Computing the rank-order correlation coefficients, a strong inverse relationship of -.90 is obtained between distance and density, and a strong positive relationship of +.73 between distance and percentage population change.

In summary, suburbanization has diffused eastward across Suffolk County from Nassau County into the western portion of the Outer Zone. Presently, Suffolk County's eastern townships demonstrate the greatest potentials for future development because of their relatively low population densities, high population growth rates, and low percentages of built-up lands. These townships also accommodate most of the county's agriculture which has been shown to be a tenuous economic activity. It is highly sensitive to the pressures of expanding urbanization. The eastern half of the county is topographically uniform, predominated by outwash plains as the Harbor Hill and Ronkonkoma moraines are highly interrupted and less evident here than in the west. But the so called "tidal wave" of urbanization has yet to crest in these transitional townships of the Outer Zone. By identifying some of the significant variables active in the county's past development trends, an estimation of future development situations is possible. The following chapter examines both past and future trends by applying three simple Monte Carlo simulation models to suburbanizing Suffolk County.

CHAPTER IV

THE SUFFOLK COUNTY SIMULATION MODEL OF SUBURBAN DEVELOPMENT

Simulation Models in Geographic Research

Since its inception and introduction as a social science research tool by Hägerstrand in 1952, the Monte Carlo simulation model of diffusion has become a common analytical technique for the study of various geographic problems (Bryant, 1975:88). The continued use of such probabilistic modeling has been encouraged by King (1969) who states:

> The development of this probability analysis in relation to patterns of locations and interactions as they vary over space and time is a challenge for future geographic research. It should not go unanswered (King, 1969: 230).

Before investigating the application of the Monte Carlo simulation model to the study of suburban expansion, a brief review of several significant applications in geography is provided.

Taaffe, Garner, and Yeates (1963) proposed a progressive series of simulation models in their study of Chicago's peripheral commuter patterns. The models were based upon empirical observations and applied to the city's western suburbs; the purpose was to simulate the distribution of the area's commuters. From the actual patterns Taaffe et al. determined that although one primary factor (distance) was nonrandomly related "to place of employment decisions," the majority of influences upon these decisions were randomly distributed. Since the actual distribution contained "a strong random element," static versions of Hägerstrand's Monte Carlo simulation of diffusion were used which enabled the identification of purely random from purely nonrandom processes. Four models were presented with the probability field of Model I arranged according to the influences of population size and distance upon commuting, the primary factors. After this first simulation, progressive modifications were integrated for each successive run to incorporate additional probabilities if the existence of a nonrandom process was indicated from a preceding run. Under the design controls set up, patterns developed from nonrandom processes were easily distinguished from those developed by random processes. Such determinations not only benefit the understanding of local (Chicago) patterns of intraurban commutation, but also aid in the development of related general theories concerning urban systems.

Morrill (1962; 1965a; 1965b) employed similar probabilistic methods to Taaffe et al. in several articles in the 1960s. In his noted study of Negro migration and ghetto expansion in Seattle, he proposes a very simple Monte Carlo simulation model (Morrill, 1965a). He begins by identifying the expansion of the ghetto "as a spatial diffusion process in which Negro migrants gradually penetrate the surrounding white area." A number of relevant elements needed to construct a probabilistic model of "ghettoization" were selected by empirical observations, including:

> ...natural increase of the Negro population; Negro immigration into the ghetto; the nature of the resistance to Negro out-migration and its relation to distance; land values and housing characteristics; and the population size limits of destination blocks (Morrill, 1965a: 350).

A probability field was constructed incorporating these empirical factors into the simulation framework. The conventional generation of random numbers was then carried out to produce several simulations of ghetto expansion from 1940-1964. In discussing his results Morrill indicates that the simulated patterns obtained need not match the actual patterns of ghettoization precisely, since minor variations are acceptable in this type of modeling. He notes:

> Simulation is a valuable technique in science and technology, in which a model is constructed to depict artificially certain major features of some real process.

And Morrill continues:

> We do want the model to generate a pattern... that corresponds in its characteristics to the real pattern, and we can satisfy ourselves of the correspondence by visual and statistical tests. The purpose and hope are to discover and illustrate the nature of the process (Morrill, 1965a:349).

In addition to their application to problems of human spatial behavior such as innovation diffusion, migration and commuting, Monte Carlo simulation models have been used extensively in the study of urban growth and land development. Garrison (1962) is credited with introducing such models into the field of urban spatial research. Since then Chapin, Donnelly and Weiss (1965) have utilized simulation techniques to study residential development patterns and later Yuill (1970) devised a comprehensive spatial simulation model of urban growth. To investigate the expansion of Seattle's urban fringe, Morrill (1965b) again used a Monte Carlo simulation model very similar to the one used in his study of the city's Negro ghetto. This model is less detailed in design and more general in context, and is based upon Morrill's hypothesis:

> ...that in spatial detail, expansion of the urban fringe may be described as a spatial diffusion process in which development of new properties is essentially random in direction (land being equal) (Morrill, 1965b:186).

In establishing the probability of development for specific sites at the urban fringe, he notes:

> ...marginal land, distance from major arterials, schools, and shopping centers, as well as proximity to existing major developments, were found to be important...(Morrill, 1965b:187).

These factors were then built into his model and a simulation was rendered which estimated the spatial patterns of development for several time periods. Concluding with an evaluation of the "fit" between the simulated and the actual patterns, the author reasserts that the method itself "does not ask for exact replication," but attempts to generate growth patterns which are spatially similar to reality.

Malm, Olsson, and Warneryd (1966) introduced a more intricate model of urban growth based upon a complex series of mathematical derivations concerning the function of distance in spatial theory. This model also utilizes traditional Monte Carlo methods to simulate urban sprawl through time. The probability matrix was formulated primarily from the inversion of an actual cost grid for the construction of new residential units in a part of Göthenburg, Sweden. Following the design of Morrill's (1965a) migration model, a resistance factor was introduced to incorporate the effects of ground conditions at potential development sites into the simulation. Urbanization was then estimated by standard procedure, that is, the matching of generated random numbers to the appropriate ranges found within the cells of the matrix. The resistance values, which range from one to three, were used to indicate the number of "hits" required to develop a cell. For example, cells delimiting sites where bedrock predominated the surface were assigned a resistance value of two, since construction would be more difficult here than at sites characterized by sand and gravel which received a value of one. And sites having clay at the surface were assigned the highest resistance value, three. The resultant simulated patterns of the city's growth from 1920-1940 are in "fair agreement" with the respective empirical patterns. Hence the model's ability to "sketch" the general features of real-world processes is demonstrated satisfactorily. In conclusion the authors evaluate its overall acceptability for studying the geographic problem of urban sprawl.

From the above review Monte Carlo simulation is considered an effective research method useful in the analysis of various spatial and temporal problems, particularly, development and land use change inside urban areas. The technique itself can be used both to identify the causative factors underlying spatial trends and to simulate, in a predictive manner, future situations resulting from those trends. These capabilities suggest its applicability to further investigate suburbanization processes and patterns in Suffolk County.

Suburbanization: A Model and Simulations

Since the end of World War Two, Suffolk County has experienced rapid and extensive suburban growth. Figure 18, compiled from USGS topographical maps, shows the extent of the county's built-up lands for 1949 and 1969. From the map gross development patterns are identifiable, as are several factors which have apparently influenced the evolution of the county's suburban landscape.

First, distance from New York City has evidently been a primary factor in this evolution. The largest portion of the county's total development took place within the Inner Zone while the Outer Zone experienced very little growth during the same twenty year period. As discussed in the preceding chapter, however, current intracounty development patterns indicate a reversal of earlier trends.

A second apparently important factor is adjacency to existing development. The expansion or sprawl of built-up places into surrounding lands accounted for a large part of subsequent development with only several instances of isolated spontaneous development occurring throughout the county. In effect localized sprawl has filled-in much of the interstitial land left vacant by "leap-frog" development, a common situation in urban fringe areas (Hart, 1976:1).

In addition to these primary factors suburbanization has also been affected by the interplay of various socio-economic, political, and environmental parameters. Land use zoning, for example, exerts direct and immediate controls upon forthcoming development.

> Land use patterns are partially created or shaped by legislative action. In other words, the zoning codes enacted by municipalities are contributory to the resultant development. One action usually complements the other (NSRPB, 1966:27).

A political mechanism shaping local suburban growth is illustrated by Suffolk County's Farmland Acquisition Program. By enabling the County to purchase the development rights to agricultural lands from their private owners, the program is an attempt to prevent the sporadic development of those lands in eastern Suffolk County. Its success would preserve presently idle agricultural lands in their natural state, and allow the implementation of a controlled development process to ensure more efficient land use for both the present and future. In essence, both zoning and land development programs reflect legislative schemes that are inherently short-term in design, channelling growth in response to prevailing public desires and concerns. Such policies, however, are oftentimes devised in direct response to environmental situations, rendering land use designations that are permanent. For instance, local topographic conditions can limit or restrict certain landscapes from specific uses as illustrated by the undeveloped sections of western Suffolk County which, for the most part, identify the hilliest areas (Figure 18).

Suburbanization in Suffolk County is influenced predominantly by:

1) distance from New York City;
2) adjacency to existing development;
3) land use policies; and
4) topography.

The first two factors (distance and adjacency) represent universally applicable parameters while the last two represent purely local parameters, applicable only within the study area itself. Since one objective of this study is toward the formulation of a general theory of suburban growth that is not overly hindered by local constraints, the latter factors of land use policies and topography are omitted from further consideration. The following comparative analyses of actual and simulated patterns of recent development examine only the importance of distance and adjacency upon suburbanization.

To begin the simulation a grid is placed arbitrarily over the entire county, with each internal cell delimiting a development site of approximately 1 square mile (2.6 square kilometers). Excluded from this grid are the south-shore barrier islands, Gardiners, Shelter, and Fishers

Islands, and the extreme eastern tip of East Hampton Township; these areas have little if any developable land. By generalizing the built-up areas existent in both 1949 and 1969 to conform to this grid several important factors concerning suburban development become apparent (Figure 19).

Since 1950, development has consumed almost all of the available land within the county's Inner Zone. In fact, without certain limitations of the physical environment and land use restrictions, this zone would be totally developed because of its proximity to New York City and urbanized Nassau County. Extensive suburbanization, as mentioned above, has taken place only in the western end of the Outer Zone, specifically in western Brookhaven Township. The major portion of this zone remains undeveloped, suggesting that it will be forced to accommodate any future county growth. The ubiquity of built-up lands throughout the Inner Zone, correlated with the localized and limited development found within the Outer Zone, indicates that suburbanization has been a highly nonrandom process. When compared to these actual patterns, simulated patterns of development generated exclusively from random methods will identify the extent of nonrandomness in the empirical process.

First, to simulate random development, each cell within the previously constructed grid that contains over one-half square mile of land is numbered. Cells identifying

FIGURE 18. SUFFOLK COUNTY: ACTUAL DEVELOPMENT, 1949 and 1969

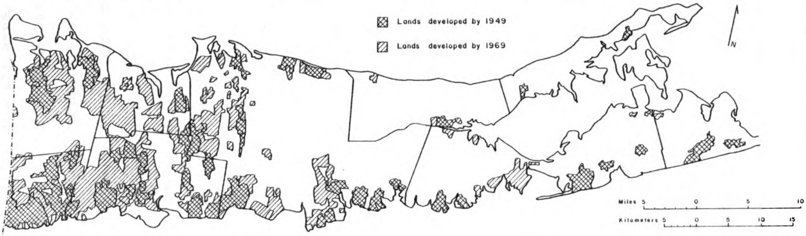
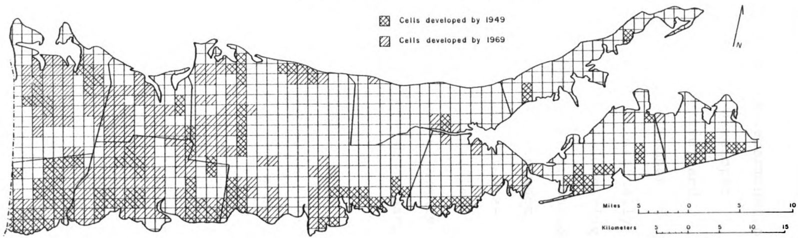


FIGURE 19. SUFFOLK COUNTY: ACTUAL DEVELOPMENT, 1949 and 1969
GENERALIZED to SIMULATION GRID



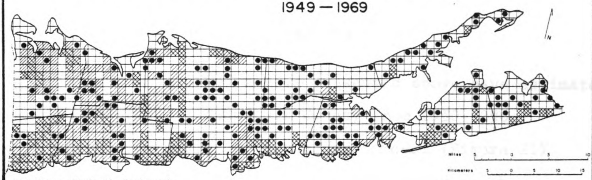
built-up land in 1949 are omitted, since the attempt here is to simulate development from 1949-1969. A determination is then made of the number of cells actually developed throughout the county over the twenty year period, and random numbers are drawn until the appropriate number of cells (200) is developed. The method itself is basically that used in simple random sampling procedures. Comparing the random development situation to the empirical situation illustrates the high degree of dependence upon nonrandom factors in the actual process (Figure 20). It is therefore necessary to incorporate the previously identified, nonrandomly distributed factors of distance and adjacency into a second simulation model, and thus gauge their spatial significance.

This second model is constructed by the same Monte Carlo techniques used in the first, but two manipulations of the numbered matrix are entered. To account for a development site's distance from New York City, the study area is divided from west to east into three sections of equal length, approximately 25 miles (40 kilometers). The western section (Sector I) being nearest to New York City (and adjacent to Nassau County), has the highest probability for development. Consequently, each cell within this sector is assigned a range of four consecutive random numbers to increase its chance of development as random numbers are drawn. Cells located in the middle section (Sector II) are assigned a slightly narrower range of three consecutive numbers, while cells located in the remaining section (Sector III) receive only single number designations. In effect, development becomes less likely with increasing distance from New York City, as suggested by the actual patterns illustrated in Figure 19. Accounting for adjacency to existing development is accomplished by assigning simple resistance values to each cell throughout the entire county according to relative location. An undeveloped cell adjacent either vertically, horizontally, or diagonally, to one that was developed in 1949, required only one hit by a drawn random number to develop. Nonadjacent cells required two hits before they were developed. The resulting simulation of growth is shown in Figure 21, illustrating a probable development pattern constructed from random processes, and controlled by the influences of distance and adjacency. Although it is far from a replication of the empirical situation found in 1969, the simulation does suggest a significant degree of overall correspondence between the model and reality. Only in a few scattered areas was development simulated where it did not actually occur, primarily in the eastern parts of Sector II. However, this discrepancy is explained by the arbitrary division of the study area into three sections. Smaller divisions would produce more spatially similar patterns. In Sector III development was neither over nor under estimated in terms of total area consumed. As a result of the omission of topographic and land use restrictions, simulated development does appear in many of the presently undeveloped parts of Sector I. Since the amounts of estimated development are generally equivalent to the actual amounts within each sector, the model erred only in locational aspects of growth, but succeeded in identifying the significant spatial characteristics. Therefore, this model seems applicable for a third simulation that can be used to investigate future growth trends in Suffolk County's Outer Zone, an area of high development potential.

This quasi-predictive simulation also examines only the effects of distance and adjacency upon suburbanization, and assumes that the total amount of land developed in the Outer Zone through 1990 will be approximately equal to the amount developed throughout the entire county from 1949-1969. The assumption is based upon the relatively large tracts of vacant, developable land distributed throughout the zone and the well developed transportation network that allows easy access to all major centers. From this operational assumption, it is also possible to estimate growth patterns for two ten year periods: 1970-1980 and 1980-1990.

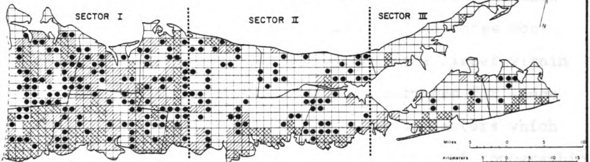
Following previous designs, the grid covering this zone is divided into three sections whose extents are determined by the intersections of the Brookhaven, Riverhead, and Southold Township boundary lines with the northern shoreline. Ranges of four and three consecutive numbers are assigned to the cells located in the western and middle (Sectors Ioz and IIoz) respectively. Since extensive development is assumed for the entire zone, the cells in the eastern section (Sector IIIoz) are assigned a range of two consecutive numbers, reducing the overall variation of development probabilities between all three sections. Resistance values are entered by the same method as before to incorporate the effects of adjacency to existing development into the model. Random numbers are then drawn and the resulting qualitative estimate of the probable distribution of developed lands across Suffolk County's Outer Zone is given in Figure 22. As the model is based solely upon previous growth trends, it remains purely speculative in nature. Thus, the patterns rendered in Figure 22 are estimations at best, since in reality future suburbanization will be dependent upon a number of factors not considered here, such as regional economics, political actions, and demographic trends. The model does, however, suggest the continued importance of two of the most locally significant influences upon suburbanization, namely distance from New York City and adjacency to existing development. By sketching these future patterns according to prescribed probabilistic methods, the model is a valuable tool that can be effectively used for the planning

FIGURE 20. SUFFOLK COUNTY: RANDOM SIMULATION OF DEVELOPMENT, 1949—1969



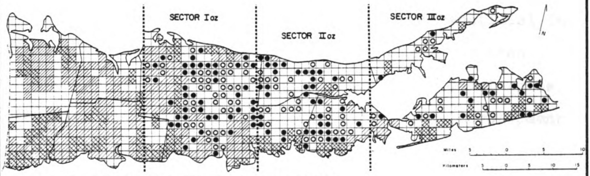
● Indicates simulated development.

FIGURE 21. SUFFOLK COUNTY: CONTROLLED SIMULATION OF DEVELOPMENT, 1949—1969



● Indicates simulated development.

FIGURE 22. OUTER ZONE: SIMULATION OF DEVELOPMENT, 1970—1990



● Indicates simulated development 1970 – 1980 ○ 1980–1990 of Suffolk County's impending suburban landscape.

Model Evaluations

The two simulation models presented above have estimated development trends in Suffolk County from 1950-1990. Although the performance of the first model (Figure 21) indicates a high degree of spatial similarity to the empirical situation, several additional considerations are suggested. By far the greatest error was found in the locational abilities of the first model; accurate amounts of development were simulated for each of the three constructed sectors, but not in the appropriate places within them. This error, however, is easily accounted for since the model examined only two of the numerous factors which influence suburban growth. The incorporation of topographic, political, and socioeconomic parameters into the model would most likely improve overall efficiency. Manipulations of the actual sizes of both the individual probability cells and the resistance sections could also prove beneficial in future investigations. These modifications would then provide the basis for a predictive simulation model to be formulated with the ability to forecast future development patterns in a highly reliable manner.

CHAPTER V

SUMMARY AND RECOMMENDATIONS

To summarize, this study has identified urbanization as the central theme of the population dynamics evidenced throughout the world today. Urbanization in the United States, however, is a multidimensional process that goes beyond the simple shifting of the nation's urban-rural population components. During the last quarter-century, for instance, suburban regions have been growing far more rapidly than their urban counterparts. Since the Bureau of the Census estimates that in 1975 about 39 percent of the population resided in the suburbs, a definite need has arisen for more geographically oriented research on this newly emergent "outer city".

In response to this need, the population patterns of the New York Metropolitan Region (NYMR)--the nucleus of Gottmann's Megalopolis -- were first examined for the three decades between 1940-1970, revealing that population change within the member counties depended upon three major factors: distance from the New York City CBD; population density; and existing level of development. For example, population growth rates through time were systematically lower in the more urbanized counties and relatively higher in the less built-up, suburban counties. These regional patterns clearly reflect the contemporary trend towards the deconcentration and decentralization of people and activities from city to suburb, or more specifically "the urbanization of the suburbs" (Muller 1976:1). The gross regional patterns analyzed within this first objective, suggested local variations in suburbanization processes that warranted a more detailed investigation of one of the NYMR's low-density, outer suburban counties.

Nassau and Suffolk Counties are located on Long Island; as of 1972 they became the nation's first all suburban Standard Metropolitan Statistical Area with a combined population of 2.5 million people. The island itself is politically divided into four counties: the western two (Kings and Queens) are boroughs of New York City, while to the east, Nassau and Suffolk are independent counties of New York State. The island is often viewed as a linear projection of land extending eastward from urbanized New York City to semi-rural Suffolk County. This situation of different conditions of development existing at opposite ends of the island has been an important theme investigated throughout this study. Population densities, for example, decrease from fifty thousand persons per square mile at the western end to less than five hundred persons per square mile at the eastern end.

The total amount of built-up lands also follows a similar decreasing pattern from west to east. Since recent suburban development has consumed almost all of Nassau County's developable lands but only those in the western half of Suffolk County, the Nassau-Suffolk SMSA provides a prime area for the study of the process of suburbanization. With suburban growth expected to continue in this region throughout the remainder of this century, and Suffolk County accommodating more than 90 percent of that growth, this county was selected as the study area to provide an "in situ" laboratory of both past and present development trends. The relatively large tracts of undeveloped land located in the county's Outer Zone also suggested a qualitative investigation into probable future patterns of development for this area of high growth potential.

Simple renditions of Monte Carlo simulation models were presented which helped to identify two of the most locally significant factors affecting suburbanization, namely: distance from New York City and adjacency to existing development. These probabilistic models were constructed and demonstrated to be effective in the estimation of existing development patterns throughout Suffolk County, as well as future patterns in the undeveloped townships of the Outer Zone.

As suburbanization has been shown to be diffusing eastward across Suffolk County, several critical problems come into view which most certainly demand additional research and investigation. First, although the county's Farmland Acquisition Program is an ambitious attempt to stem the tide of advancing suburban sprawl, it does little to encourage the economic vitality of those farmers who presently farm some of the most valuable land in New York State and the New York City area. The loss of such lands, predominantly fruit and truck crop oriented, would no doubt have negative affects upon local and regional seasonal crop availabilities. Second, Long Island is basically an environmentally sensitive area that has recently been exhibiting signs of ecological devastation. In some parts of Nassau and Suffolk County, for example, intensive post World War Two urbanization and industrialization have severely contaminated local groundwater reserves, thus endangering the island's sole fresh water resource (Galant, 1977:28). Continued growth, characterized by more concrete, more asphalt, and less open space, would definitely intensify these problems. Finally, the most pressing problem now threatening suburbia in general reflects the simple dilemma of the diminishing urban tax base in today's complex metropolitan region. It has been indicated that although suburban counties have prospered tremendously over the past three decades by developing their local job bases,

> ...those bases are built upon city-earned incomes and their growth really is the growth of the city's economy beyond its political boundaries (Stern, 1976:E7).

Therefore, as suburban Suffolk County continues to grow, it is inadvertently drawing vital resources away from New York City and weakening the economic structure of the entire urban region.

More geographic research into the environmental and socioeconomic problems which result from contemporary suburbanization is needed. It is hoped that this study has suggested some possible directions and methodologies toward that frontier.

APPENDIX

APPENDIX

LILCO's Population Survey

The following is taken from the Long Island Lighting Company's 1977 Population Survey and explains their methods of estimation.

> Essentially, LILCO's annual estimate of present population is determined from census figures and active residential electric meters. For each community a factor, people per meter, established at the time of the most recent census, is multiplied by the recorded number of meters added or subtracted each year to yield the annual population change in each community. The estimates are also weighted by type of dwelling unit to compensate for the increasing trend to apartments, condominiums and senior citizen housing, which have fewer occupants per dwelling unit. In addition, establishments that have group accommodations are contacted to insure a correct count of this segment of the

> population. For example, contacted were the state hospitals in Suffolk County where the present population of 10,295 represents a decrease of 12,413 persons since the 1970 census.

An illustration of the accuracy of this method is obtained by comparing the findings of the U. S. Bureau of the Census special census on Brookhaven Township to the LILCO estimate for 1975. The census reported 320,677 in April, 1975; LILCO estimated a January 1 population of 321,150.

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