URBAN MORPHOLOGICAL THEORY AND SPATIAL DIFFERENTIATION IN A CARIBBEAN CITY: RESIDENTIAL LAND USE FROM 1948 TO 1975 IN SANTO DOMINGO, THE DOMINICAN REPUBLIC

BY

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TABLE OF CONTENTS

Abstract of Dissertation Presented to the Graduate Council
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Land use change, specifically the spatial patterning of residential land use change, in the capital city of the Dominican Republic was examined over a 27-year period when both the nation and city underwent many important changes, including urbanization. The principal objective of this study is to assess the usefulness of urban morphological theory to explain the growth of Santo Domingo. Associated objectives include the identification of trends in the urban change and alternatives for development over the remaining decades of the century.

The research methodology employed three data bases. Both 1948 and 1974 aerial photographic coverage of the city provided information for a five-category land use classification system, and the results of the interpretation were mapped in units of one hectare. Final maps are scaled at 1:80,000. The third data base was a 10-percent sample of all streets in which land uses were determined in a block-by-block canvass that included sampling for 40 variables measuring lot and structure conditions.

The data bases were merged by the location of each hectare of urban land included in the city. Zone and sector models were tested to assess whether they were useful in explaining the spatial differentiation over the study period. The 45 variables describing urban land use in both 1948 and 1975 were factor analyzed to discriminate among low-, medium-, and high-income residential land uses.

The city, entering the early stage of industrialization accompanied by extensive urbanization, exhibits a sectoral pattern of land use change. The single example of a zone was found for high-income residential land that had aggregated at what had been the urban fringe about 1948, before the inception of the present phase of modernization. A general absence of filtering, little suburbanization, and extensive marginal housing at the city's edge are evidence that this Caribbean capital departs from the morphological patterns identified for Anglo-American cities of comparable size and importance.

CHAPTER ONE
INTRODUCTION

Purpose of Study

Contemporary urban theory explaining the areal differentiation of the city can be organized according to social systems, group decisions, and habitat. First, there is the theory which relates to the system of social organization at the local community level and involves the social structure and associated institutions that constitute the urban environment. Second, there is the theory of behavior of city dwellers expressed in attitudes and ideas and manifested in decisions affecting urban development. Third, there is the urban habitat in its more inclusive sense of people, technology, resources, and interrelationships. The latter is the concern of human ecologists and urban geographers. These geographers as well as urban ecologists are specialists in the physical expressions of social systems, group decisions, and habitat that are termed urban morphology. This study is concerned with the formal, or structural, city that is included in residential land use and which is assumed to be representative of the ecological relationships among urban systems.

Accumulating urban morphological theory is based upon wide-ranging conditions encompassing urban experiences in different cultures. However, a majority of published research reflects a Western, developed society orientation, and there is the possibility that the theoretical constructs may not apply to developing economies which are not yet as fully modernized nor capitalistic.

Research into the urban milieu of other regions could be useful for testing the validity and reliability of urban theory drawn from Anglo-American and Western European cities. Urban morphological study of Caribbean cities, modest by comparison with that accomplished elsewhere in the Western Hemisphere, is insufficient to conclude that the hypotheses advanced for urban change are applicable to such rapidly modernizing cities as Kingston, Havana, or Santo Domingo.

If modernization in these Caribbean cities departs from the process identified in the United States, then these capitals may evolve spatial configurations distinct from Anglo-American cities. The implications for urban growth planning are important, especially for those officials who are concerned with efficient utilization of scarce resources. Research of Caribbean urban geography has the potential of contributing additional, valuable information expanding our knowledge of the processes of urban change. Dwyer (1975, 248) has said,

> What is needed is more extensive investigation into the Third World city in such disciplines as geography, sociology, social anthropology and psychology in order to evaluate further the economic, social, cultural and other forces at work in shaping patterns of urban development. . . . Existing knowledge of the urbanization process . . . in the nature of housing problems in particular is all too often either ignored or badly applied.

Santo Domingo, capital city of the Dominican Republic, is a rapidly urbanizing city that is undergoing modernization. Because of its importance both as a regional and national center, Santo Domingo has required a proportionally larger share of the nation's resources than other Dominican cities. Because of its more rapid population growth, the capital will require an even larger share in the immediate future.

This study is directed specifically at identifying base-line conditions in Santo Domingo of land use and housing which must be evaluated in formulating a comprehensive housing program. "Housing clearly reflects the economic and demographic structure of a society—its level of development, the distribution of its income, the rate of population growth, and the pace of expansion" (Gilbert and Ward 1978, 285). This study of residential land use change will identify conditions in intra-urban form under the tacit assumption that housing is indicative of socioeconomic classes and that there is a reasonably clear relationship between social structure and housing.

There is a need for systematic investigation of housing grouped to explain urban structure and social area differentiation (Herbert 1973, 124-127). Recent quantitative studies generally have ignored residential structure and land use in modernizing societies.

This study of Santo Domingo is an effort to uncover cross-cultural urban ecological conditions explained by general theory of urban change including three models of land use change. These models include concentric zones, sectors, and multiple nuclei. Santo Domingo was selected as representative of the urban environment in a Caribbean setting. It is undergoing modernization in a region experiencing much change that may be best understood within the context of urban theory.

The complexity of urban conditions restricts the scope of any analysis of the mechanisms and the social organization which accompany change. But land use study is a necessary step in developing a comprehensive understanding of conditions in the city. Residential land use, specifically housing in its physical and social connotations, represents the largest area of the city, the majority of all structures, and the greatest portion of the metropolitan population, and involves a great many of the daily activities of city dwellers.

This research is focused on land use change in Santo Domingo over the 1948-1975 period. Included in the land uses were three residential categories representative of socioeconomic status; another category of other land use that was an aggregation of public, commercial, and industrial uses; and a fifth use of open, undeveloped land. The research involved the analysis of several data bases in order to address a number of timely, important questions.

Research Objectives

There were four major goals of the study. Each included a number of specific questions relating to land use and housing within the context of urban ecological conditions. These four objectives are

1. To determine the extent of modernization Santo Domingo sustained over more than one-quarter century. Specific objectives included (a) determining whether modernization had transformed the traditional morphology of the city; (c) determining whether land uses were becoming more homogeneous; (d) determining whether growth of residential land use was concentrating, and, if so, whether this occurred along the transportation corridors; (e) determining whether there was evidence that density of land use was increasing and that a gradient of land use existed; (f) determining whether there was an evolutionary sequence to growth which included evidence of decentralization.

2. To determine which of the ecological models of urban change was (were) best in explaining land use patterns. Specific objectives included (a) determining the direction of change; (b) determining whether there was evidence of a housing cycle that incorporated filtering, the shift in the use of housing from higher to lower socioeconomic levels of the occupants.

3. To identify housing according to socioeconomic level. Specific objectives included (a) determining whether the field survey of housing could predict land use as identified from aerial photography; (b) ascertaining whether housing aggregated by ecological divisions in land use change models.

4. To isolate those aspects of the urban condition in Santo Domingo which would assist in planning for the future of the city. Specific objectives included (a) determining the likely trends in the immediate growth of the city; (b) identifying desirable alternatives to expected urban change; (c) recommending possible means for achieving desired alternatives to growth patterns identified for the city's continued expansion.

The Study Plan

There were three data bases incorporated into the study of land use and housing in Santo Domingo. Aerial photographic coverage, accumulating since 1916, was examined at the Geographic Institute of the Autonomous Univeristy of Santo Domingo, and two flights were selected which were representative of the city's condition, one prior to the latest transformation from a traditional to modern capital. The 1974 coverage was the most recent available and provided up-to-date information about the extent of modernization.

The photographs were interpreted during 1979-1980 at the Cartographic Laboratory of the University of Florida's Center for Latin American Studies. The 1974 photography was interpreted first, and land use was grouped into three residential categories according to socioeconomic indicators of low-, medium-, and high-income housing. The land use information was transferred to a land use map scaled at 1:12,500. A grid of one-hectare cells was overlaid on the land use map in order to aggregate the predominant use into hectare-sized blocks that would be comparable with the 1948 conditions as well as the field survey results. Thus, the largest proportion of any land use determined the classification for the hectare cell. The coordinates of longitude and latitude for each cell were used to store the land use information for the later analysis that was to include both comparison with 1948 aerial photography and the 1975 field sample of city streets.

The photography for 1948 was interpreted in like manner. A land use map, scaled at 1:12,500 was produced, and the information, aggregated into hectare-sized cells, was stored according to the geographic location in the same grid system as used for the 1974 base year.

In 1975, a survey of approximately 10 percent of the nearly 1,400 streets was conducted in order to collect information about housing in Santo Domingo. The entire length of each randomly selected street was traversed. Field information concerning 40 variables relating to socioeconomic level of residents, the building materials used in construction, general state of repair of structures, number of floors, and extent of infrastructural services was collected, as well as data about other land uses and nonresidential structures also found along the street. Over 9,100 structures were included in the sample. They were located as sites on a map of the city which included the same hectare-sized system of cells used for location of the remotely sensed data. One-half of the sites found in each sample hectare were randomly selected and stored for analysis.

From the aerial photographs, five land use maps for each of the two years were completed which displayed the individual land use categories and which became the bases for comparative analysis. The merge of the computer-stored data produced land use change information aggregated by hectare cells which were mapped to display the 1974 land uses of all 1948 hectares which had changed use during the intervening years.

In order to test the applicability of the zone and sector models as explanations of the land use change patterns, the models' geometric configurations were superimposed upon the 1974 and 1948 land use maps. Each hectare cell of land was given a value for its location in both a zone and sector. Variations from the expected frequencies of land use in each zone and sector were tested for significant differences.

The field survey of structures included 747 hectares of the city's area in 1974-1975. Only 44 percent of the survey area was found to be exclusively residential. Of 520 hectares found to contain some proportion of residential structures in both the survey and 1974 aerial photography, 333 were entirely developed in housing. It was necessary to arrive at some criterion for designating the remaining hectares as either residential or nonresidential in order to relate the housing information to land use and land use change over the 27-year period. All proportions of residential to nonresidential structures per hectare were considered in relation to the loss of information that would occur under various land use mixes. The 50-percent criterion was chosen after careful analysis.

Once the minimum proportion of residential structures allowable in any hectare cell designated residential was arrived at, the survey data were merged with the remotely sensed data bases by cells of residential land use in order to estimate housing conditions throughout the city during the 1974-1975 period. The field variables relating to housing and neighborhood conditions were augmented with others which included the land use change model configurations and the distance of each hectare to the city center. To reduce the housing information to a few indicators of socioeconomic levels of residential land use, the data were factor analyzed. Four factors were produced, three of which discriminated among the field variables relating to socioeconomic levels.

CHAPTER TWO
THE STUDY AREA

The Dominican Republic

The Dominican Republic is the larger of the two nations sharing the island of Hispañola in the Caribbean archipelago. Its long Spanish heritage began with the founding of the first permanent European settlement in the New World at what is now the capital city of Santo Domingo. Culture and language continue to bind Dominicans to their Latin American cousins and the Spanish mother country. But four hundred years of insularity, demographic and economic stagnation resulting from Spanish colonial indifference, and numerous foreign incursions have contributed to the evolution of a provincial, traditional island society which shares a Caribbean culture based on similar history, ethnicity, politics, and economy. Ruled by a small elite of ranching families who were neither wealthy nor a landed aristocracy so typical in Latin America, the republic was two centuries later than the rest of the Spanish-speaking New World in experiencing the concentration of riches and power in a Dominican aristocracy (Bell 1981, 111-116).

The Dominican oligarchy is comprised of a few families of colonial Spanish heritage and a small number of wealthy Dominican families who became successful under the long Trujillo era from 1930 to 1961 and managed to retain their influence and continue to share power. In 1960, Bosch (1978, 266) described this class as including politicians, bankers, industrialists, wholesalers, doctors, lawyers, merchants, landowners, military officers, prelates, and intellectuals.

The Dominican Republic can be described as a social democracy committed to private ownership of property and free enterprise. Although the government has been antisocialistic, the extensive holdings of the Trujillo family that were expropriated after the dictator's assassination in 1961 remain to a large extent in the public sector.

The island nation's economy is primarily agricultural. A warm, moist climate influenced by the Trade Winds coupled with a relatively large expanse of arable land, especially the rich Cibao Valley of the Yaque del Norte River, have sustained the traditional cash cropping of sugarcane, coffee, and tobacco, while substantial harvests of food crops including rice, beans, peas, and fruits are grown on the many small holdings found throughout the nation. Even the industrialization is tied to the agricultural base, for sugar growing and processing employ about 54 percent of all industrial labor (República Dominicana 1977, 4).

Relatively rich in natural resources in comparison with the other Caribbean nations, the Dominican Republic has a large labor supply as well, but does not enjoy sufficient capital to pursue a massive national development program simultaneously incorporating improvements in all sectors of the economy. Between 1966 and 1972, total national expenditures averaged RD$ 249.01 million with social and economic portions about equal in the national budget (Table 2-1).

General economic conditions include the need to increase agricultural production and the food-processing industries that help feed a rapidly increasing population. But such economic expansion is impeded

Table 2-1: Dominican National Budgets, 1966-1972, in RD$ Millions

	1966	1967	1968	1969	1970	1971	1972
Social Services							
Education	58.2	60.6	65.7	73.0	87.3	98.5	110.2
Health	28.8	28.8	30.4	36.3	41.9	43.9	46.4
Housing	0.7	5.0	4.4	5.0	9.1	13.2	13.1
Labor	0.6	0.5	0.5	0.6	0.6	0.6	0.6
Community Development	3.4	0.8	1.1	0.8	2.1	2.5	2.5
Water and Sewers	4.0	3.9	5.3	4.7	4.6	6.0	14.2
Economic Services							
Agriculture	13.5	14.0	18.0	17.1	15.2	15.4	17.5
Irrigation	5.7	4.8	3.5	10.4	12.4	14.4	12.3
Industry and Mining	1.8	3.9	1.3	1.0	3.1	3.5	2.6
Transportation and Communications	24.7	27.9	30.5	34.2	42.0	58.4	49.1
Energy	—	—	0.4	1.9	2.7	6.8	4.6
Urbanization	2.3	4.0	3.6	5.3	5.7	8.2	30.7
Other	—	2.1	2.4	0.3	0.5	1.3	1.0
General Services							
Internal Security	17.1	17.2	17.6	17.6	17.0	17.7	18.6
Defense	32.8	28.3	28.7	29.8	30.8	31.2	32.5
General Administration	19.2	15.4	18.4	20.4	23.2	24.1	29.4
Transfers to Municipalities	15.2	13.3	11.0	11.0	9.7	9.3	9.1
Debt	7.3	6.5	6.5	10.7	11.8	12.3	12.9
Other	0.1	0.1	—	2.6	3.4	3.9	3.8
Total Expenditures	198.0	198.1	207.6	235.3	264.8	305.0	334.3

Source: República Dominicana. Secretariado Técnico del Presupuesto. Presupuestos de Ingresos y Gastos. Santo Domingo: Oficina Nacional de Estadística. For each year cited above.

by the loss of capital from the profits expatriated by extranational corporations. There is the loss of valuable foreign exchange expended to purchase foodstuffs that might have been grown at home had more land and capital been invested in food staples rather than cash crops. The high prices that are charged for the fuel that the republic must import deprive the economy of badly needed revenue.

Probably about one-half of all Dominicans now reside in cities. Although the provincial capitals draw many rural poor, still the largest numbers of migrants are found in Santiago and Santo Domingo (Figure 2-1). It can be estimated that 20 percent of all Dominicans live in the capital.

Santo Domingo City

Founded about 1502 along the Caribbean coast at the mouth of the Ozama River, Santo Domingo was established as the colonial communication link and base for Spain to explore the New World. The island is in the hurricane track; the town was moved from its original site on the east bank of the river to the present position after a hurricane destroyed it shortly after its founding. Even as recent as 1930, Santo Domingo was destroyed by another tropical storm.

The entire city (Figure 2-2) is in relatively homogeneous terrain. The immediate geologic structure is porous, well-drained, soft calcareous and very hard, coraliferous limestone rocks arranged in relatively flat terraces which parallel the sharply sculpted coastline. Kilometer-wide, nearly level ledges rise to about 70 meters elevation in the west, about 40 meters in the east.

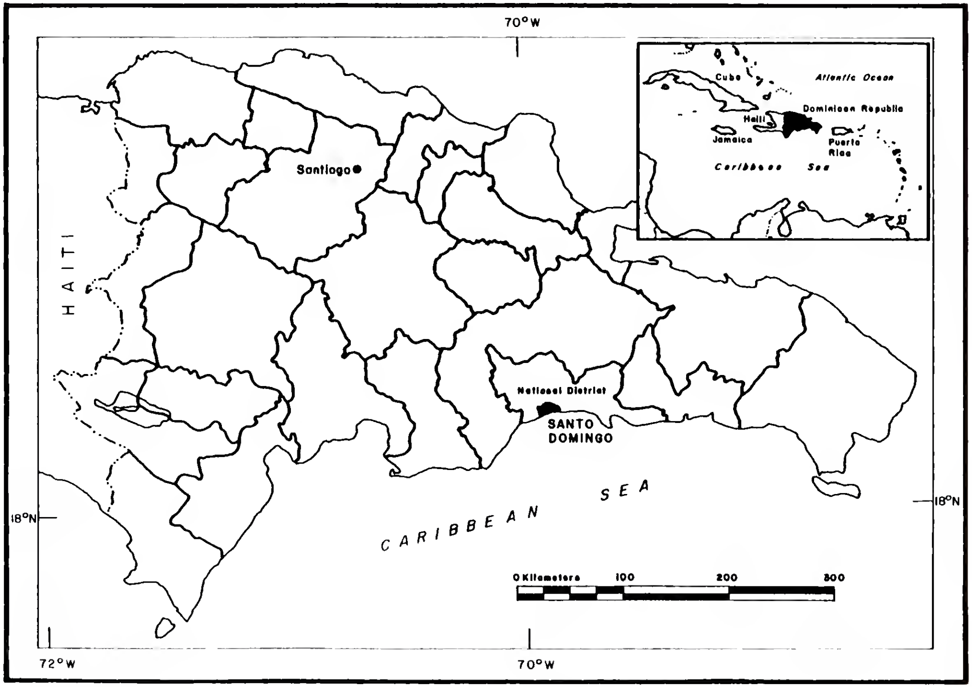

Figure 2-1: Provincial Boundaries and the Two Regional Capitals of the Dominican Republic

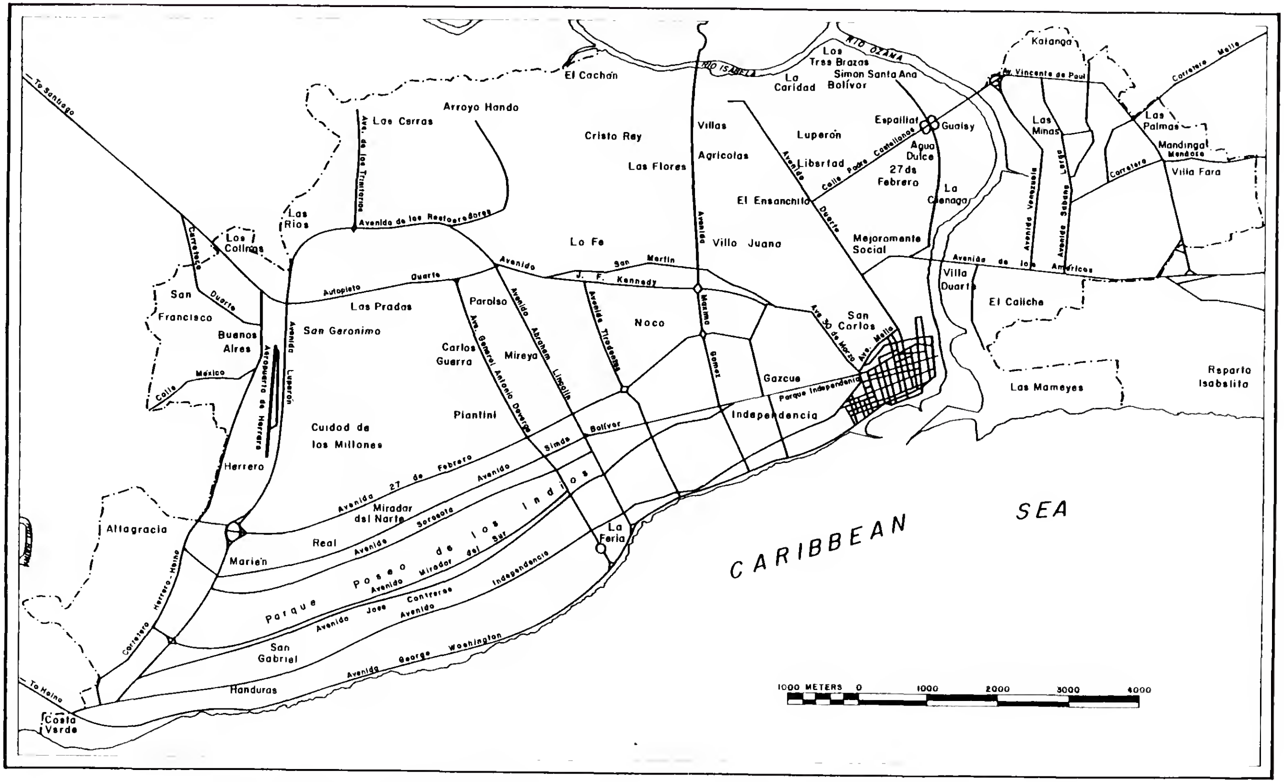

Figure 2-2: Major Transportation Routes in Santo Domingo in 1975

The Ozama River joins with the Isabela River at the northeast limit of the city. These rivers drain a broad watershed which incorporates an agricultural interior largely cultivated in sugarcane. They have cut deep channels in the hard limestone substrata. Three bridges in the city crossed these in 1975, one spanning the Isabela River, and the other two connecting the eastern part of the city to the main commercial, industrial, recreational, cultural, and residential city. There are a few narrow marshlands along the floodplain which disappears in places along the Ozama as it flows through the city to the Caribbean.

The western part of Santo Domingo is built upon a flat peninsula between these two rivers and the Haina River. In the northwest, the land is dissected by steeply sloping stream beds that have created a relatively hilly terrain. Until recently, land here had been sparsely settled. High ground has made the cost of providing water mains and sewers prohibitively expensive, and local water shortages impede development.

To the east across the Ozama, the land tends to be flat with shallow, poor soil and extensive rocky outcroppings that contribute to an arid, desolate landscape of small trees, shrubs, and grasses. Actually, most land within the present confines of the city is of poor quality except for a few areas in both the northeast and northwest where rural settlements used to exist.

The city's presently developed area is extensive in comparison with its size prior to World War II. The historic center, as shown in Figure 2-3, with its colonial structures several floors high and ruined fortifications, comprises an area of slightly more than one square

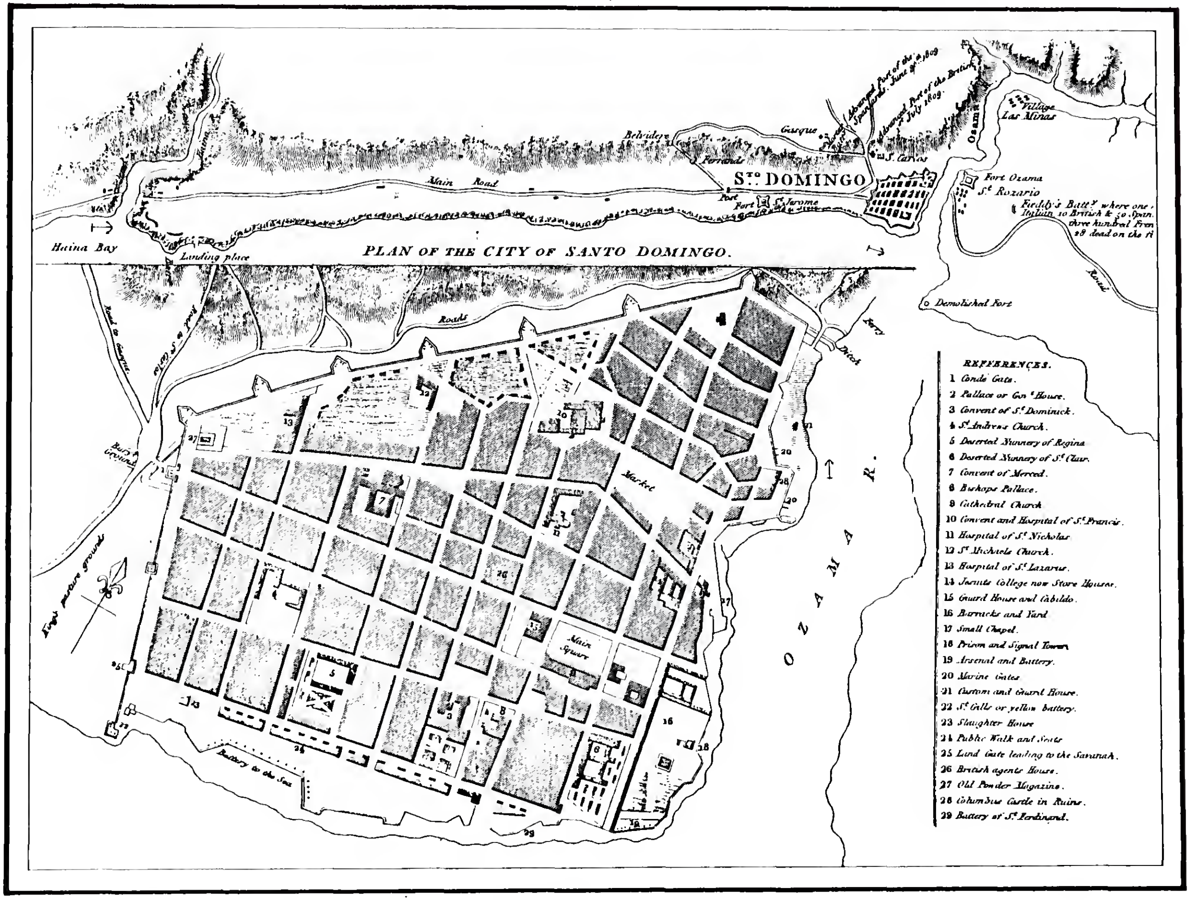

Figure 2-3: Colonial Santo Domingo (Walton 1810)

kilometer. Included in this nearly five-hundred-year-old city are the restored castle of Diego Colón, the oldest cathedral and hospital, the Plaza Colón, city hall, main post office, and other important structures. According to the first national census in 1908, the colonial center contained 45 streets and had 2,862 houses. The focus of the city was the Plaza Colón which is linked to the ruin of the city wall at the main gate, Puenta del Conde, by an avenue of the same name. Unlike many colonial cities elsewhere that were defensive in function, Santo Domingo still has some of its original fortifications. Since the wall foundations remain in place, circumferential streets with radial connections to the main plaza are not in evidence around the city center. On the east, the fortifications terminate at the steep bank of the Ozama where the port wharves have been built. Across the river on hills to the northeast was the small village of Pajarito and a few homes scattered along the bank (Hazard 1873, 219-223).

President Trujillo took office the same year a hurricane in 1930 demolished the capital and claimed thousands of lives. There were 10,000 families without homes. During the next five years, the government and private enterprise rebuilt over 6,000 homes, but one-third of the storm's victims were without permanent housing (Bonnelly 1960, 40). By 1950, an additional 23,000 housing units had been constructed, bringing the total stock of housing to 41,161. The deficit in housing was estimated to be about 1,000 units (República Dominicana 1960, 40).

Other major developments in the city included the port development project begun in 1935. The Ozama entrance was deepened, a breakwater was constructed at the western side of the river mouth to protect the inner harbor, and over one and one-half kilometers of wharves and 56,000 square meters of warehouse space needed.

By the beginning of World War II, the city had increased in area contiguous to the west and north of the colonial center. To commemorate his silver jubilee in 1955, Trujillo authorized construction of the international fair project which was built at what was then the western edge of the city. La Feria cost over RD$ 30 million, a huge sum at a time when the national budget was about RD$ 120 million, but the Dominican economy was flourishing. To accommodate the anticipated thousands of visitors to the exhibition, the government, with U.S. investment, constructed a major tourist hotel, El Embajador.

The Dominican Republic was relatively late entering the Caribbean tourism industry. The Jaraqua Hotel had been the first large tourist hotel, but the stigma of the dictatorship discouraged tourism, and only three large hotels had been built in the city by 1965, none of which was kept in good repair (Bell 1981, 339-341).

After order was restored following the civil war in 1965, the nation has enjoyed nearly two decades of reasonably peaceful, ostensibly democratic government. An ambitious project to restore the colonial center is nearly completed and is encouraging a growing tourist industry. Many of the centuries-old structures have been returned to their former magnificence when Santo Domingo was the capital of the New World.

The city port is now used almost entirely for welcoming the thousands of tourists who arrive by cruise ship. Since 1968 when tourists numbered 68,500, the flow of visitors has reached half a million, 10 percent of whom travel to the island aboard these ships (República Dominicana 1978). Most commercial shipping now unloads and loads at the port of Haina at the western fringe of the capital. In 1978, the government authorized the expenditure of RD$ 4.7 million to develop Haina as the main commercial port.

Recent Urbanization

The old city remains the hub of commercial and social activity. Many large shops, offices, churches, and businesses share the crowded space, and the lack of high-rise structures, the narrow streets and traffic congestion, and the noise and dust are inducing some activities to relocate. With a population that is doubling each decade, this city that was built to serve 30,000 must now provide for nearly one million inhabitants.

Business, commercial warehousing, and light manufacturing can be found in newly constructed structures along many avenues, especially Avenida J. F. Kennedy, the northern extension of Avenida Máximo Gómez, along Autopista Duarte and Carretera Sánchez, and in the industrial complex of Herrera. There are over 600 firms scattered over the city, e.g. Metadom, a scrap metal processing plant established by a Spanish firm at what was once the edge of the city but which has been surrounded by residences. There are other industrial concentrations in the neighborhoods of La Fe and Luperón, and across the Ozama along Carretera Mendoza in Los Minas (Bergés 1973, 3-4).

The city's growth has been largely unregulated. Although builders are encouraged to observe such official regulations as published in the New York City housing code, the absence of zoning restrictions and a comprehensive plan for urban development have left the expansion of Santo Domingo to the designs and whims of the construction industry and a host of official agencies which have little power to enforce compliance with building codes. It is commonplace to find residences, stores, professional offices, and even light manufacturing scattered along a street. A new apartment house of six floors can be built next door to a middle-income, ranch-style home.

Strip commercial activities can be found throughout the city. The more notable stretches include the extensive development along Avenida Duarte, beginning at the downtown market area and extending along most of its length. Similar strip development is found along Avenues San Martín, 30 de Marzo, Máximo Gómex, Sabana Larga, María Montez, and Padre Castellanos.

In the most recently constructed residential areas, commercialism has been centralized to a large extent. The shopping centers, supermarkets, and public markets accommodate neighborhood shoppers. An example is the Naco shopping center which services a middle- and high-income residential community built on land that had been the only international airport for the nation (Figure 2-4). In 1955, the airport was moved to Punta Caucedo, 29 kilometers to the east of Santo Domingo. Aeropuerto de las Américas was completed in 1971.

Other widely dispersed commercial enterprises include food stores, called colmados. They are often managed by their owners and resemble the Ma-and-Pa corner grocery store in large U.S. cities (Norvell 1969, 105, 108-109). Other domestic shopping can be done at the few central public markets.

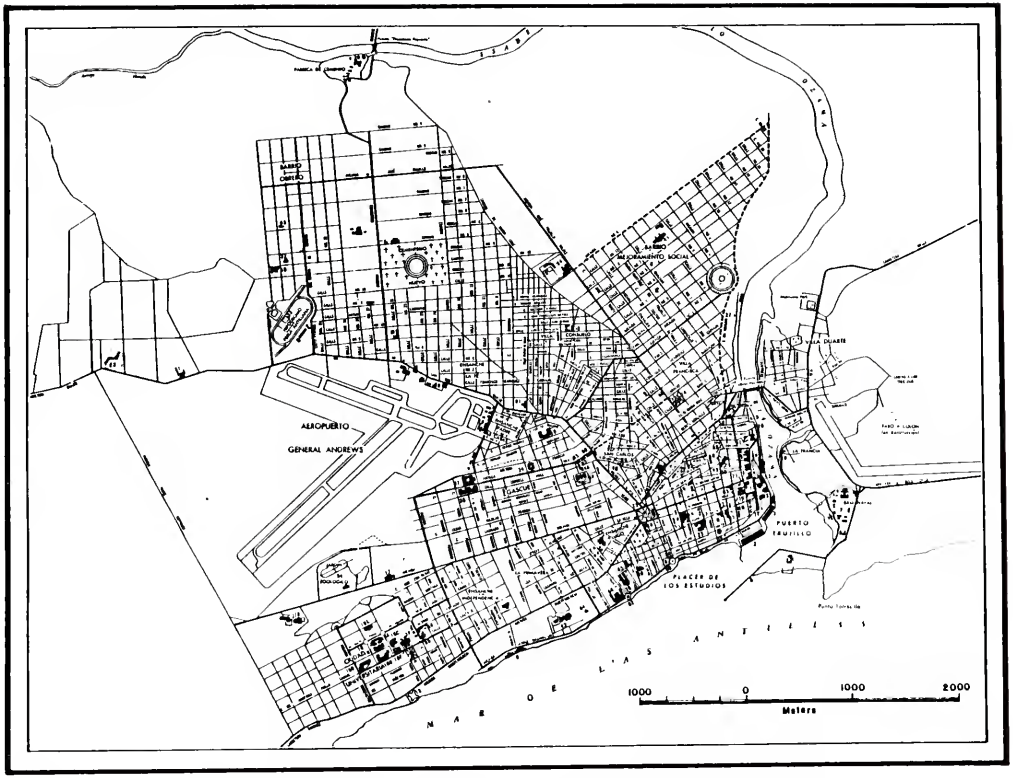

Figure 2-4: The Transportation Network in Santo Domingo About 1948

Produce is trucked into the city primarily to the wholesale district adjacent to the public markets, and the storage wholesalers distribute to the markets and the colmados.

Public and institutional buildings, especially schools and ecclesiastical structures, also are dispersed widely. There are concentrations in the colonial city where restored buildings are providing the government with much badly needed space. There are other public complexes at La Feria and at the Huacal (a major government office building), at the sports stadium, around the national palace and along Avenida P. Henriquez Urbana, at the Museum of Man and symphony hall facilities, the universities, and at the intersection of Avenida Luperón and Avenida 27 de Febrero.

From 1970 to 1977, the Dominican government spent an average of RD$ 28 million on roads and bridges, with most construction on projects in or near the capital. These included a four-lane, divided highway extension to San Cristóbal, another along the northern part of the city to connect this by-pass with a fourth bridge crossing the Ozama River, and the Avenida de las Américas which now extends beyond the airport to San Pedro de Macorís. The Sánchez bridge has helped to ease traffic congestion at the Ozama River.

Automobile traffic has become a major problem. In 1948, there were fewer than 1,400 registered automobiles and by 1961, they had increased to only 6,000 private cars in the entire nation; however, 10 years later, there were over 26,000. In 1975, there were about 49,000 registered automobiles, most operated in the capital city (República Dominicana 1952; Bell 1981, 140).

Several reasons account for this rapid expansion in private auto ownership. In 1962, President Balaguer decreed the end to the Trujillo-owned taxi monopoly and conferred ownership of 5,000 city taxis on their drivers. The operators have had a powerful union which supported the president during his long administration, and, in exchange, they received a gasoline subsidy that kept the price of fuel low. Additionally, most intracity public transportation was relegated to the taxis called públicos which numbered 25,000 in 1977 and provided an informal public service on a fee-for-hire basis along routes selected by their drivers. Bus registration increased from 316 in 1961 to about 1,860 in 1975, with most of the buses being used in intercity transportation. The municipal bus service has increased dramatically since President Guzmán expropriated all public transport in 1981, including the públicos which are now rented at reasonable rates to their operators.

The Dominican Republic has a better articulated system of cities than have Cuba and the non-Spanish-speaking Caribbean nations (Clarke 1974, 225). Yet, much industrial growth between 1968 and 1977 occurred in either Santo Domingo or Santiago. The industrial Incentive Law was enacted to encourage "the most rapid and effective industrial promotion of the country's economy with the purpose of obtaining permanent sources of employment and income for our population and a diversification of our national economic base" (Presidential Decree of April 23, 1968). The law allows new industries to be exonerated from 90 percent of import duties and taxes on raw materials, containers, packing materials, fuel and lubricants, and 50 percent of net income when reinvested in the industry. In order to discourage the concentration of investment in areas already industrialized, the government planners proposed that Santo Domingo- and Santiago-based firms be allowed an 8- and 12-year exemption, respectively, while elsewhere exonerations were extended to 15 to 20 years. Although the plan was to encourage industrial dispersal, create new jobs in smaller cities, and, thus, slow urbanization in the metropolitan areas, nevertheless, many of the new industries established under the law were capital intensive. Only 9,400 new jobs were created in a decade when population increased by more than one million (Bell 1981, 349-351).

There are 10-20 rural laborers underemployed or out of work for each small farm. The goal of the agrarian reform program begun in 1962 was to improve rural living conditions sufficiently to stem the flow of farmers whose numbers threatened to inundate the provincial and regional capitals. From 1960 to 1970, the national population increased from 30 to 40 percent, and Santo Domingo almost doubled in size (República Dominicana 1971b, 26). An annual urban growth rate of 5.9 in the capital was well above the annual national rate of 3.6 (Davis 1972), an indication of the magnitude of rural-to-urban migration.

By 1975, another 200,000 migrants are believed to have moved into Santo Domingo. Most are believed to have been without jobs and poor. They probably became new residents of such marginal settlements as those that have clung to the steep banks of the Ozama River where at least 200,000 may have sought shelter (Fanger 1978, 26).

The Housing Problem

Residential land use is a reflection of demographic conditions and, although not directly tied to economic conditions, is nonetheless often the largest portion of urban investment (World Bank 1978, 285). The traditional values manifested in urban institutions as well as the particular social and economic conditions of city life have caused rapid in-migration to cities. Where urbanization has outpaced the expansion of the housing sector, severe housing shortages have occurred.

In the Caribbean, the rate of absorption of land into urban use has increased less rapidly than the rate of population growth. The requirement for space is a function of the total urban population and the density or intensity of use for diverse urban activities. Land development often includes the loss of open space, some of which is vital for groundwater recharge, recreation, future urban growth needs, the control of pollution, etc. The horizontal sprawl of cities increases transport costs, the need for streets, water, sewer, electricity, telephone and other utility extensions, provision of more clinics and hospitals, more schools, more fire stations and police barracks, more branch stores, supermarkets, etc. This expansion requires both land and capital which may be severely limited. Improving municipal services often can be accomplished more cheaply and consume less land by intensification than by extension (Lamm 1973). By connecting additional utility customers on existing systems, adding more floors to hospitals, schools, and police stations, it is possible to conserve land, while savings in costs can be used to improve housing for the city's inhabitants.

Since the growth of population and structures will lead to changes in a city's structure, residential land use has been of principal concern to those investigating or seeking control of urban land use

(Bourne 1981, 19). There is the advantage to property owners, mortgage investors, realtors, and others of knowing the probable or alternative patterns of city growth.

Unlike the Anglo-American experience where climate and absence of adequate housing have acted as a constraint on urbanization (Forrester and Mass 1975, 25-26), conditions in Dominican cities have not impeded in-migration (Makowski 1975, 55-56; Aversch and Levine 1971, 157). Widespread, endemic poverty coupled with a moderate, subtropical cli- ate allows year-round occupancy of rudimentary shelter, fostering extensive marginal housing.[1]

Forrester (1974, 22-24) suggests that housing supply may be related to stages of urban growth, exerting an independent effect on interurban migration as the city progresses through the industrialization phases of modernization. If this is the case in Santo Domingo, then Dominican urban problems may be similar to those experienced in Anglo-American cities at the turn of this century (Herbert 1973, 36-45). But unlike the latter places, the island capital has far less capital and access to resources to engage in the similar solutions to housing demand.

There is an important difference between the U.S. urban situation in housing and that found in Santo Domingo. In the former cities, there is an excess of deteriorated, even abandoned buildings, while in Santo

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[1]Alonso (1971, 4) prefers the term marginal. See John Collins (1973, 118) for a discussion of other terms: squatter emphasizes legalities in obtaining shelter; shantytown implies certain physical conditions; uncontrolled urban growth is preferred by Collins because it implies the interdependence of physical, social, and economic factors. The latter choice also implies planning which is generally lacking in the Caribbean.

Domingo, there is simply no housing available for the majority of those requiring it, at any price, and certainly not within the means of most urban poor. The spread of cardboard and palm-thatched huts is the marginal dweller's response to unsuccessful housing searches. As long as vacant urban land exists to accommodate these poor people, it is likely that the inflow of more people can be expected to continue. Assuming that the Dominican population was over five million and that the average family size was five persons in 1974, the Secretary of State for Health and Public Welfare estimated the national shortage as nearly 400,000 units, of which 30-50 percent was located in Santo Domingo (República Dominicana 1974; Fanger 1978, 26; Sánchez Córdova 1975, 42).

Five agencies participate in the Dominican housing program: the National Housing Bank, the Technical Office of the President, the National Institute of Housing, the Institute of Public Housing, and the Savings and Loan Bank. Combined annual production of housing has averaged 3,000 units, 1,000 of which were built in the capital. There is a yearly increment in the demand for housing of about 10,000 units. In the 1975-1985 decade, it has been projected that 115,000 more housing units will be required to prevent a further increase in the present shortage. At a conservatively estimated cost of RD$ 4,000 per unit, the annual cost would amount to RD$ 45 million, well above the expenditure now being made for housing (Table 2-1).

There are approximately 200,000 households in Santo Domingo, and only about 42 percent of them are able to obtain housing within the commercial market. Less than half of all families needing housing were able to quality for the minimum standard provided by those agencies actively participating in the housing construction industry (Fanger 1978; Alonso 1971, 7; Sánchez Córdova 1975, 42). The rest, numbering over 100,000 families, have had to house themselves, often in marginal settlements comprised of structures costing one-third of what is considered the minimum standard home. It is reasonable to assume that 70 percent of all housing each year has been improvised from discarded or nearly worthless materials; only about 10 percent of these ranchos are of the permanent type incorporating some concrete or other substantial building material (Sánchez Córdova 1973; Sadove 1973, 30; Turner 1967, 168; Vernez 1973, 23, 61).

In 1969, almost half of all public investment in new construction was made in loans to state-owned but decentralized (so-called autonomous) financial institutions which spent about RD$ 2 million out of RD$ 80 million on housing. These loans had to be secured, and they were issued to recipients who had dependable, stable incomes, usually the middle- and high-income residents, not the unemployed or underemployed poor (Academia de Ciencias de la República Dominicana 1977).

Government efforts to expand low-cost housing construction, initiated in the late 1950s, faltered during the mid-1960s and have since tended to favor the small portion of the urban low-income population that has secured reliable employment and is able to afford public housing remote from the commercial and industrial areas of Santo Domingo (Vernez 1973, 95-100; Fanger 1978, 26-27; Crassweller 1966, 373-374). Aspiring middle-class residents are following the same pattern as extension of urban infrastructure underwrites more distant development (Vernez 1973, 28; Kaiser and Weiss 1968, 57-58). As the population of bureaucrats, business people, and technicians, who comprise the middle class, expands, suburban development is expected to occur, but presently they are often the occupants of public housing (Sadove 1973, 29; Turner 1967, 167-168, 179; World Bank 1972, 30). The use of interior space, the choice of location, the cost and the financing arrangements for mortgages, have contributed to making public housing unacceptable to or unobtainable by low-income familes.

In 1970, RD$ 89 million in public funds were spent on construction, but only 3.5 percent was for new housing, much of it in the capital. By 1975, public expenditures for all new construction was RD$ 251 million, 68 percent for housing (a cost-of-living index at 100 in 1969 rose to 188 at the end of 1975). In addition to losses due to inflation, land speculation and widespread corruption within the construction industry absorbed substantial proportions of the RD$ 31.6 million committed to the capital's share of new housing (Academia de Ciencias de la República Dominicana 1977; Bell 1981, 187-189). Since that peak housing construction year, rising fuel prices and high inflation have curtailed public investment in housing.

Denied access to either the government or commercial housing markets, the poor people in most Caribbean cities have shared cramped quarters with kinspeople and erected shacks throughout the city. Often such spontaneous or self-help housing is built on land owned by the government or in squatments where ownership rights are blurred. Such settlements may have few if any municipal services (Turner 1967, 168; Alonso 1964a; Havens and Flinn 1970; Vernez 1973, 12).

It is true that marginal housing is being replaced by other kinds of housing. Since public funds loaned by autonomous financial agencies tend to go to the construction of high- and middle-income housing, urban renewal in Santo Domingo resembles renewal in U.S. cities during the 1960s and 1970s. The deteriorated areas were demolished, some to be rebuilt in high-rise and expensive apartments, others to remain as open spaces. In either instance, poor residents were displaced, forced to move into other neighborhoods. The new residents increased demands on already inadequate services and facilities, and higher densities led to more congestion. Further deterioration often resulted in these communities (Bourne 1981).

Because urban land is limited, there is a tendency toward higher density settlement in rapidly urbanizing cities. Much of the growth of Kingston's population lives in densely settled, substandard housing either in the center city slums or in peripheral marginal housing areas (Clarke 1975, 96-97). It is believed that one-quarter to one-half of Santo Domingo's population lives in downtown tenements and dense neighborhoods at the city fringe (Sánchez Córdova 1975; Fanger 1978). Following the 1975 hurricane that flooded and devastated a large expanse of marginal housing on the Ozama River floodplain, a plan was proposed to resettle about 100,000 people living in a community illegally sited on the bank of the river.

There is the belief in Caribbean capitals that squalor constitutes the prevalent condition in marginal housing areas although there is clearly difficulty in determining what standards ought to be applied to defining substandard housing. Often the official position reflects values that are unrealitic and hardly shared by the bulk of inhabitants of these cities. Recent Dominican governments have been concerned about the increase in people who are unemployed or underemployed and living in the marginal settlements. Especially during elections, attention has focused on these inhabitants who participate in the political process (Bell 1981, 92, 124). But Latin American ecological research proposes that the urban poor are not a homogeneous group and have varying socioeconomic status and life-cycle stages which can be identified in particular urban patterns (Gans 1968, 210; Alonso 1971, 4; Gilbert and Ward 1978, 302-303; Turner 1968, 369; Mangin 1967, 68; Cortén 1965, 5; Souza and Porter 1974; Herbert 1973; Safá 1974).

Turner (1968) considered the housing needs of low-income, low-status inhabitants of several Latin American cities. Two patterns were consistent. The poorest, usually the more recently arrived in-migrants, were usually young, single, and with few marketable skills. They were dependent upon accessibility to the employment opportunities in the central business district and in the homes of middle- and upper-income families. Given time, many of the inner-city poor acquired sufficient experience to be employable in skilled, even permanent work. The resulting improved economic condition permitted marriage and a family; the new life-cycle stage required more living space. In the poor family, however, housing is the largest proportion of the urban family's budget expenditure (Sadove 1973, 29-30), and the minimum "low-cost" home is beyond reach, so there is little opportunity in the commercial market to acquire the needed space. Unlike the low-cost public housing in Anglo-American cities which offers an alternative to the poor urbanite, middle-income Caribbean families, caught in an extremely tight housing market, have monopolized such housing. The result is that the poor family must house itself by building marginally adequate homes on land that is owned by others. In Santo Domingo, perhaps one-half of the poor have moved into self-built homes (Sadove 1973, 29; World Bank 1972, 41; Bell 1981, 188).

There are at least three types of illegal housing settlements: (1) those built on private or public land invaded by people who have made no payment for its use; (2) the "pirate" housing areas constructed on land sold in lots, legally, by entrepreneurs who have disregarded municipal development codes that specify that basic infrastructural services must be installed first; (3) the rentals erected by speculators concerned for their otherwise vacant city land that is exposed to possible squatter invasion (Turner 1967, 1968; Mangin and Turner 1968; Mangin 1967). Whereas the third type is often a single house, the first two types tend to occur at the city's edge in massive communities that are often adjacent to middle- and upper-income developments.

Marginal housing at the city's edge tends to be occupied by the more economically stable of the urban poor. These urbanites may have moved several times in the process of making a long-term commitment to purchasing a lot and building a modest home. It is a "step up" for them and represents a substantial investment in a more secure future (see Usandizaga and Havens 1966; Flinn 1966; 12-20; Vernez 1973, 16-20; Turner 1968, 359). These marginal settlements are, thus, agents for the social advancement of the poor just as home purchase in the commercial market is a status decision for the other classes. Such settlements house a substantial portion of the urban population in societies which are slow to change and have failed to pace urbanization (Eyre 1972, 395; Herbert 1973, 48; Turner 1966, 508-509; World Bank 1972, 41).

In the central business districts of these cities, the increased competition for limited space is gradually transforming the traditional plaza. The old homes of the urban well-to-do are being converted into commercial and professional offices; the demand for rentals is resulting in their conversion into apartments and rooming houses. The upper-income residents who once preferred the convenience and excitement of center-city living, with its old churches, parks, and proximity to work, are opting for luxurious and fashionable new homes being built in private residential neighborhoods at the city's edge (Grubb and Phares 1972, 14; Johnston 1971, 311-312; Eyre 1972, 397-398; Schwirian and Smith 1974, 327; Quijano 1967, 11). This suburbanization, however, still remains a minor phenomenon in some Caribbean cities.

Brown (1970) and Uzzell (1975) have found that where services are available in the inner city, low-income residents exhibit much more stability. They have resisted the efforts of landlords to evict them in order to renovate or remodel buildings to house even larger numbers of people. Consequently, the more recently arrived poor may have to look for inexpensive housing further from the city center. This has been substantiated by Ward (1976) who found that newly arrived migrants tended to settle in the older, established neighborhoods rather than the inner-city tenements. Similarly, Vernez (1973) discovered that in-migrants moved into rented rooms in poor neighborhoods scattered about the edge of the city.

Thus, at the city's edge, there are usually three types of housing. They are publicly financed housing, the high-income housing, and the illegal settlements. The first two types are more orderly uses of the land and result in regular patterns that accommodate the local topography and the use of the automobile for transportation. Their neighborhoods have curving streets which contrast with the rectangular grid of the old neighborhoods of the colonial city. The illegal settlements often leap-frog vacant land adjacent to the central business district and spread out haphazardly across large areas at the city's edge (Turner 1968; Amato 1970; Vernez 1973, 25).

Social planners of the mid-1960s reacted negatively to these marginal communities, thinking them undesirable, the results of pathologies of lower-income people, and debilitating to the health of the modernizing city (see, for example, Bonilla 1964; Shulman 1968; Berckholz 1963). The prevailing belief persisted that home ownership is the major mechanism for maintaining family ties and controlling social disorganization. Furthermore, the prospective buyers of a home obligated themselves to fixed monthly installments; occupants of marginal houses remain outside the conventional world of planners and bureaucrats who wish to restrict such residential land use. But public policies seeking to control marginal settlements have encouraged squatting. Slowly, officials have begun to permit, even encourage, self-help housing constructed in areas designated for planned "slums," in the hope that by doing so this can preserve other open space for future development (Corrada 1969, 246).

There seems to be little doubt that marginal settlements at the urban fringe have offered inner-city poor a way of improving themselves.

Given stable employment, the poor are willing to convert their wood and cane shacks into concrete-block dwellings roofed with corrugated steel sheeting and floor them in concrete. Continuing modernization is bringing official acquiescence, especially legalization of claims to their lands, and the introduction of municipal services—electricity, water, sewers, street paving, garbage collection, police protection, schools, medical clinics, etc.—over the years establishes and encourages these communities (Turner 1968, 1976; Roberts 1973). There is much evidence that land and home ownership are important values to the urban poor as well as other, more fortunate city dwellers (Cornelius 1975; Lomnitz 1975; Stepnick 1979; Turner 1972, 1977; Mangin 1970).

CHAPTER THREE
URBAN SOCIAL DIFFERENTIATION

People residing in the city pass through several stages during their lives that involve changes in their living habits. These changes are manifested in land use patterns. For example, the selection of housing is associated with changes in life stages. People are likely to leave behind the neighborhood in which they were brought up and eventually move to another residential area in the city which facilitates their changing roles as spouse, parent, career person, retiree, and elderly citizen.

Because of the intricate nature of the city, the evolutionary sequences of city forms have been premised upon key, large-scale variables that include population, institutions, environment, and technology (Berry and Kasarda 1977, 14). The geographic assessment of urban change involves formal and functional relationships which vary importantly with differences in scale. The formal city incorporates such diverse phenomena as land use, settlement patterns, and population dimensions. Urban morphology is assumed to be evidence of functional relationships. Urban form is culturally associated, but it also contains patterns similar to those in all cultural milieux. At some point in time, these forms may tend to converge into a single, general pattern (see Hawley 1971, 290-315 for a discussion of the urbanization process in developing nations).

Social geography of cities can be traced to early work in areal differentiation and man-land geography, both of which often viewed the urban environment as one of economic specialization (see Whittlesey and Wellington 1925; Hartshorne 1959; Sauer 1941). The little attention given to the characteristics of residential change was due in part to the emphasis on the features of places rather than population characteristics. But the improvements in national censuses and availability of such data encouraged social scientists interested in a wide range of noneconomic processes to explain urban morphological change. By 1930, more Americans lived in U.S. cities than in the countryside. Cities had become the centers of change, and it increasingly became popular to search for ways to innovate in shaping this growth.

The social differentiation of the city into patterns of concentric zones that have spatial identity was founded on the work of early sociologists Robert Park, Louis Wirth, and Ernest Burgess. Homer Hoyt proposed a second, sector model; both the sector model and Park and Burgess' concentric zone model were modified by others including Chauncey Harris, Edward Ullman, and Amos Hawley, but these first two models remain the "classical" explanations of urban morphology and ecological differentiation. It is likely that they are not contradictory but rather represent stages in city growth. Thus the concentric zone model emphasizes change during a period when the city contains many population groups at various points of assimilation. The sector model describes residential patterns of cities that have progressed further along a continuum of ethnic assimilation when prestige or status become a significant determinant (Herbert 1973, 74). With continued city growth, Harris and Ullman proposed that the relocation of economic activities and population movement was fundamental to the formation of multiple urban nuclei within the context of metropolitanization.

Concentric Zone Model

The Park-Burgess concentric zone model, resembling a nineteenth-century model of an agricultural market town devised by von Thünen, was influenced by the work of Hurd (1903) on central and axial urban growth. Park and Burgess used the nonhuman ecological concepts of invasion and succession through competition and dominance to explain human community use of space (Burgess 1925). Thus the city was seen as a product of environmental competition and interdependence characterized by the social and geographic mobility of its heterogeneous population. Change in the location of people and institutions and the subsequent social reorganization were explained as concentric circles delimiting zones of homogeneous socioeconomic level,[1] density, and distance from the center of an idealized city. The gradient, developed by Duncan and Duncan (1955, 396) became the model's index of centralization. A negative value indicated a tendency for the group to be concentrated beyond the center of the city; a positive value suggested a trend toward centralization. The model is an application of the distance-decay principle of centripetal force inversely proportional to distance based upon inductive generalizations about forces responsible for mobility in the city (Burgess 1923; Park and Burgess 1921; Park 1925).

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[1]It has been shown that these zones are not as homogeneous as proposed.

Assuming equal accessibility in all directions, Park and Burgess measured distances in units of time and cost (Quinn 1940, 212). Social distance resulting in a circular ecological structure could thus be consistent with a rectangular spatial configuration in which accessibility would be determined by a network of intersecting streets at right angles.

Urban land, aggregated into four grades, was found to group into concentric bands that were hypothesized to be internally homogeneous. These were called zones, four of them encircling the commercial center. In the central business district (CBD) is found the retailing establishments including the main department stores and the chic specialty shops, the central offices of major financial institutions, office buildings, clubs, the headquarters of civic and political organizations, the more expensive hotels, theaters, and museums. At the outer edge are wholesale businesses including markets, light industry, and warehousing. As the most accessible area, and with the largest daily number of trips into and out of it, this zone contains the main transportation terminals. Although when the city was youthful and growing this area was the site of many fine residences, growth with increasing functions and resulting competition for limited space has left only a few pockets of housing which are much deteriorated and occupied by transients.

The second zone is adjacent to the wholesale district. Originally the main suburban residential area for the city before the advent of rapid transit and the automobile, it has been experiencing changes in functions characterized by encroaching business and industry from the CBD replacing the deteriorated housing. Landlords are either unwilling or unable to maintain the tenements and remodeled houses. Neighborhoods have changed and the few homes are badly outmoded. The rentals, in tenements and rooming houses, are densely occupied by the newly arrived migrants who are often unskilled, the very young and old, and survivors of broken homes.

The independent working people occupy modest homes in the third zone. These people desire proximity to employment in enterprises close to the CBD, and they have had to trade off the amenities of living further from the congestion of the city center for this accessibility. However, the continued expansion of the CBD and the influx of new workers tend to intensify land use in this zone, with the result that some of the more fortunate in this area will invade the less dense, more desirable residential areas farther from their present homes.

In the fourth zone are the homes of the middle class, people who own and operate the smaller businesses of the city, the clerks and salespersons, the professionals who comprise the middle class in U.S. society. There is no distinct boundary separating this from the next, outer zone, unlike its other border contiguous with the working peoples' zone. For, beyond this residential area can be found the small towns and hamlets that are the dormitory suburbs of the city and in which reside high-income commuters and their families. These commuters have chosen to live here on the weekends, in segregated neighborhoods, and commute to city-center jobs in long, daily trips or live in city-center apartments during the work week.

Burgess identified two zones beyond the built-up area of the city. The far-reaching agricultural district is within commuting range of the city, while the hinterland extending beyond it still is linked to the metropolitan area even though too far away for daily commutation (Burgess 1930, 181-182).

The model assumes that urban population growth is due primarily to in-migration, especially of low-income people seeking economic and social improvement. This urbanization results in segregated housing as the residential land use expands and new housing development occurs. Newly arrived migrants tend to settle in the transition zone tenements and rooming houses where rents are cheap, but densities are high and conditions are often squalid. As in-migration continues, the housing opportunities become scarce, both because of increased population and the loss of structures to other land uses. Gradually these people are forced to invade nearby low-income housing that has been vacated by families seeking better homes farther out from the city congestion. Thus, the process of change occurs on a gradient, the oldest urban development closest to the CBD. The oldest neighborhoods are gradually changed by this process of intermixing and sorting out that once again establishes neighborhood stability with a different character.

Unfortunately, the condition of neighborhood homogeneity is contradictory to the notion of a gradient in the value of social attributes. Discrete, homogeneous concentric zones conflict with gradations in income level, population density, etc., and human ecologists have demonstrated that socioeconomic status increases with distance from the center of the city. The model assumes that population density decreases from the inner to the outer zones. Dwelling unit density and the percentage of home ownership have been found to increase with distance from the CBD to the zone of most recent growth (and in the 1930s, this was 11 to 13 kilometers); beyond, both housing value and ownership were found to decrease (Blumenfeld 1954). As the growth edge moves outward, it carries the greatest concentration of activity and experiences the most rapid rise in population density.

As long as the pressure for expansion and the resistance to invasion are uniformly dispersed across the urban landscape, isochronal lines of zonal growth move out from the city center in a circular pattern. The pressure for housing in one zone leads to pressure on the adjacent, outer zone, and each is transformed as people invade from one zone to another.

The concentric zone model is a special case of a city with a central business district, with sufficiently large population to permit functional heterogeneity distributed in relation to work opportunities. In that major employment center, city functions operate in a market economy at the industrial/developed stage including the segregation of activities based on minimum levels of accessibility. The older and larger the city and the less active the growth, including the annexation of new territory, then the more likely the "expected" pattern of the concentric zones will occur (Schnore 1967).

Modernization has modified the conditions upon which Park and Burgess formulated their model. The massive impact of automobile use since World War II has greatly increased the extension of urbanized land, has been directly responsible for strip development, and has made multiple centers of commercial activity necessary (Angel and Hyman 1972; Richardson 1976). In some European cities, for example, the relocation of industry near a source of cheap labor left the center of London, Paris, and Moscow to the elite, while the poor were relegated to peripheral land on the outskirts of the cities. These patterns persist even today in spite of post-war modernization (Hauser 1968).

There are topographical impediments to development in most urban sites. But there are also such obstacles as historical inertia and policies that tend to distort the ideal pattern that the concentric zone subsumes. Thus, the functions which in a previous time were useful for controlling change may persist even though they have ceased to be so. Municipal ordinances may curtail certain kinds of growth. Vertical space can become more important than horizontal space in the city that has spread out so much that accessibility is at a premium and must be stringently regulated. However, land use controls may not include air rights protection nor encourage rational vertical development.

The Applicability of the Concentric Zone Model to the Caribbean

In spite of criticism of the model, the concentric zone model remains the principal paradigm explaining urban growth. Enough evidence has yet to be collected, however, to assume the Caribbean capitals, with continued growth and development, are evolving as suggested by the idealized model. There have been some cross-cultural comparisons made with Anglo-American and Asian, African, and Latin American cities (see Hansen 1934; Hayner 1946; Caplow 1949; Dotson and Dotson 1954; Hauser and Schnore 1965; Schwirian and Smith 1974; Clarke 1974; Schwirian and Rico-Velasco 1971; Turner 1968, Mangin 1967; and Alonso 1964b for Latin American research).

From a study of the literature about ecological patterns in Latin American cities, Schnore (1965) concluded that there is an evolutionary process of urbanization including residential patterns indicative of social differentiation. The socioeconomic status of neighborhoods gradually changed with development to assume the concentric zone configuration. In the more traditional cities, the higher-status group preferred city-center residences; however, with modernization (and all of the cities displayed change in this direction), the upper class vacated their older city residences for new homes built on larger land parcels at the city edge. Schwirian and Smith (1974) found that in the smaller Puerto Rican cities, social status was negatively associated with distance from the CBD, while in San Juan, there was a reversal of this pattern as well as decreased density of residential neighborhoods with increasing distance from the city center. Clarke (1974) found some evidence for the same patterns in Kingston; however, there did not appear to be a commuter zone, and the transition zone was difficult to demonstrate. The social status gradient held true generally except for the peripheral "shantytowns" and public housing developments (Clarke 1975, 132).

Turner (1968, 359-360) considered the applicability of the Park-Burgess model to low-income, low-status housing in Latin American cities. Two patterns were consistent: The inner area in the zone of transition which houses the poorest and the newly arrived followed the model; an outer, peripheral area of poor inhabitants exists, however, which is inconsistent with the concentric zone hypothesis that proposes a commuter zone of well-to-do residents. Turner (1968, 360) labeled the inner-city poor as bridgeheaders, and described them as barely skilled, largely unemployed upon arrival, and dependent upon the few jobs to be found in the central city businesses and in the homes of middle- and upper-income residents. Turner identified another group at the perimeter of the city as consolidators, poor people who had apparently secured more permanent employment and were able to forego city-center proximity to improve their housing situation.

Such research, which seems to conflict with the concentric zone model, in fact, may not indicate that the model does not apply to Latin American or Caribbean cities. Evidence exists for an evolutionary sequence in the development of urban residential structure. Schnore (1963) computed the age of Latin American cities from the decade in which they achieved 50,000 in population, concluding that it appeared the best predictor of urban spatial structure. The smaller, and thus younger, city was likely to have high socioeconomic-status people living in the city center. With time and increased population, decentralization becomes pronounced: the middle class often establishes residence at the urban periphery first, but, once its numbers become sufficiently large, is soon followed by the upper class. Schnore attributed the differences between young and old cities to the nature of the housing market. In central cities' older areas, there are many obsolete buildings, whereas in young cities without such older, inner neighborhoods, there are many high-status buildings because decentralization has not been present long enough to encourage extensive growth of a transition zone. With such growth and expansion of the urban core accompanied by improved accessibility, the upper class will vacate the center city, leaving behind their homes which are modified to accommodate low-class residents.

Schnore (1964) pointed out that larger, older cities which used annexation less often to accommodate growth were more likely still to exhibit the expected concentric zonation. Thus, the more rapidly growing the urban center, the less likely that concentric zones will persist; the older, larger cities display the most apparent Park-Burgess concentric zone pattern.

Although Davis (1969) disagreed with Schnore on the sequence of out-migration from the city center pressured by urbanization, both researchers concur in an evolutionary model of residential change that consists of four stages. There is a preindustrial stage when the city is small and growing slowly. The elite resides adjacent to the central business district. In the industrial take-off stage, urbanization is accompanied by transportation innovation promoting improved accessibility. The upper class is able to move to the edge of the built-up zone. The lower class dominates the inner zone, and the middle class is left intermediate to these two. In the third stage, which is a continuation of industrialization, increased pressure for change in residential areas is prominent. A new elite, emerged from prosperity based on industrial expansion, can afford and demands new, luxurious housing. Innovations in housing technology result in obsolescence. As the process of occupancy change called filtering permits other, less affluent people to occupy once high-income homes, a pattern of decreasing status toward the CBD results. The general prosperity encourages expansion of the middle-income group and leads to more clearly defined zones of socioeconomic level. The fourth stage is postindustrial, characterized by stable residential patterns. Growth is most conspicuous in middle-income suburbia which encircles the older, high-income area at the fringe of the city's built-up land.

In studying Latin American cities, Amato (1974) failed to identify a middle-income group intermediate to an inner-city, low-income zone and a suburban high-income zone. Rather, the elite lived in low-density, dispersed neighborhoods, all of which were approximately equally distant from the center city. The middle-income group lived in closest proximity to the CBD at relative high density, suggesting their willingness to exchange space for accessibility. The low-income neighborhoods, also relatively dense, were more dispersed and at locations farther out than the middle-income neighborhoods.

Individual urban communities, i.e., inner suburbs and outer suburbs in a metropolitan area, may also differ in development stages at any particular point in time. Wils (1974) suggested that it is possible that urban conditions measured during recent censuses, for example, may reflect a single stage of development. Thus, studies of Latin American cities restricted to very recent data collections may fail to support an evolutionary model of urban spatial structure only because the period of information gathering is short by comparison with the Anglo-American research base of census data extending well into the nineteenth century for many coastal cities. If a general theory of urban spatial structure is to exist, then researchers must consider the possibility that cities may be at various development stages and moving toward experiences similar to those of Anglo-American and Western European cities. Preindustrial cities do not display as clear a differentiation of residential neighborhoods according to socioeconomic and life-cycle status as do postindustrial cities. Comparative studies of spatial structure in other cultural milieux are needed to substantiate present theory (Herbert 1973, 178-179; Abu-Lughod 1969, 209-211). As Johnston (1971) stated in his review of the literature of urban spatial patterning, the concentric zone model is incomplete and contradictory. The effect of population growth and modernization on the urban fringe remains unclear to him as well as to students of Caribbean urbanization.

Sector Model

Hurd (1903, 59) noted that city growth was evident in two patterns, central and axial, which ranged outward in all directions from the city center provided there were no impediments to development. Such growth tends to parallel transport lines, making adjacent land more valuable because of improved accessibility. The evolutionary character of growth results in the obliteration of the physical evidence of unequal growth in the immediate advance of central growth, but a star-shaped configuration persists in the wake of axial expansion ahead of the main city development.

In the 142 U.S. cities which Homer Hoyt (1939) examined, railroad and water transportation routes attracted industry, and local residential growth accompanying industrial expansion tended to extend out from the center of the city in a wedge-shaped pattern. The prevalent wind direction carrying industrial airborne pollutants reduced the desirability of land in its path for residential use. Land that escaped this pollution was sought after, often by the well-to-do; once established, the high-income neighborhoods tended to remain homogeneous as they expanded outward within a sector bounded by transporation corridors (Hoyt 1939, 53-58). A slowly urbanizing city was expected to have much central expansion and less active axial growth and fewer outer settlement nuclei along transport lines. A rapidly growing city, by contrast, would expand overall, intensifying land use in both axial and central development including filling in during this growth process.

Residential land use intensification included vertical growth and the change from single- to multiple-family, higher-density structures, the development of what had been vacant land, and the outward extention of the city perimeter. Hoyt (1939, 69) identified the high-rent residential area as the initiator of expansion and the force attracting all other housing on a gradient of rental based on land value; the gradient sloped downward in all directions from it. Originally sited near the retail and office center which was close to employment and usually far from industry, the high-income residential sector encompassed a relatively large area for the number of people housed within it. But the desire for upgraded neighborhoods, modern living conditions, little or no congestion, and other beneficial attributes induced people with means to relocate farther out along nearby transportation corridors which provided accessibility and rapid journey-to-work routes. Often these routes extended to more distant commercial centers.

Usually the best land was selected for the high-income housing. It was best when sited at a high elevation, commanding a fine view, safe from flooding, and accessible to cooling breezes. The best land could be found along unspoiled waterfronts, and wherever there were few natural barriers to transporation. Such land, once established as the upper-class residential area, with continued urbanization would eventually extend outward in a wedge from the CBD. The direction of this expansion resisted change although real-estate promoters were known to modify the trend by convincing city leaders to relocate elsewhere outside the sector (Hoyt 1939, 69-71).

In the portion of the sector closest to the CBD and which was being filled in change persisted. Luxury apartments were built on cleared residential land. Immediately adjacent land on either side of the sector tended to accompany outward extension of the wedge. At any distance from the city center, mutually exclusive activities competed for space, i.e., manufacturing concerns and multiple-dwelling structures, but inertia helped to preserve the integrity of the sector's homogeneity in both social class and land use. In the ideal form of the model, Hoyt proposed that the sector was actually heterogeneous due to invasion and succession which modified the land use intensity. Thus, for example, the upper-income sector would include specialty shops catering to its well-to-do customers, expensive high-rise apartments, older luxury apartments, elaborately constructed homes, and those industries such as hospitals and laboratories which employed professionals who could afford to live in these communities.

The Applicability of the Sector Model to the Caribbean

In a later assessment of the sector model's applicability to Latin American cities, Hoyt (1963) found that single-family homes of the elite and their luxury apartments tended to concentrate in one side of a city. The sector model incorporates a growth process for expansion of the sectors. Increased demand leads to development that is simply added to the outermost portion of the wedge. Thus, as Latin American cities became crowded, urbanites migrated outward from the center city to new housing constructed at the urban edge but within a sector already established as predominantly homogeneous in socio-economic status. Amato (1974) demonstrated that Bogotá was continuing to develop along the same sector pattern identified by Hoyt. The elite remained on the east side of the city opposite the industrial development. Vernez (1973) found, however, that marginal housing settlements competed for land at the periphery of Bogatá, and assumed that over time there would be further evidence of the trend toward heterogeneous residential growth. Nevertheless, he concluded that Bogatá was growing "somewhat along the lines of Hoyt's theory of urban development" (Vernez 1973, 22).

The sector model suggests that high-income residents are the trend setters and the most important participants in residential land expansion, establishing both the timing and direction of growth. In both Latin American and Caribbean cities, new residential areas often exhibit California-style ranch homes built in closed developments that include shopping centers, churches, private schools, and extensive street networks. The occupants were once inner-city residents who lived in colonial mansions since remodeled as multifamily units and occupied by middle-income renters.

The expansion of elite residential areas often occurs along higher elevations where climate and view are best and where the homes are most distant from the noxious industrial and commercial activities. Portes (1977, 68-69) concluded that isolation and space are as important to the Latin American elite as they have been to the well-to-do in Anglo-American cities. Once ensconced in their exclusive communities, they are served by fine highways and paved streets, municipal services, and private commercial and professional services. Increasingly, sharp divisions along socioeconomic lines are segregating Latin American cities (Portes 1977; Gilbert and Ward 1978).

Economic growth in Latin America since World War II has included expansion of management opportunities and the professional services, resulting in growth of a middle class (Gilbert and Ward 1976, 287-288). These urbanites have access to most social services, consumer goods, recreation, and good housing.

Aspiring, middle-income urbanites in Latin America have been found to seek out housing close to the elite sector (Johnston 1971). Besides the status which accompanies residence in such neighborhoods, there are substantial advantages to middle-income communities which are able to utilize the transportation system servicing the elite as well as municipal services extended to the homes of the well-to-do at the urban fringe. Since middle-class renters occupy the remodeled center-city mansions left by migrating high-income residents, Gilbert and Ward (1978, 295-298) have concluded that this socioeconomic group is becoming a major influence in determining residential patterns in Latin American cities.

Much criticism of the sector model has centered on its descriptive nature (Firey 1947, 86). It is believed that cultural and social explanations exist for human adaptation to physical space. Thus, locational behavior is directly determined by the values of the social milieux with associated activities the result of rational assessment of the environment. Alonso (1964b, 227-231), in a reinterpretation of the concentric zone and sector models, dismisses them as historical explanations. Rather than accepting the processes of invasion and succession for the changing socioeconomic patterns, he offers a structural hypothesis which assumes neighborhood choice is a result of one's preferences. Such a criticism appears to ignore Hoyt's emphasis on choices made by social groups as determining residential site selection and thus patterns of urban morphology.

Multiple Nuclei Model

The most desirable points in a city are often those most accessible to other points. On the theoretical economic plane, that locus is the central business district, ignoring the influences of speed and mode of transport (Odland 1977, 3; Hamburg and Creighton 1959, 68). The CBD is assumed to draw the labor force to the major employment opportunities. These lines of communication include numerous points of unusual activity, i.e., breaks on transit lines where there are connecting routes or changes in the mode of transport. At these sites, establishments serving the commuters will proliferate. Over time the agglomeration attracts more activities until the emerging node may include industry, businesses, schools, residences, recreation facilities, etc. At the center of such diverse activities, a node becomes stable and begins to generate its own traffic, thereby contributing to the growth of a city. Such expansion in a series of many nuclei is the contribution that Harris and Ullman made to understanding urban spatial structure (Harris and Ullman 1945, 14-15; Mayer 1969, 33; Hamburg and Creighton 1959, 68).

The initial nucleus in a city will have been based on such functions as defense, transportation, administration, education, religion, mining, manufacturing, recreation, marketing, etc. But the appearance of separate nuclei is due to one or more of four conditions. Certain activities require specialization, others profit from cohesion, still others experience exclusion because their activities are detrimental to neighbors, and, finally, there are activities that cannot afford the more desirable locations and must opt for remaining space (Harris and Ullman 1945, 14-15).

Multiple nuclei, therefore, tend to be homogeneous in their functions, at least during their initial formation. They are also primarily phenomena of the metropolitan area rather than the central city (Anderson and Egeland 1961, 394). Beyond the central business district where accessibility is less and rents are lower, a wholesale and light-manufacturing nucleus may develop along a transportation route at a crossroad. A heavy-industry district may be sited at the edge of the city. The cultural and entertainment centers and outlying business districts may become other, minor nuclei. The residential district requires some measure of accessibility, but is selective of topography and nuisances (Harris and Ullman 1945, 15).

It is likely that Anglo-American cities and their metropolitan areas have manifested aspects of all three models of urban spatial structure. The zonal model has been confirmed as characteristic even where sectoral change dominates (Johnston 1971). In most cities, however, there is a clear sector patterning of socioeconomic status of the urban population. Berry (1965, 100) concluded that the three models contribute independently to the understanding of the socioeconomic structure of neighborhoods. Herbert (1973, 74) proposed that the hypotheses may represent stages of growth. The concentric zone model represents the early stage when the city was more homogeneous in population and activities. Development and the reduction of social distance caused the neighborhoods to expand sectorally. Eventually a multiplicity of activities and the extension of transportation corridors induced the competition of other centers.

The Applicability of the Multiple Nuclei Model to the Caribbean

Since multiple nuclei are primarily associated with large cities, it is apparent that in an evolutionary scheme explaining land use change, the city will have had to experience extensive development for conditions to have occurred that made multiple muclei possible. Thus, the city that experienced both vertical and horizontal expansion would most likely exhibit such a configuration.

When models fail to predict spatial structural change, reasons include modifications of the present market system, the introduction of some artificial constraint on free-market forces of supply and demand, or the slowing down of urbanization. Increasing governmental intervention including such regulatory policies as planning and zoning ordinances can modify the expected zone or sector change. Even the spread of prosperity to other urban groups can result in decreasing social distance and cause residential neighborhoods to become heterogeneous (Robson 1969).

Johnston (1971, 195-196) noted that a major criticism of socio-economic evolutionary urban models of residential land use is the failure to account for cultural values that are important for individual examples; however, on a broad scale, these three hypotheses of urban spatial structure may serve as a baseline for generalizations about urban change.

An essential research area that remains to be adequately explored is the applicability of these theoretical constructs on a cross-cultural sweep, for general theory building requires that behavior be predictable under universally measurable conditions. In consideration of the common Western heritage and interaction among peoples of North American, it should be possible to expand our knowledge of urban experiences that share interregional similarities. Identifying such commonalities is a necessary step in isolating and identifying the general causes of urban change. Planning for this change in the Third World is becoming critical under the mounting pressures of urbanization in the Caribbean and Latin American and the future likelihood that the phenomenon will spread to Africa and the Far East. In the Caribbean as in the rest of the developing world, limited space and scarce resources will permit few mistakes in preparation for the societal changes that will accompany urbanization.

CHAPTER FOUR
INDENTIFYING LAND USES AND HOUSING CONDITIONS

Aerial Photography Data Base

In addition to being the largest city on the island of Hispañola, Santo Domingo is the regional capital and administrative seat of the National District which extends into a rural hinterland well beyond the metropolitan area. Local conditions and associated problems of a large city are of concern to officials of the municipality, but their proposals have not often taken precedence over regional and national considerations involving city resources. The need for boundaries which help define responsibilities of city departments and limit urban infrastructure has been recognized by national leaders. In September 1975, President Balaguer submitted a national commission's proposal for the city's future growth to the National Congress which included a message in which he explained that such a plan was needed to stem the horizontal spread of Santo Domingo.

The proposal included 16 articles, the first of which defined the city borders which enclosed an area of approximately 80 square kilometers. The third article called for the periodic revision of these limits, while the fourth specified the need for an inventory of land use. The most politically sensitive issue addressed in the proposal was the suggestion that land developers would have to pay for the extension of municipal services beyond the city borders.

For purposes of this research, the study area was extended beyond the national commission's recommendation in order to include developed land that appears on the aerial photographs as linked to the urban communications network and is close to the contiguously built-up city. The preliminary study area was 16 kilometers wide, stretching from the residential community of San Francisco in the west to Reparto Isabelita in the east, and 9 kilometers from the Caribbean coast to the Isabela River at Puente de Pontones. The site is about 144 square kilometers and is outlined in Figure 4-1.

Temporal and Spatial Framework

The aerial photographic coverage in 1948 and 1974 was selected for interpretation. Prior to World War II, most of the urbanized area was confined to the colonial center and contiguous land to the north and west of the old city walls, and included the communities of La Fe, Mejoramento Social, Naco, La Esperilla, and Villas Agrícolas. There was little development on to the east bank of the Ozama River, and the large airport impeded extension at the western edge. The earliest postwar photography, in 1948, was chosen as the base year for analyzing land use change in order to demonstrate the city's spatial patterns shortly before extensive areal growth occurred. The 1948 photography reveals a city limited to an area contained between the Andrews Air Force Base in the west and the Ozama River in the east, with a few, scattered buildings along the eastern bank of the river. The population of Santo Domingo is estimated to have been less than 250,000 in that year. The colonial center and the area to the north, in what was once a rural village called San Carlos, are the most clearly

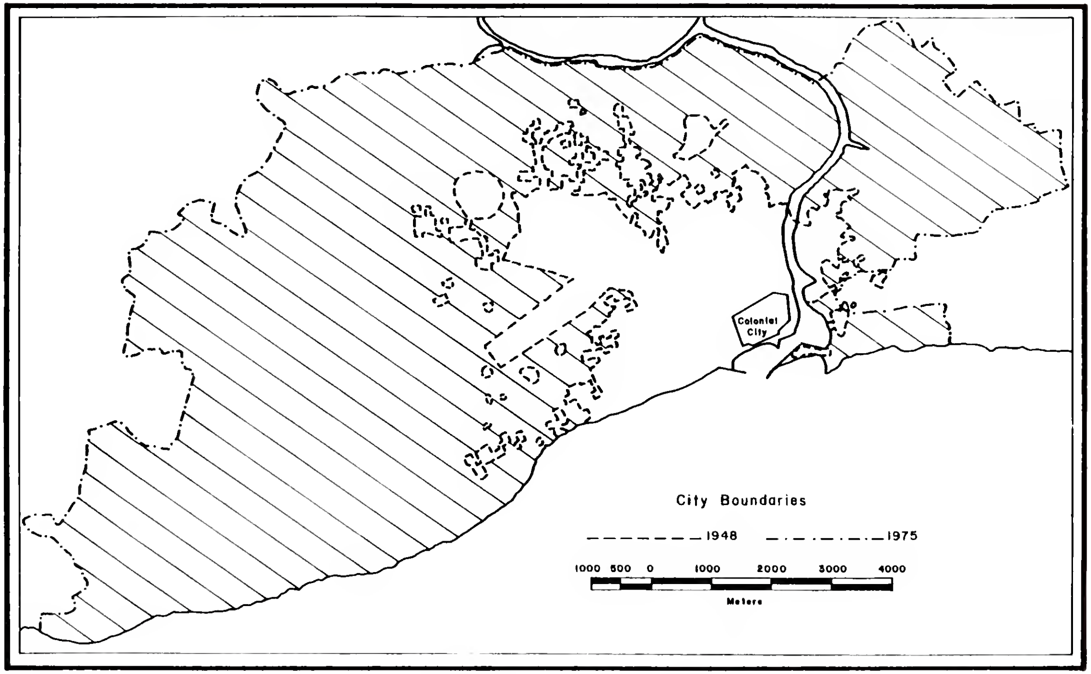

Figure 4-1: City Limits of Santo Domingo in 1948 and 1975

defined developed areas. The transportation network does not extend much beyond these except as unpaved streets with widely dispersed houses. Undeveloped plots are scattered throughout the build-up city lying outside the colonial walls.

In 1974, there were three times as many people living in Santo Domingo which covered an area five times as great. The airport had been removed, eliminating a major impediment to growth to the west. Paved streets, two new bridges which replaced the single span over the Ozama River, and portions of a circumferential highway were in evidence. Although there appeared to be less open space interspered with developed land, there was much undeveloped land at the edge of the built-up city.

Since land use information obtained by sampling the city was to be correlated with that obtained from the analysis of the aerial photography, it was necessary to devise a land use classification which would permit interfacing the survey data with the type of development, and indicators of socioeconomic level with the remote sensing information. The aerial interpretation was structured so that the land use categories would coincide with the field survey land use designations. There were three data bases: the 1948 and 1974 aerial photography and the 1975 field sample of streets in the capital. All land use information and a measure of distance from the site to a central point were aggregated into one-hectare cells of a grid system centered at the central business district. A 1973 city map of the transportation network served as a base map. Figure 4-2 shows the steps taken to analyze both the photography and field information. Interpretation of the former data bases produced land use and land use change maps. The

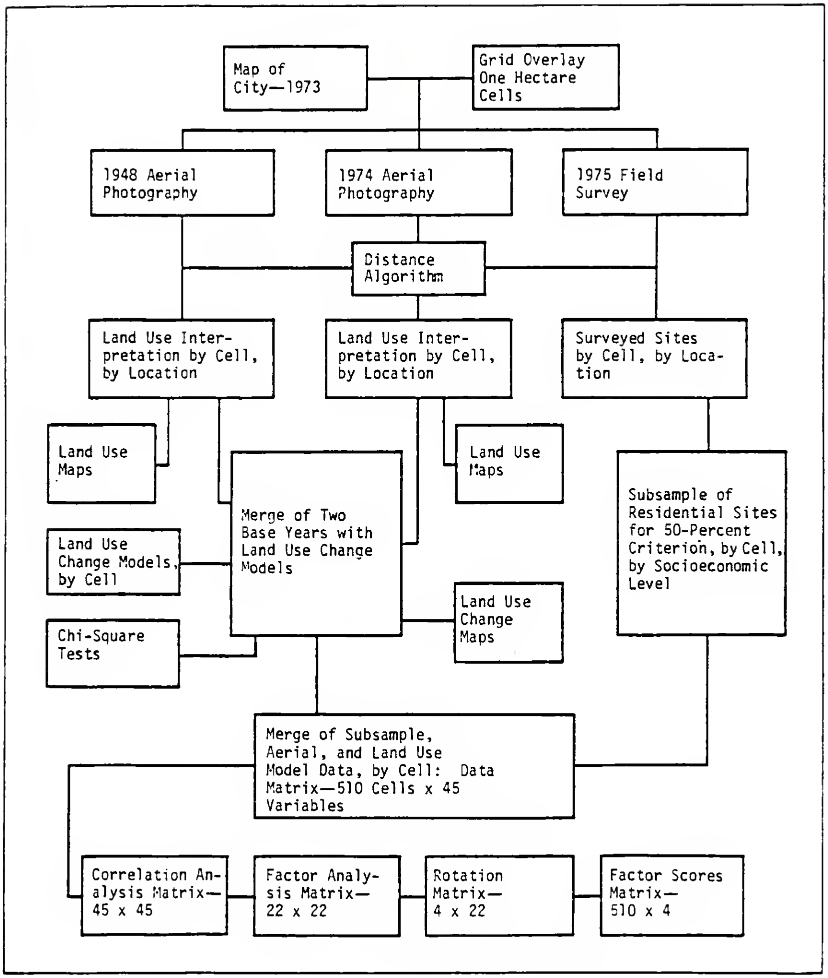

Figure 4-2: Flow Diagram of Research Methodology

field survey included more than 140 streets and over 9,100 sites, all of which were mapped. An overlay of hectare-sized cells was used to sort the data which were merged with the aerial photographic data. Factor analysis of residential land use produced three important factors defining socioeconomic levels of housing.

Five land use categories were selected: low-income residential, medium-income residential, high-income residential, open space, and other use, which was a combination of commercial, industrial, and public uses. The aerial photography was interpreted before the field results were analyzed, and the field sample variables were taken into consideration in establishing the residential land use groupings.

Mapping Criteria

Residential land use was segregated into three socioeconomic levels based on a variety of conditions which were included in the 1970 Population and Housing Census and which were believed to discriminate among the broad income levels. Previous work by Thruston (1953), Rapoport (1969), Cortén (1965), Openshaw (1969), Amato (1969), Johnston (1969), Eyre (1972), and Vernez (1976) suggests that there is a relationship between socioeconomic class and building materials used in the homes constructed for the occupant families. For example, the colonial-type house resembling the courtyard-centered structure familiar throughout Spanish America can be found in Santo Domingo. A large, several-storied, European-type house is found with a wide range of exteriors dictated by style changes over the years. The American ranch-style house is built by middle- and upper-income owners who desire the modern conveniences which accompany these residences.

Popular, multiple-family housing for middle- and high-income urbanites, often found in the center city in the form of high-rise buildings, offers the advantages of convenience and excitement so important to those who relish city life. Another housing opportunity for the middle-income families is public housing. Although ostensibly constructed for low-income families, nevertheless, public housing projects often become middle-income neighborhoods whose relatively affluent occupants, the bureaucrats, professionals, and technicians of a modernizing society, are much more desirable tenants than poor people with tenuous salaries.

Low-income housing varies considerably. Single-family, low-income homes are often simple, one-room shelters at first, usually no larger than 30 square meters and constructed of wood, recycled materials, and palm thatch. Subsequently, as the family income stabilizes, the occupants may improve their homes. Wooden and cardboard walls are replaced with concrete blocks, and the roofs are weatherized with galvanized steel sheeting. The dirt floors of the original homes are covered with cement. Cement is the most popular, least expensive building material for improvements which may include the addition of a kitchen and bedrooms, and even space for a small business. Eventually, the lot surrounding the homesite will be fenced to protect a garden plot. Over several decades, the home may increase in size three to four times. Community densities of 200 to 500 persons per hectare are not uncommon in low-income neighborhoods (Vernez 1976, 9-11).

Large poor populations often receive the attentions of municipal officials who were once disinterested in the problems of only a few needy families. The older, more permanent low-income communities have paved streets, curbing, sidewalks, schools, parks, and even sewer and water connections. In Santo Domingo, for example, electrical service is available throughout the metropolitan area and is the result of an ambitious national hydroelectric development program that is providing extensive if unreliable electrical service to the city. Although the lines may be illegally tapped, nevertheless, most low-income neighborhoods have power.

The residential land use categories were finalized after confirming that these features of housing were visible on the aerial photographs. Land use was determined for each cell of a grid overlay of hectare-size units positioned over the aerial photographs to coincide with a grid of units of equal area drawn on a 1973 city map prepared by the Geographical Institute of the Autonomous University. The following characteristics were used:

1. Low-income residential structures are small, usually less than 100 square meters; they have no landscaping and no evidence of automobile ownership; roofs are constructed of palm thatch or steel sheeting; they have few building edges (indicating a small number of rooms); they are closely sited with little or no open space between; they are close to a rectangular network of streets and connecting, serpentine pathways; there are few paved streets; there is frequent irregularity in building alignment. Where the majority of structures in the hectare could be so grouped, the use was deemed low-income residential.

2. Medium-income residential structures have concrete, tile, or asbestos roofs, there is much open space between buildings indicating moderate to low density per hectare; the structures may be landscaped; the lots are often fenced but do not include garden plots; there are driveways and carports; there are many edges to the structures; there is a regularity in the alignment of buildings and streets which often form a rectangular grid.
3. High-income residential housing is significantly different from the other two groups. There are very low densities, often one large building to a hectare; the structure has many edges, extensive landscaping, driveways and fencing; it is found in areas that have rectangular and curving street patterns that suggest much use of the automobile. Terrain that is sloping is desirable because of the privacy and ambience it affords, and the land is often heavily wooded. There is a general absence of commercial and industrial activity which includes parking for numerous automobiles, large buildings with few edges, proximity to well-traveled highways, pollution, and little landscaping.

Other use was the category with the greatest variety of activities, including government, commerce, manufacturing, and any other urban, nonresidential purposes. Indicators include high density of very large, many-storied structures with only a few edges, proximity to similar structures, much automobile parking space, extensive storage area, evidence of congestion and pollution, accessibility to transporation, large machinery, and absence of landscaping.

Open space is indicated by the absence of development. When over half of the unit area had ground cover, did not have paving, and was not included in the fenced site of a residence, then it was designated as open space.

Aerial Photography Interpretation

The grid overlay was centered at the Parque Independencia, the hub of the commercial center of the city, and each cell of the grid was given coordinates of longitude and latitude. These coordinates were used to compare land use over the 27-year period between photographic coverages.

While the 1974 photographs were scaled to the 1973 city map, the 1948 aerial photography required scale adjustments before a land use map could be compiled. The 1973 map of the city was photographically reduced to accommodate the larger scale of the older aerial photographs. The information was transferred to the 1973 city map. A final reduction of the map was accomplished in order to scale equally both land use maps for the land use analysis. As in the case of the 1974 land use data, each hectare cell was coded for coordinates and land use, and the data were stored for computer-assisted comparison and evaluation.

A final determination of the city boundaries was accomplished following the interpretation of the aerial photographic coverage and compilation of the 1974 land use map containing the location of each hectare of land use. One procedure would have involved connecting the "outside" edges of all developed land and designating this line as the city perimeter. The resulting boundary would have approximated the executive proposal included in the presidential degree of 1975.

To have used these limits, however, would have excluded some development that is of much interest but would have lain beyond the contiguously built-up area.

Land speculation is an important influence on urban development in the Caribbean. Land ownership and the economic advantages of keeping land undeveloped as the city expands are common in an island economy that tends to be inflationary. The land use map for 1974 indicated that defining the city limits on the basis of contiguity of developed land would have excluded significant expanses of residential land, including the marginal housing identified at the edge of the city, such as the communities of Katanga, Puerto Rico, Mandinga, and Villa Faro. The solution was to determine the outside limits of built-up area that was larger than five contiguous hectares in a particular land use category. All such developed land was connected at its outside edges to form the city boundary.

Field Survey

A field survey was undertaken in 1975 to characterize housing conditions in the city. The urban area was too large to permit a complete investigation of all housing, and, therefore, a stratified, unaligned random sample of housing was conducted. The sampling design included 10 percent of all streets involving nearly 150 streets ranging from a single block to many blocks in length (Figure 4-3). Avenida S. Bolívar was included in the sample, for instance, and this major thoroughfare extends from the Parque Independencia to the western edge of the city. The investigation of all housing along these streets provided reliable information about the number and type of structures,

Figure 4-3: Location of Streets Included in 1975 Field Survey of Santo Domingo

the land uses, building construction materials, indicators of socio-economic status of the occupants of residences, the condition of streets including curbing and sidewalks, traffic congestion, and pollution.

A key objection of the research was to determine land use, especially residential land use, and it was assumed that, controlling for the independent influences of such factors as socioeconomic status, each newly arrived city inhabitant theoretically could find housing anywhere within the urban confines. The mix of residents was presumed to result from independent decisions related to income level, education, employment, life-cycle stage, family size, marital status, and similar situations in which people exhibiting similar socioeconomic status aggregate. There are socioeconomic differences when comparing a hectare of high-income residential land use in the city center with high-income status in residential land use at the suburban fringe. This research effort is at a more generalized level, however, and seeks to identify gross distinctions between residential land use whicn would allow comparisons to be made between Anglo-American and Caribbean urban land use.

The urban area of Santo Domingo is generally subdivided into lots of about one hectare. Land is sold in square-meter increments. The colonial unit of measurement of one <u>solare</u> was slightly more than 100 meters and the old portions of the city reflect a subdivision pattern of blocks 100 meters in length. It was decided that the hectare, 100 meters in length, would be the most efficient measurement unit for the field survey.

The sample size may be determined by estimating the population parameters. For a degree of accuracy equal to 0.05 percent for one-half of the normal curve, or a total interval width of 0.10, the formula for estimating the population is

$$\bar{X} \pm 1.96 \ (\sigma \ / \ \sqrt{N}).$$

and

$$0.10 = 1.96 \ \sigma / \ \sqrt{N}.$$

Solving for N,

$$N = (1.96 \ \sigma \ / \ 0.1)^2,$$

and σ is to be estimated from the sample data. The estimate of the standard error of the mean, σ, is obtained from the Student's t distribution. The degrees of freedom are ∞ since, for testing purposes, this is nearly accurate. A level of confidence of 0.95 is acceptable; most morphological research has had lower levels, and, although direction is expected to be predictable, a two-tailed test will be used. Thus, at 0.95 confidence and a two-tailed test, the sample size will be

$$N = (1.96 \ \hat{\sigma} \ / \ .1)^2,$$

$$N = ((1.96 \times 1.96) \ / \ .1)^2,$$

and

$$N = 1{,}476.$$

The sample size would have to be 1,500 structures.

The mix of structures and land use in Santo Domingo is heterogeneous. A preliminary investigation of the city done by automobile indicated that residential use was homogeneous on a block-by-block basis, this regularity often continuing for many blocks along the street. It is more efficient to use the stratified sampling procedure where there appears to be greater homogeneity within than between aggregates (Harvey 1969, 352). Spatial sampling can include random collection from an infinite number of points comprising the area, or it can consist of a finite number of small areal units which make up the total.

The research includes sampling traverses that extended the full length of any particular street sampled. Because of the linear trend of development and of land use associated with the accessibility which accompanies the networks of streets, pathways, and highways that dissect the city, the stratified sample was based upon the city atlas published by the National Police. A 10-percent random sample of more than 1,400 streets was drawn from the atlas. Each traverse was field surveyed, structure by structure. The field survey measured 40 variables including all structures, the external condition of the buildings, the type of building materials used in walls and roofing, the number of floors, the outward appearance including landscaping, evidence of automobile use by the occupants, the additional activities of a commercial or professional nature in a residence, the street conditions, and whether the area exhibited congestion and deterioration. Each block was determined by intersecting streets or the terminus and an intersection. The information was recorded on tally sheets, similar to Table 4-1, identified by the name of each intersecting street.

The purpose of the field survey was to group land use into five general categories: residential, governmental, commercial, industrial, and open, or underdeveloped. The residential land use category included a seemingly endless assortment of housing types, especially in the poorest areas of the city where almost any discarded materials would be pressed into service as shelter. Apparently, building materials are dependent upon the inventiveness of the occupants. Outside the

Table 4-1: Field Survey Instrument for Recording Land Use and Building Conditions in Santo Domingo

Residential				
Single Family				
Multiple Family				
Apartment				
Improvised				
Governmental-Institutional				
Commercial				
Industrial				
Open Space				
Structure—Walls				
Concrete				
Cement Block				
Wood				
Palm				
Galvanized Steel Sheeting				
Brick				
Limestone-Colonial				
Structure—Roof				
Concrete				
Galvanized Steel Sheeting				
Asbestos				
Tile				
Yagua-Cana				
Number of Floors				
One				
One and One-Half				
Two				
Three				
Four				
Five or More				
Landscaping				
Recently Painted				
Driveway				
Carport				
Louvered Windows				
Grated Windows				
Fenced Property				
Professional-Commercial Use				
Street				
Congested				
Sidewalks				
Curbing				
Pavement—Good				
Pavement—Poor				
Clean				

marginal settlements, however, low-income persons tended to occupy long wooden structures which housed four or more families, each household possessing several rooms and a doorway facing the street. These multiple-family structures contrasted with middle- and upper-income apartments which more closely approximated those found in Anglo-American cities. Whenever the structure varied from the single-family residential home, it was necessary to determine its predominant use, and this was accomplished by ruling out public, commercial, or industrial activities, by interviewing the occupants, checking for multiple mail boxes, listening for the sounds of playing children, looking for drying laundry, observing pets roaming the hallways, and other manner of information-gathering strategies.

Public housing was conspicuous for its uniformity. The national government sponsored construction of urbanizaciones, or projects, which were composed of housing types, e.g. "type A" or "type B." These were blueprint structures that were found throughout the more recently developed sections of the city in public housing projects. Other middle-income apartments were distinguished from tenements by their general state of good repair and cleanliness, lack of open doorways and unemployed, poorly dressed occupants, and absence of children, who were assumed to be in school.

There was little difficulty in separating commercial from either public/governmental or industrial use. In the downtown commercial center, the main avenue was surveyed structure by structure on each floor, and the dominant use noted. There were many structures in primarily residential areas which included small stores or offices. Other observations included whether there was evidence of fresh paint, an indication of expenditures for upkeep which helps to distinguish low- from middle-income housing. If, at the time of the survey of streets, which occurred between 8:00 A.M. and 7:00 P.M., there were trucks and buses passing along, if many cars were present, and if the consequent noise made hearing normal conversation difficult, the street was determined to be congested at that site. The major avenues and main government buildings in much of the commercial colonial center were often congested. Heavy traffic and associated noise were prevalent in some residential areas, as well, even in front of the private home of the president of the republic.

Each of 140 streets was surveyed. The linear trend of this kind of investigation introduces serial correlation. To control for the regularity in the data, one-half of all data sites were randomly selected for the data analysis. The stratification allowed the number of sites in each block to remain the same proportionally while minimizing spatial auto-correlation (Harvey 1969, 363).

The field survey data for 40 nominal and ordinal scale variables were stored in a computer by plotting the 140 streets on the city map, overlaying the cell-grid system of hectares, and determining the location of each site. Since the field data were collected and recorded geographically, each site could be located on the city street network between intersecting streets, in sequence, according to the order of data collection. The surveyed sites could be readily assigned the longitude and latitude of the grid overlay. However, where streets were oblique to the grid, it was necessary to interpolate the location. The location designation became the grid coordinates that were closest to more than one-half of the sites lying between the recorded intersections. The result was that all field sites were relegated to a total of 757 hectares of land within the grid overlay. A simple algorithm was employed to add another variable of distance from the cell center to an arbitrary city focus at the Parque Independencia, where much urban activity is concentrated.

Residential Land Use Definition of the Field Sample

Much of the developed land was residential, but the general absence of land use controls in the city resulted in mixed uses in the field survey sites. A residential land use category would not be obvious since it might range from strictly housing to only 14 percent housing. The field investigation results required some criterion for designating the predominant land use before progressing to the analysis of the field results.

Limiting the residential land use designation to these field survey cells containing only homes would have been misleading since the number of residential cells would have amounted to 333 out of the total survey count of 757 cells. Where all the structures were residential, 44 percent of the surveyed city would be considered as residential.

Establishing a land use designation for each cell where there were several uses present would have required determining the proportional relationship and weighing the consequences of accepting a land use mix that might fall somewhere within 14-99 percent (which represented the range of the proportion of housing to other structures in a cell). As the field survey data identified the number of structures by activity, it was possible to compute the percentage of total structures in the hectare which were residential. There is no "correct" mixture of land uses to guide one in assigning to each cell of the grid a particular land use category. The problem was to arrive at the most reasonable proportion of residential use to other uses.

The proportion of residential to nonresidential structures in any cell was determined by the following equations:

$$RES = \text{Single Family} + \text{Multiple Family} + \text{Apartment} + \text{Improvished Housing}$$

$$RES\% = (RES / (RES + INT + COM + IND)) (100)$$

The number of residential structures (RES) was the total of all housing in a hectare cell. The percentage of residential land use within the hectare (RES%) was calculated by dividing the total number of residential structures by all structures, including public (INT) and commercial (COM) and industrial (IND) structures also found in the cell. The percentage conversion was obtained by multiplying the resulting proportion by 100.

Therefore, once the field survey cell was determined to be developed land, the proportion of residential sites to all sites within it was used to arrive at a land use designation. Beginning with 14 percent (the smallest proportion of residential to nonresidential structures in any hectare found to contain housing), increasing proportions of residential to nonresidential structures were computed to determine at what level most or all field-surveyed land would be included which had some housing present in 1975. The field-survey cells were compared with the 1974 aerial interpretation. Table 4-2 indicates the results of the analysis. At a criterion of 25 percent residential, 658 hectares (or 87 percent) with some housing were in agreement.

Table 4-2: Proportions of Land Use for Residential Designation, in Cells/Hectares by Comparison of Two Data Bases: 1974 Aerial Photography and 1975 Field Survey

Minimum Percentage Residential Structures	Number of Cells[a]	Number of Cells Non-residential Both Bases	Aerial Base/ Residential Cells			"Growth" Field/ Residential Aerial/Non-residential	Number of Cells Residential Both Data Bases	Number of Cells Growth and Two Bases	Total Number of Cells Analyzed
			Field Base < 100% Res. Struc.	Field Base 100% Res. Struc.	Field Base Non-residential Structures				
25	757	39	187	333	58	138	520	658	755
30	757	39	187	333	58	135	520	655	752
50	749	39	179	333	58	130	512	642	739
75	700	39	130	333	58	112	463	575	672
100	333	0	0	333	0	0	333	333	333

[a]The number of cells differs from the total number of cells analyzed due to inclusion of two which had less than 24 percent residential structures; eight cells were included due to disagreements in city boundaries.

This assumes that housing growth over the nearly one year that elapsed between the aerial coverage and the field sampling included the development of open land for housing purposes. Such an assumption is not unreasonable because of the rapid appearance of marginal housing. Just one such settlement, Buenos Aires in the western extreme of the city, is at least twice as large as the surveyed area of 658 hectares and much of its growth occurred after 1968.

The 138 hectares which changed from nonresidential to residential over the year amount to less than 2 percent of the urban area. If residential land area expanded at a rate to accommodate the exisitng density, developed land area would have had to increase 5.94 square kilometers over the year. But it is known that marginal settlements absorb large numbers of newly arrived inhabitants. Furthermore, land that may be designated other than residential can include large numbers of residences. Thus, one hectare of land containing tens of small shacks sheltering hundreds of people, crowded against a concrete wall surrounding a huge mill, will be designated as industrial on the basis of area.

Another 58 hectares were designated as residential in the field sample but were interpreted as nonresidential. Undoubtedly, some of these cells included instances of land clearance for other development over the year that elapsed between the aerial reconnaissance and the field survey. There is the presumption that interpretation error occurred, that structures which appeared to be residential were not so when examined in the field survey.

Land conversion was infrequent. The city population doubled in each of the post-World War II decades, a rate exceeding 6 percent since 1950 (Durand and Paláez 1965, 179; World Bank 1972, 185). There is little vertical construction. The city area expanded at a continuous annual rate of 6.5 percent over the 1948-1975 period. The built-up area increased over 400 percent, from 17.09 square kilometers (10.62 square miles) to 91.45 square kilometers (56.82 square miles). Much of this expansion occurred during the rapid economic growth period that followed the end of the 1965 civil war.

The 58 hectares were grouped into 15 hectares of industrial use, 8 hectares of commercial use, and 35 hectares of open space. Over 60 percent of the area in disagreement was undeveloped at the time of the field survey. The proportion of open space to other land uses as determined in the aerial interpretation is about the same, suggesting a consistent error in the interpretation.

The largest group of cells in disagreement, open space versus residential, was analyzed. Most of the interpretation errors were among cells that had middle- and high-income residential use. Thus, the higher the income level of the occupants, the more often the field survey indicated that the land was undeveloped. This raised the question of whether interpretation errors were due to the low density of the higher income, residential land use which made distinguishing between the two uses more difficult. Mapping all 58 cells did not reveal patterns that would suggest another explanation for the disagreement between the two data sources.

Another 187 hectares of land were interpreted as residential and found to have varying degrees of nonresidential use interspersed with housing. The analysis of these cells indicated that over 80 percent of the nonresidential use was commercial, followed by 16 percent institutional, and 2 percent industrial. Experience in the field indicated that where the land use mix was often residential, commercial use was usually corner convenience stores.

Based upon the comparison of the two data bases, Table 4-2 indicates that 520 hectares had some housing and were designated as residential as a result of the aerial photography interpretation. Therefore, over 90 percent of the land common to the two data sources was in agreement as to land use. In 333 hectares, there was no other use indicated other than residential.

A comparison of the aerial photography and field data was made in order to ascertain the degree of confidence that could be placed upon the residential classification. Because the sample size is quite large, the central limit theorem applies where the distribution of the sample means approaches normality. The text of proportions can be seen as a special instance of such means, involving a simple, dichotomized, nominal-scale sample. By assigning a value of one to residential cells, and zero to nonresidential cells, the scores can be treated as an interval scale not requiring the determination of the exact difference between the degree of residential versus nonresidential treatment. Because all cells are concentrated into a bimodal distribution, normality is not present; however, with the large sample size, the distribution of sample means will be approximately normal. The mean of this population of values of one or zero is their sum divided by the total number of cells. The number of residential cells is the total number of cells multiplied by the proportion that are residential.

With the use of the 50-percent criterion for designating residential land use (where there was a land use mix of housing and other activities within the cell), there were 739 hectares included in the analysis. Of these, 45 percent were entirely residential in both data sources; 179 hectares were interpreted as residential in the aerial photography but found to have a mixture of uses in the field survey. Fifty-eight cells were nonresidential in the field survey but residential in the interpretation. Another 130 cells were just the opposite, i.e. nonresidential in the photography and residential in the field survey. Thus, out of the total sample size of 739 cells, 333 plus 179, or 512 cells, could be classified as residential in both data bases. The initial hypothesis, that no significant differences existed between the population proportion of residential cells and the sample proportion of residential land use, was tested.

The test was the single sample of proportion. The test statistic, the Z score, is computed from the formula

$$Z = (p_s - q_u) \;/\; \sqrt{(p_u q_u / N)}$$

where the proportion of residential hectares in the aerial interpretation is p_u, the remaining proportion of cells is q_u, and the proportion of area in housing in the field survey is p_s.

The Z score for the proportion of residential cells that were in agreement in both data sources and were entirely residential was not significant at the .01 level for a critical region of a one-tailed test.

The initial hypothesis that there were no significant differences of proportion was not rejected. The possibility that other percentages of housing to nonresidential structures in a hectare were significant remained to be tested.

Beginning with 95 percent and decreasing at 5-percent intervals, the other proportions were tested. At the 85-percent level, the test was significant; the difference of proportions between the sample survey and the aerial photography was great enough to conclude that it was probable that land found to be residential in 1974 would not be completely residential in the next year.

Most land use studies of Anglo-American cities have concluded that residential land use is approximately one-half of the total developed urban space. Where suburbanization has been a long-term occurrence, land use sorting will have reduced housing in the center city which is replaced by nonresidential uses. The suburban cities, on the other hand, contain higher proportions of residential land use.

In Santo Domingo where land use controls are weak or nonexistent, the proportion of residential to nonresidential use should be lower. A wide dispersal of housing in heterogeneous communities is more likely, and unless the suburbanization process has been a significant influence, there should be few exclusively residential areas.

The 50-percent criterion included 87 percent of field survey cells. Most of the sample is included in the analysis: 739 of the 757 surveyed cells. Choosing a lower proportion would have expanded the number of residential cells only slightly while including those that would obviously be better classified as commercial, industrial, or another nonresidential use. At a higher proportion, too many cells would be excluded from consideration in the analysis.

The 50-percent criterion for the minimum proportion of housing to nonresidential structures in a cell became the basis for tabulating averages. Each field variable was summed for all cells, and an average, median, and range of values were calculated based upon the sample size of 739 hectares.

Both the concentric zone and sector models of urban change emphasize residential land use. In order to test the probability that one configuration was more applicable to Santo Domingo's growth, it was necessary first to delimit probable zones and sectors of homogeneous residential land use. This required an examination of the 1948 and 1974 land uses and transportation networks to determine the areas of greatest discontinuity of activities where zone and sector limits would be indicated.

CHAPTER FIVE
TESTING URBAN ECOLOGICAL THEORY

Allocating Zone and Sector Location

If the city experienced succeeding waves of growth radiating outward from a central business district, then Santo Domingo's housing would exhibit some aggregation into zones in which the within-zone variation in housing type would be less than that between zones. The Park-Burgess concentric zone model suggests a socioeconomic gradient of housing with the poor located near the CBD and in a transition zone containing tenements and other low-income rentals. Farther from the center of the city are middle-income homes which are superceded by high-income residences as the distance from the central business district increases. Santo Domingo's residential land use does not resemble the ideal model, however, since it is sited at the Caribbean coast which has prevented the complete evolution of a circular pattern.

The land use data analysis confirmed the clustering of both low- and high-income housing and dispersal of medium-income housing. Therefore, utilizing an average distance for each type of housing would not delimit the probable zones. A comparison of land use over the 28-year period, shown in Figure 5-1, revealed that the least change in land use was concentrated at approximately 1,000 and 2,500 meters from the city center established at the Parque Independencia. Concentric zone theory would argue that the boundary areas between zones would

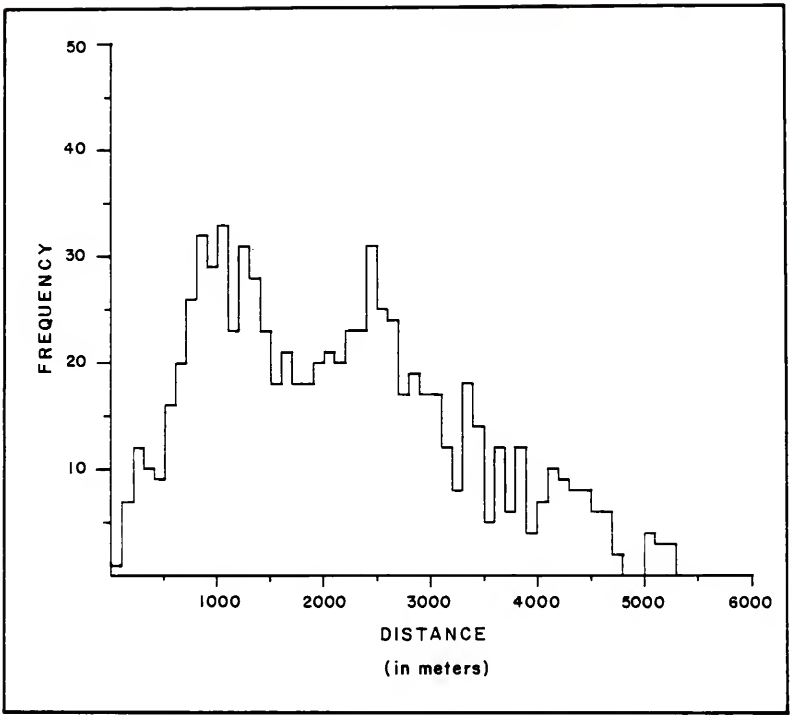

Figure 5-1: Frequency in Hectares, of Stable Land Use, 1948-1975, by Distance from the City Center

experience greatest instability. For Santo Domingo, then, the zonal boundaries would be indicated between the stable modes. The inner limit of the first zone was established at 1,000 meters, and it was assumed that low-cost housing lay beyond a radius of 1,750 meters from the CBD, or one-half of the distance between this and the other stable mode.

As Table 5-1 shows, 542 meters separated the average distances for medium- and high-income housing. One-half of the distance, 271 meters, was added to the average distance of high-income housing, 4,741 meters from the city center, and this distance of 5,022 meters was designated the boundary between high- and medium-income residential land use. The boundary between low- and high-cost housing was one-half the distance from this to the inner limit of low-income housing. All that remained was to establish a maximum extent of the outward reach of residential land use. Since the open land averaged 7,000 meters distant from the CBD, medium-cost housing was extended approximately 1,700 meters to equal the distance arrived at between the boundaries of low and medium income.

The final zone configuration is shown in Figure 5-2. The zones, including their ranges, are

Zone 1 - Other land use, 0 to 1,674 meters;

Zone 2 - Low-cost residential land use, 1,675 to 3,348 meters;

Zone 3 - High-cost residential land use, 3,349 to 5,022 meters;

Zone 4 - Medium-cost residential land use, 5,023 to 6,696 meters;

Zone 5 - Open land use, 6,697 to 11,700 meters, at the western extreme of the city.

Table 5-1: Compilation of Land Uses and Distances from City Center, Aerial Photography for 1974 and 1948

Aerial Data	Low-Income Residential	Medium-Income Residential	High-Income Residential	Other Uses	Open Space
Area in 1974 in Hectares	2,076	1,374	983	1,944	2,768
Mean Distance in Meters	4,676	5,292	4,751	4,555	6,936
Range, Minimum, in Meters	316	282	282	0	100
Range, Maximum, in Meters	11,992	11,986	12,614	11,412	12,212
Area in 1948 in Hectares	370	147	236	835	121
Mean Distance in Meters	2,023	2,031	1,395	2,571	1,933
Range, Minimum, in Meters	400	282	223	0	100
Range, Maximum, in Meters	4,904	5,220	3,905	5,375	3,982

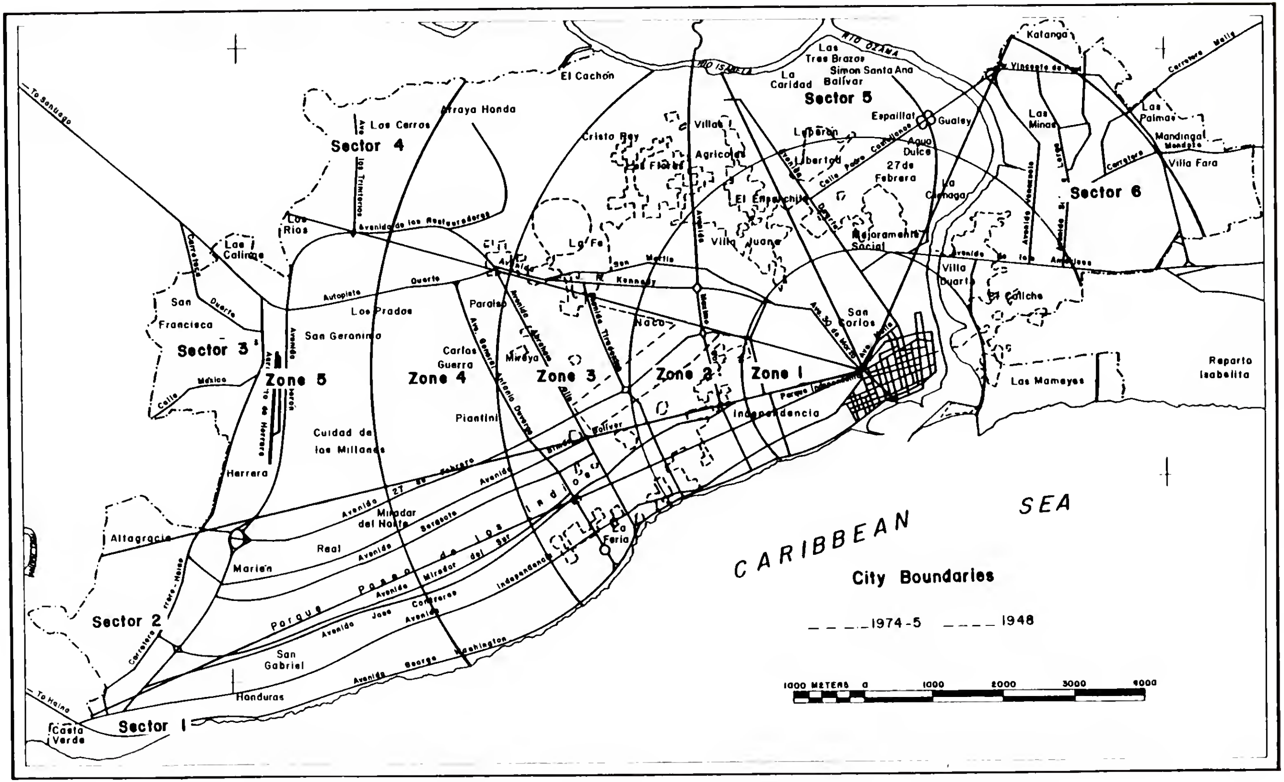

Figure 5-2: Location of Zone and Sector Model Configurations on Map of City

Establishing sectors was less complex. Hoyt hypothesized that sector boundaries, influenced by topography and evidenced in the location of major transportation-communication corridors, continue to grow with outward expansion of the city. Growth of residential neighborhoods became dependent upon the corridors for continued accessibility to central business district activities. McElrath's (1962) study incorporated 10 sectors which were found to be too many. Johnston (1971, 334) concluded that linear gradient change as evidenced in within-zone heterogeneity was best controlled utilizing only a few sectors.

Both the land use and the city maps, as well as the field experience, suggested that six sectors would be needed to differentiate land use sufficiently to test the applicability of the sector model. These six, bounded by the coastline, the river, the limestone terraces, and the major avenues, are as follows (Figure 5-2):

Sector 1 - Caribbean Sea and Avenue J. Contreras;

Sector 2 - Avenue J. Contreras and Avenue S. Bolívar;

Sector 3 - Avenue S. Bolívar and Avenue S. Martín;

Sector 4 - Avenue S. Martín and Avenue J. Duarte;

Sector 5 - Avenue J. Duarte and the Ozama River;

Sector 6 - Ozama River and the Caribbean Sea.

The least elevational change is found in Sector 1. The second sector rises from 10 to 25 meters, while Sector 3 has the highest elevation found along the limestone terraces extending east to west parallel to the sea. The remaining sectors, 4, 5, and 6, range from 50 meters to sea level and include steeply sloping land in the deep arroyos in the northwest corner of the city, along the riverbanks, and at the seacoast.

The two model configurations were superimposed on the 1948 and 1974 land use maps. Every hectare was assigned both a zone and sector designation; thus, any cell of land as determined in the 1974 land use mapping was given a location in the grid, and all other cell characteristics were associated by this location variable. Many of the land use cells comprised the five zones which crossed all the sector boundaries. Most of the sectors contained portions of all five zones.

Testing the Models of Land Use Change

In the assessment of the zone and sector models, the residential land use determined by aerial interpretation represented the population of all such land use in the two base years. The field survey of 10 percent of all land use in the city included 739 of the 9,145 hectares of urban land. A merge by cell of two data bases resulted in the selection of 512 hectares established as residential in the 1974 aerial photography and having at least 50-percent residential in the field survey. The allocation of every hectare in the city to one of five concentric zones and six sectors meant that each hectare of urban land could be given scores for its location in both a zone and sector.

Total residential land use in the 1975 field survey data base was sufficiently large, at 512 hectares, to be tested as representative of the entire city. The 512 hectares were 12 percent of the 1974 residential land area. The field survey information was grouped into low-, medium-, and high-income land use as established by the aerial interpretation, and the frequencies were recorded in a matrix of land use type (Table 5-2). The zones were the rows and the sectors were the column figures in the initial 5 x 6 matrices for each of the three residential land use types.

Table 5-2: Frequency Matrix of Field Survey, 50-Percent Criterion, for Zone and Section Models, by Residential Land Use Type

Zones		Sectors						
		1	2	3	4	5	6	Totals
Low-Income Residential	1	3	0	0	2	5	7	17
	2	0	0	0	26	18	29	73
	3	0	0	1	19	43	38	101
	4	0	4	3	0	0	6	13
	5	4	0	19	0	0	0	23
	Totals	7	4	23	47	66	80	227
Medium-Income Residential	1	10	0	0	1	0	0	11
	2	5	2	4	3	14	12	40
	3	4	0	5	8	5	21	43
	4	12	3	4	0	0	5	24
	5	7	40	33	0	0	0	80
	Totals	38	45	46	12	19	38	198
High-Income Residential	1	12	9	7	5	0	0	33
	2	9	3	5	0	0	0	17
	3	0	2	11	0	0	0	13
	4	1	2	4	2	0	0	9
	5	5	6	1	2	0	0	14
	Totals	27	22	28	9	0	0	86

The chi-square test is a general procedure that can be used to evaluate whether these frequencies of grouped, empirically collected data differ significantly from expected frequencies. Several assumptions were involved. These included random sampling, independent selection, and equal proportions. Expected frequencies were calculated for each contingency problem involving a land use type. The resulting matrices are given in Table 5-3.

Since housing sites can range from very small to all-inclusive plots within a hectare and theoretically could encompass an entire zone or sector, any matrix cell could have a wide range of possible values. However, since land development tends to reflect a much more limited range, the cell frequencies are whole numbers of low value, the result of a measurement unit that forced a single land use cell designation. A random sorting of the field data would result in a matrix of 30 cells in which all land would be evenly distributed. Deviation from the expected frequencies was tested using the chi-square test of significance. Its use required a correction for continuity in order to ensure that the sampling distribution approximates the sampling distribution of the chi-square table. Generally, the fewer the number of matrix cells and more nearly equal the marginal totals, the smaller the sample size must be, but whenever any of the expected frequencies is less than six, it becomes necessary to make some adjustment (Blalock 1972, 285-286; Taylor 1977, 110). In practice, such an adjustment involves combining categories in a rational manner in order to reduce the number of matrix cells by combining where frequencies number less than six. Rather than exclude field data and in consideration of the influence that topography

Table 5-3: Expected Frequency Matrices for Field Data, 50-Percent Criterion, for Zone and Sector Models, by Residential Land Use

Zones		Sectors 1	2	3	4	5	6	Totals
Low-Income Residential	1	0.5	0.5	1.7	3.5	4.9	6.0	17
	2	2.3	1.3	7.4	15.0	21.2	25.7	73
	3	3.1	1.8	10.2	20.9	29.4	35.6	101
	4	0.4	0.2	1.3	2.7	3.8	4.6	13
	5	0.7	0.4	2.3	4.8	6.7	8.1	23
	Totals	7.0	4.0	23.0	47.0	66.0	80.0	227
Medium-Income Residential	1	2.1	2.5	2.6	0.7	1.1	2.1	11
	2	7.7	9.1	9.3	2.4	3.8	7.7	40
	3	8.3	9.8	10.0	2.6	4.3	8.3	43
	4	4.6	5.5	5.6	1.5	2.3	4.6	24
	5	15.4	18.2	18.6	4.9	7.7	15.4	80
	Totals	38.0	45.0	46.0	12.0	19.0	38.0	198
High-Income Residential	1	10.4	8.4	10.7	3.5	0.0	0.0	33
	2	5.3	4.4	5.5	1.8	0.0	0.0	17
	3	4.1	3.3	4.2	1.4	0.0	0.0	13
	4	2.8	2.3	2.9	0.9	0.0	0.0	9
	5	4.4	3.6	4.6	1.5	0.0	0.0	14
	Totals	27.0	22.0	28.0	9.0	0.0	0.0	86

and accessibility play in land use, several possible borders were tried in delimiting the sectors and assessing the resulting impact on the cell frequencies. As Table 5-4 indicates, it became resonable to combine smaller sectors, which failed to discriminate among the sectors. In a like manner, some zones had little or no influence upon residential location and were eliminated by recombination.

After the final matrices were compiled, and expected frequencies were calculated (Table 5-5), each land use was tested to determine whether a significant difference existed between the zone and sector models in terms of the land use type. The test statistic requires that the expected frequencies be calculated for each cell of observed hectares of that land use under investigation. The observed frequencies represent the extent to which this is incorrect, for, in the case of a residential land use type, the observed and expected frequencies would be equal when the zonal configuration does not preclude the simultaneous presence of the sector pattern.

Chi square was computed for each residential land use by the formula

$$\chi^2 = \sum_{i=1}^{r} \sum_{j=1}^{c} \frac{(O_{ij}-E_{ij})^2}{E_{ij}}.$$

The degrees of freedom are equal to the number of columns in the final matrix of each land use less one lost for the single element to the right side of the equation. A conservative level of significance of .001 was chosen.

The test statistic was significant for low-income and medium-income residential land use. High-income residential land use displayed

Table 5-4: Final Frequency Matrices for Field Data, 50-Percent Criterion, for Zone and Sector Models, by Residential Land Use

	Zones	Sectors				Totals
		1-3	4	5	6	
Low-Income Residential	1-2	3	28	33	36	90
	3-5	31	19	43	44	137
	Totals	34	47	66	80	227
	Zones	Sectors				Totals
		1	2	3-4	5-6	
Medium-Income Residential	1-2	15	2	8	26	51
	3	4	0	13	26	43
	4	12	3	4	5	24
	5	7	40	33	0	80
	Totals	38	45	58	57	198
	Zones	Sectors				Totals
		1	2	3-6		
High-Income Residential	1	12	9	12		33
	2-3	9	5	16		30
	4-5	6	8	9		23
	Totals	27	22	37		86

Table 5-5: Final Expected Frequency Matrices for Field Data, 50-Percent Criterion, for Zone and Sector Models by Residential Land Use

	Zones	Sectors				Totals
		1-3	4	5	6	
Low-Income Residential	1-2	13.5	18.6	26.2	31.7	90
	3-5	20.5	28.4	39.8	48.3	137
	Totals	34.0	47.0	66.0	80.0	227
	Zones	Sectors				Totals
		1	2	3-4	5-6	
Medium-Income Residential	1-2	9.8	11.6	14.9	14.7	51
	3	8.3	9.8	12.6	12.4	43
	4	4.6	5.5	7.0	6.9	24
	5	17.3	18.2	23.4	23.0	80
	Totals	38.0	45.0	58.0	57.0	198
	Zones	Sectors				Totals
		1	2	3-6		
High-Income Residential	1	10.4	8.4	14.2		33
	2-3	9.4	7.7	12.9		30
	4-5	7.2	5.9	9.9		22
	Totals	27.0	22.0	37.0		86

a clear pattern of zonal expansion on the land use maps, but there was no indication of this in the chi-square statistic. Another combination of zones and sectors was attempted. The matrix was reduced to represent a reasonable alternative to the initial configuration. Again, the test was not significant. However, because the value for chi square was very near the acceptable limit for rejection of the null hypothesis and because the sample size for high income was the smallest of the three land uses tested, it was decided to consider all the land use as identified in the aerial photography.

The initial matrix of high-income use as given in Table 5-6 was reduced to that shown in Table 5-7. At the .001 level, the null hypothesis was rejected, indicating that in the population of high-income residential land use, there was an important difference between the zone and sector models.

Testing the Models for 1948 Residential Land Use

The area of the city in 1948 was considerably smaller than in 1974-1975, with the result that there were fewer hectares of residential land to be included in the analysis of the relative importance of the zone and sector models in explaining change. Since the cells of urban land were the same in either year, it was only necessary to merge the zone and sector designations with the land use map for 1948, and each hectare was assigned both a zone and sector score. The matrices of observed frequencies shown in Table 5-8 in several instances contained less than six observations. This was especially true with the zonal configuration, for only the first through third contained sufficient developed land to be included. It is permissible to combine

Table 5-6: Initial Observed and Expected Frequency Matrices for High-Income Residential Land Use, for Zone and Sector Models, 1974 Aerial Photography

		Sectors						
	Zones	1	2	3	4	5	6	Totals
Observed	1	40	19	40	15	0	0	114
	2	38	29	66	0	0	0	133
	3	0	12	50	1	0	1	64
	4	3	29	100	75	0	0	207
	5	61	67	23	30	0	0	181
	Totals	142	156	279	121	0	1	699
		Sectors						
	Zones	1	2	3	4	5	6	Totals
Expected	1	23.2	25.4	45.5	19.7	0	0.2	114
	2	27.0	29.7	53.1	23.0	0	0.2	133
	3	13.6	14.3	25.6	11.1	0	0.1	64
	4	42.1	46.2	82.6	35.8	0	0.3	207
	5	36.8	40.4	72.2	31.3	0	0.3	181
	Totals	142.0	156.0	279.0	121.0	0	1.0	699

Table 5-7: Final Observed and Expected Frequency Matrices for High Income Residential Land Use for Zone and Sector Models, 1974 Aerial Photography

	Zones	Sectors 1	Sectors 2	Sectors 3	Sectors 4-6	Totals
Observed	1	40	19	40	15	114
	2	38	29	66	0	133
	3	0	12	50	2	64
	4	3	29	100	75	207
	5	61	67	23	30	181
	Totals	142	156	279	123	699
Expected	1	23.2	25.4	45.5	20.1	114
	2	27.0	29.7	53.1	23.4	133
	3	13.0	14.3	25.6	11.3	64
	4	42.1	46.2	82.6	36.4	207
	5	36.8	40.4	72.2	31.9	181
	Totals	142.0	156.0	279.0	123.0	699

Table 5-8: Frequency Matrix of 1948 Residential Land Use, for Zone and Sector Models

	Zones	Sectors 1	2	3	4	5	6	Totals
Low-Income Residential	1	0	0	3	30	86	22	141
	2	0	0	0	113	23	68	204
	3	0	0	2	20	0	0	22
	4	0	0	0	1	0	0	1
	5	0	0	0	0	0	0	0
	Totals	0	0	5	164	109	90	368
Medium-Income Residential	1	8	3	3	10	17	20	61
	2	7	1	0	8	37	14	67
	3	1	1	0	15	0	0	17
	4	0	0	0	2	0	0	2
	5	0	0	0	0	0	0	0
	Totals	16	5	3	35	54	34	147
High-Income Residential	1	65	14	51	22	1	8	161
	2	33	11	26	0	0	0	70
	3	0	0	0	5	0	0	5
	4	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0
	Totals	98	25	77	27	1	3	236

these matrix cells as long as the number of observations is relatively large.

The population of 1948 residential land use was tested under the assumption that all ways to group the residential land became the theoretical population. Each arrangement thus constituted one frequency distribution which would produce three matrices for the land use types. Any other arrangement would be slightly different, with different frequencies appearing in the matrices. If the zone and sector models constituting one, nonarbitrary arrangement had an effect on the urban land use patterning of residential land, then these patterns should have been clearly discriminated in each of the two models. Differences between them would be the result of random relationships produced by the interaction of the models with the land use patterns. An arbitrary classification could result in a clear arrangement of residential land use. The chi-square test measures the probability that the nonarbitrary classification would be the result of sampling only one of all possible arrangements, and the null hypothesis assumed that there was no significant difference between the two models. That is, there was thought to be no difference that could not have occurred as the result of the choice of some other arbitrary explanation unrelated to the land use process. Taylor (1977, 113) discusses this use of the population of data points rather than a sample to fulfill the matrix of observation frequencies for the chi-square test.

The 1948 matrices of residential land use indicated that a clearer discrimination occurred between the two models; consequently, the final matrices were more easily determined (Tables 5-9 and 5-10). The

Table 5-9: Final Frequency Matrices for Aerial Photography, 1948 Residential Land Use, for Zone and Sector Models

Low-Income Residential

Zones	Sectors 1-4	5	6		Totals
1	33	86	22		141
2	113	23	68		204
3-5	23	0	0		23
Totals	169	109	90		368

Medium-Income Residential

Zones	Sectors 1-3	4	5	6	Totals
1	14	10	17	20	61
2-5	10	25	37	14	86
Totals	24	35	54	34	147

High-Income Residential

Zones	Sectors 1	2	3	4-6	Totals
1	65	14	51	31	161
2-5	33	11	26	5	75
Totals	98	25	77	36	236

Table 5-10: Final Expected Frequency Matrices for 1948 Residential Land Use, for Zone and Sector Models

	Zones	Sectors				Totals
		1-4	5	6		
Low-Income Residential	1	64.8	41.8	34.5		141
	2	93.7	60.4	49.9		204
	3-5	10.6	6.8	5.6		23
	Totals	169.0	109.0	90.0		368
	Zones	Sectors				Totals
		1-3	4	5	6	
Medium-Income Residential	1	10.0	14.5	22.4	14.1	61
	2-5	14.0	20.5	31.6	19.9	86
	Totals	24.0	35.0	54.0	34.0	147
	Zones	Sectors				Totals
		1	2	3	4-6	
High-Income Residential	1	66.9	17.1	52.5	24.6	161
	2-5	31.1	8.0	24.5	11.4	75
	Totals	98.0	25.0	77.0	36.0	236

reduction process left only one matrix cell that had a value of less than six. Each residential land use was tested at the .01 level of confidence, and the null hypothesis of no significant difference between the two models was rejected in all instances.

Factor Analysis

The field survey variables numbered 40 initially. After the summary statistics were analyzed, four building materials including palm thatch, galvanized steel sheeting, brick, and limestone used in wall construction were eliminated. Asbestos and cane (*cana-yagua*) roofing materials also were found so infrequently that they were dropped from further analysis. Since nearly all residential structures were found to be under two floors, all other residential buildings with more floors were also eliminated.

To the remaining variable list were added the distance of the cell to the CBD, a density of residences within the hectare, three socioeconomic levels of residential land use, five zones, and six sectors. These 45 variables were evaluated for 510[1] cells of land use included in the subsample of the city.

The data set containing the values for these variables was basically ordinal data. The three types of residential land use as dependent variables were expected to exhibit dissimilarities in socioeconomic status as measured by the field survey of *a priori*

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[1]Although 512 cells were included in the field survey subsample based on the 50-percent criterion, 2 cells were not included within the city confines as delimited by the aerial photographs.

selected indicators of the income level and associated social status of the residents.

In order to identify which of the field variables were the best predictors of socioeconomic level of city dwellers, factor analysis was utilized to collapse the field data into meaningful, parsimonious factors indicative of an underlying structure assumed to be based upon individual decisions by urban dwellers. Factor analysis differs, however, in that there is no distinction made between independent and dependent variables. Rather, the entire set of variables was analyzed in order to discover whether some order could be determined that explained land use decisions.

The factor problem has, as its main concern, the manipulation of all the correlations between variables in such a manner as to achieve the smallest number of factors and the least amount of error. However, it is also necessary that the small number of variables be interpreted in a meaningful way so that the entire set can be understood. Thus, the derived factors can be thought of as the "dependent" variables in the manner of the usual probabilistic approach.

Factor analysis begins with a table of intercorrelations between the variables that are being investigated. The Statistical Analysis System (SAS) (1979) has a FACTOR procedure which permits the researcher to circumvent much of the computer programming needed to perform the analysis. The data must first be prepared in the form of correlations, and the Spearman rank correlation coefficient was selected for this purpose. The SAS procedure CORR is programmed to produce a specially structured SAS data set containing a correlation matrix that can be used as the input to the FACTOR procedure. Computing was performed at the Northeast Regional Data Center of the State University System of Florida, at the campus of the University of Florida.

The Spearman rank correlation statistical procedure compares the rankings on two variables at a time by taking the differences of ranks, squaring these differences, adding them, and then assigning a value of +1.0 whenever there is perfect agreement, -1.0 when there is perfect disagreement, and zero if there is no relationship (Blalock 1972, 416). For ranked data, Spearman's rank correlation coefficient is computed from the formula

$$r_s = 1 - \frac{6\Sigma\, d_i^2}{n^3 - n}$$

in which d_i is the difference between ranks.

The matrix of correlation coefficients, size 45 x 45, was examined for significant correlations. Those with values greater than ±0.50 were the following: single-family housing, multiple-family housing, improvished housing; concrete, cement block, and wooden wall construction; concrete and galvanized steel roofing; one floor, landscaping, recently painted exterior, driveway/carport, louvered windows, grated windows, and fenced property; sidewalks, curbing, clean surroundings; density of residences; low-, medium-, and high-income housing designations. Of the total of 990 correlations, 64, or 6 percent, had values of ±0.50.

Those variables eliminated from further consideration included tile roofing, commercial/professional use as a secondary use to the residential nature of the structure, street paving, congestion, the land use model configurations, and the distance. The roofing was not common enough to be useful in differentiating between income groups. The small number of houses with a secondary use also made this variable unnecessary to the analysis. Both congestion and paving were apparently more evenly dispersed than anticipated, and the relatively rapid growth in new housing areas scattered along the urban fringe preceded the extension of certain municipal improvements including pavement to the high-income and low-income residential communities.

The automobile use tends to concentrate in nonresidential sections of the city. Consequently, this variable did not help to discriminate among the residential land use types.

Neither between-zone nor between-sector differences were great enough to separate the residential land use by income groups. One explanation would be that the area included in these configurations was not inclusive enough. Also, the boundaries could have been sited differently. In any case, the models were of no use in differentiating socioeconomic levels of housing and were eliminated in the factor analysis of the field survey information.

The distance variable lacked a weighting to incorporate the average distance of each land use to the central business district. Without this, it failed to reflect residential patterns and was dropped from the variable list. But there remained the possibility that land use is so dispersed as to make the models useless as descriptions of change, including the failure of the distance variable to identify homogeneous socioeconomic housing patterns.

The multiple housing and apartment designations were combined. The former had moderately high correlation while the latter did not, but the actual field differences were not sufficient to produce discrimination in the data analysis. In theory, apartments would be found in the tenement district and areas of change elsewhere, e.g. in the transition zone, close to the CBD, as well as in the suburban fringe and along the transportation corridors. Such a zone was not apparent in the land use maps. Only a relatively small number of apartments existed in the city.

Multiple-family housing in Anglo-American cities is found in areas where increasing density is associated with filtering and urban renewal. Since both processes were not much in evidence in Santo Domingo, it was decided that to combine the two variables would ensure that multiple-family housing would be considered in the factor analysis in a form more in keeping with the local conditions.

In general, the Spearman rank correlation coefficients were low. The implication was that the measured variance was more unique than general, that the variation on one variable was not as predictable of variation on the second. Factor analysis is based on one of two possible models selective of the type of expected variation.

The principal component model is closed. No unique variance is assumed to exist for the variables. Instead, the technique assumes that variance is common to all the variables in the data set. The common variance, called communality of the variables, is important since it and all other communalities of the remaining variables are employed as estimates of the diagonal of the correlation matrix before it is manipulated to produce eigenvectors. The maximum communality is one, limited to the total variance of a variable, and its range extends to a minimum that is equal to the multiple correlation coefficient between one variable and all others in the data set.

Principal component analysis uses communality estimates of one, thus excluding the possibility of a specific factor or measurement error associated with variance particular to a single variable. When all variables are assumed to have communalities of one, the resulting closed model differs methodologically and theoretically from the common factor model (Taylor 1977, 142-245).

In contrast to the principal component analysis which does not provide for outside effect, the common factor method is more realistic. Although it does not provide a mathematically derived solution, nevertheless, it is useful where the correlation coefficient matrix has a preponderance of low values. To estimate communality at a maximum in this situation would overemphasize the influence of each variable in subsequent statistical procedures of the analysis. The results of common factor analysis differ from principal component especially where the number of variables is large with a resulting large number of low correlations.

Both approaches were employed in the research. Each procedure involved five matrices. The first was composed of the 510 observations and the initial collection of 45 variables. This variable list was then reduced to 22, and a second correlation matrix was tested. Out of 231 coefficients, 49 had values greater than ±0.50 (which was 21 percent of the total), and 86 percent were significant at the .01 level.

Table 5-11 contains the result of substituting prior estimates of communality taken from the correlation coefficient matrix, by selecting the highest absolute values in an initial factoring which generated eigenvalues for each variable. The first four factors explained 94 percent of the cumulative variance, and beyond that there was a noticeable decrease in all other eigenvalues.

The initial factoring is shown in Table 5-12. From the results of the loadings, it was apparent that most of the variables were associated with the first two factors.

Rotation by the varimax procedure utilizing the final communality estimates produced the factor loadings shown in Table 5-13. In general, values greater than 0.55 are acceptable for inclusion of the variables as indicators of the nature of the factors established by the analysis. This part of the procedure presented a simplier relation between the variables and the factors.

Finally, with the use of the SAS SCORE procedure, the factor scores were calculated. This matrix contained the values of the factors on the original observations derived from the preceding matrix loadings for each weighted according to its relation to the original variables. The remainder of the research effort was devoted to identifying the factors and labeling them in such a manner as to express the patterns of the variable loadings.

The land use maps and land use change maps are presented in the next chapter. These synthesize a wide range of improvements into five

Table 5-11: The Variables, Estimated Communalities, Common Factor Analysis

Variable	Communality Estimates	Eigen Values	Percentage of Total Variance	Cumulative Percentage
Single Family	0.570	8.079	0.491	0.491
Multiple Family	0.552	4.940	0.300	0.792
Improvised Housing	0.786	1.380	0.084	0.876
Concrete Walls	0.811	1.056	0.064	0.940
Cement Block Walls	0.778	0.543	0.033	0.973
Wooden Walls	0.854	0.487	0.030	1.002
Concrete Roof	0.811	0.363	0.022	1.025
Galvanized Steel Roof	0.854	0.290	0.018	1.042
One Floor	0.865	0.171	0.010	1.053
Landscaped	0.797	0.076	0.005	1.053
Recently Painted	0.658	0.064	0.004	1.061
Driveway/Carport	0.797	0.050	0.003	1.064
Louvered Windows	0.732	-0.007	-0.000	1.064
Grated Windows	0.730	-0.021	-0.001	1.062
Fenced	0.728	-0.030	-0.002	1.061
Sidewalks	0.887	-0.041	-0.003	1.058
Curbing	0.887	-0.003	-0.003	1.055
Clean	0.659	-0.005	-0.005	1.050
Density	0.865	-0.006	-0.006	1.045
Low-Income Housing	0.711	-0.006	-0.006	1.038
Medium-Income Housing	0.711	-0.015	-0.015	1.023
High-Income Housing	0.403	-0.023	-0.023	1.000

Table 5-12: Initial Factor Loadings, Common Factor Analysis

Variable	Factor 1	Factor 2	Factor 3	Factor 4
Single Family	0.411	0.416	0.503	0.013
Multiple Family	-0.341	0.459	-0.418	0.019
Improvised	-0.704	0.350	0.198	0.023
Concrete Walls	0.785	0.234	-0.258	0.066
Cement Block Walls	-0.576	0.524	0.210	-0.138
Wooden Walls	-0.748	0.485	0.081	0.036
Concrete Roof	0.745	0.347	-0.235	-0.003
Galvanized Steel Roof	-0.726	0.570	0.146	-0.007
One Floor	-0.320	0.829	0.255	-0.089
Landscaped	0.848	0.051	0.210	0.123
Recently Painted	0.649	0.311	0.193	-0.008
Driveway/Carport	0.846	0.167	0.250	0.055
Louvered Windows	0.731	0.434	0.058	-0.074
Grated Windows	0.595	0.561	-0.004	0.031
Fenced	0.686	0.350	0.214	0.099
Sidewalks	0.379	0.636	-0.479	-0.063
Curbing	0.279	0.714	-0.450	-0.048
Clean	0.685	-0.047	0.144	0.063
Density	-0.173	0.914	0.071	-0.033
Low-Income Housing	-0.639	0.379	-0.050	0.271
Medium-Income Housing	0.395	-0.223	0.049	-0.788
High-Income Housing	0.323	-0.201	0.003	0.537

Table 5-13: Factor Loadings, Varimax Rotation, Common Factor Analysis

Variable	Factor 1	Factor 2	Factor 3	Factor 3
Single Family	0.739	0.212	-0.053	-0.037
Multiple Family	-0.292	0.406	0.495	0.085
Improvised	-0.280	0.744	-0.145	0.071
Concrete Walls	0.546	-0.393	0.536	0.034
Cement Block Walls	-0.122	0.803	-0.015	-0.094
Wooden Walls	-0.320	0.831	0.011	0.098
Concrete Roof	0.570	-0.275	0.573	-0.030
Galvanized Steel Roof	0.240	0.901	0.016	0.053
One Floor	0.218	0.881	0.186	-0.057
Landscaped	0.774	-0.417	0.081	0.050
Recently Painted	0.709	-0.107	0.194	-0.058
Driveway/Carport	0.834	-0.316	0.118	-0.017
Louvered Windows	0.743	-0.103	0.394	-0.116
Grated Windows	0.667	0.043	0.473	0.006
Fenced	0.771	-0.099	0.205	0.046
Sidewalks	0.276	0.081	0.835	-0.038
Curbing	0.250	0.207	0.829	-0.016
Clean	0.573	-0.407	0.038	0.003
Density	0.268	0.793	0.414	0.003
Low-Income Housing	-0.332	0.635	0.070	0.330
Medium-Income Housing	0.171	-0.352	-0.020	-0.818
High-Income Housing	0.204	-0.365	-0.057	0.505

categories of use which, when compared for the two base years, indicate the extent of filtering as well as the patterning of change. By identifying these conditions, it is possible to determine what ecological model or models best explains urban change in the city.

CHAPTER SIX
LAND USE CHANGE

1948 Land Use

Santo Domingo for much of 500 years was contained in the relatively small area between the river and Avenida A. Lincoln. In 1948, there was almost no development on the eastern side of the Ozama except at Villa Duarte. The communities of San Carlos, Independencia, Lugo, Gaszué, Villa Consuelo, Mejoramiento Social, El Ensanchito, Santa Fe, and Villas Agrícolas comprised most of the built-up city. Avenida Duarte extended north-northwestward beyond M. Social at the edge of a wide expanse of open land. This open space later was to become the neighborhoods of Luperón and Espaillat. The Andrews Air Force Base was sited on the largest expanse of open, level land in the city.

The land use statistics in that year and 1974 indicate that the urbanized area included 17.01 square kilometers. Residential land use represented nearly one-half of both the total area and the developed land included in the city boundary established from the aerial photographic information. The photographic interpretation indicated a general absence of extensive marginal housing, and the more clearly defined socioeconomic levels at the time were manifested in housing which was aggregated into high-, medium-, and low-income residential land use. About one-half of all housing in the city was low income. High-income residential use included one-third of the urbanized area, and there was a relatively small medium-income area.

The average distances of each land use category to the city center are useful for approximating the general gradient of socio-economic level in housing. A high-income residential land use was nearest to the central business district (Table 6-1). This is consistent with the traditional plaza-oriented Latin American city. The land use map in Figure 6-1 indicates that this high-income residential land was located in a tightly confined area that included Gaszué, Lugo, and Independencia, all of which were to the west of the colonial center. The area extended along the coastline to the city's edge and included level land up to Avenida M. Gómez. Development stopped at this point.

The relative proximity of open land to the CBD, as measured by the average distance in meters, is due in part to the presence of several city parks at the city center. The nearness of open space enhances the ambience of high-income residential communities.

The location of middle-income housing, shown in Figure 6-2, suggests several explanations. The homogeneity of the residential land use types suggests that there had been little land use change. The large distances between the few middle-income and high-income communities leads to the conclusion that the former may have been a relatively recent occurrence, especially since middle-income housing is located at the urban limits.

In Figure 6-3, low-income housing is closer to the central business district than is middle-income residential land use. There is less homogeneity: Wide dispersal includes a mixture of low income and open land, producing a pattern of housing which stretched in a line along the northern and eastern edge of the city, beyond San Carlos. The

Table 6-1: Summary Statistics for 1948 and 1974 Land Use, Aerial Photography Data

1948 Land Use Type	Frequency in Hectares	Percentage	Cumulative Percentage
Low-Income Residential	370	21.7	21.7
Medium-Income Residential	147	8.6	30.3
High-Income Residential	236	13.8	44.1
Other Uses	836	48.9	92.9
Open Space	121	7.1	100.0
1974 Land Use Type	**Frequency in Hectares**	**Percentage**	**Cumulative Percentage**
Low-Income Residential	2,076	22.7	22.7
Medium-Income Residential	1,374	15.0	37.7
High-Income Residential	983	10.8	48.7
Other Uses	1,944	21.3	69.7
Open Space	2,768	30.3	100.0

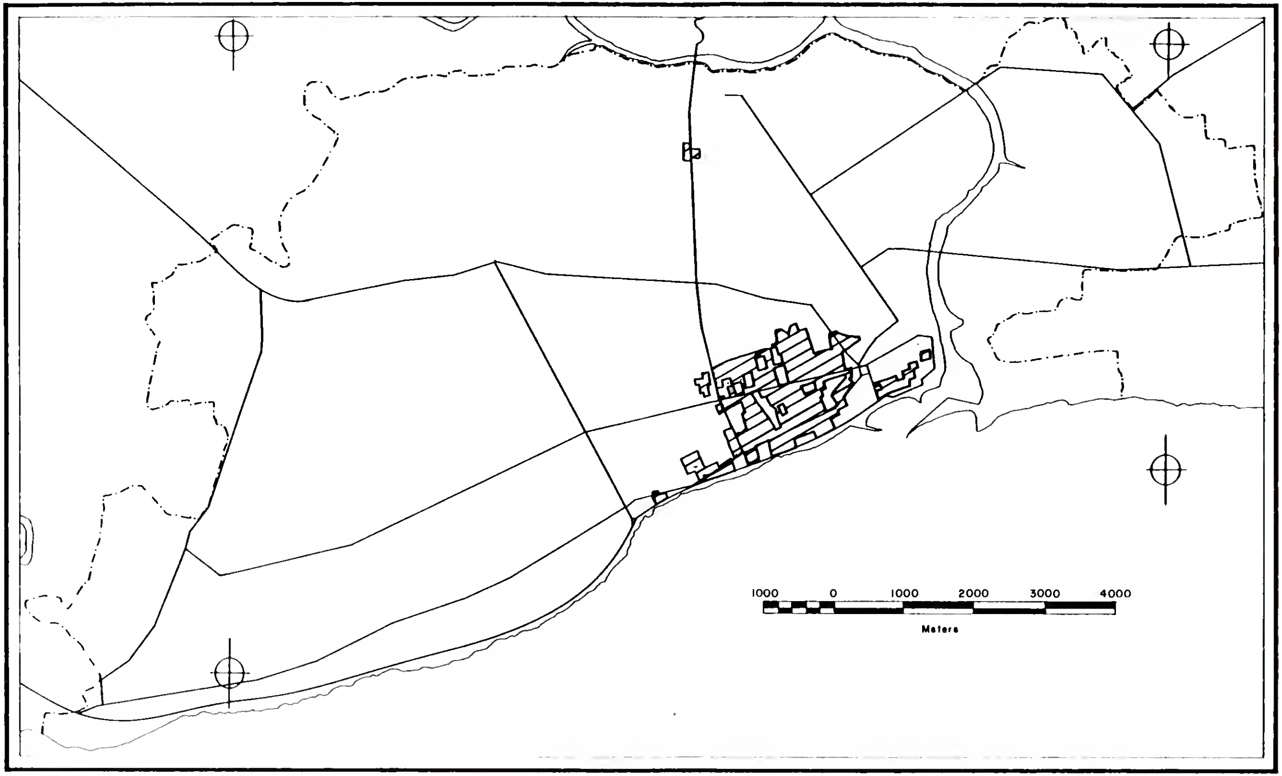

Figure 6-1: High-Income Residential Land Use, 1948

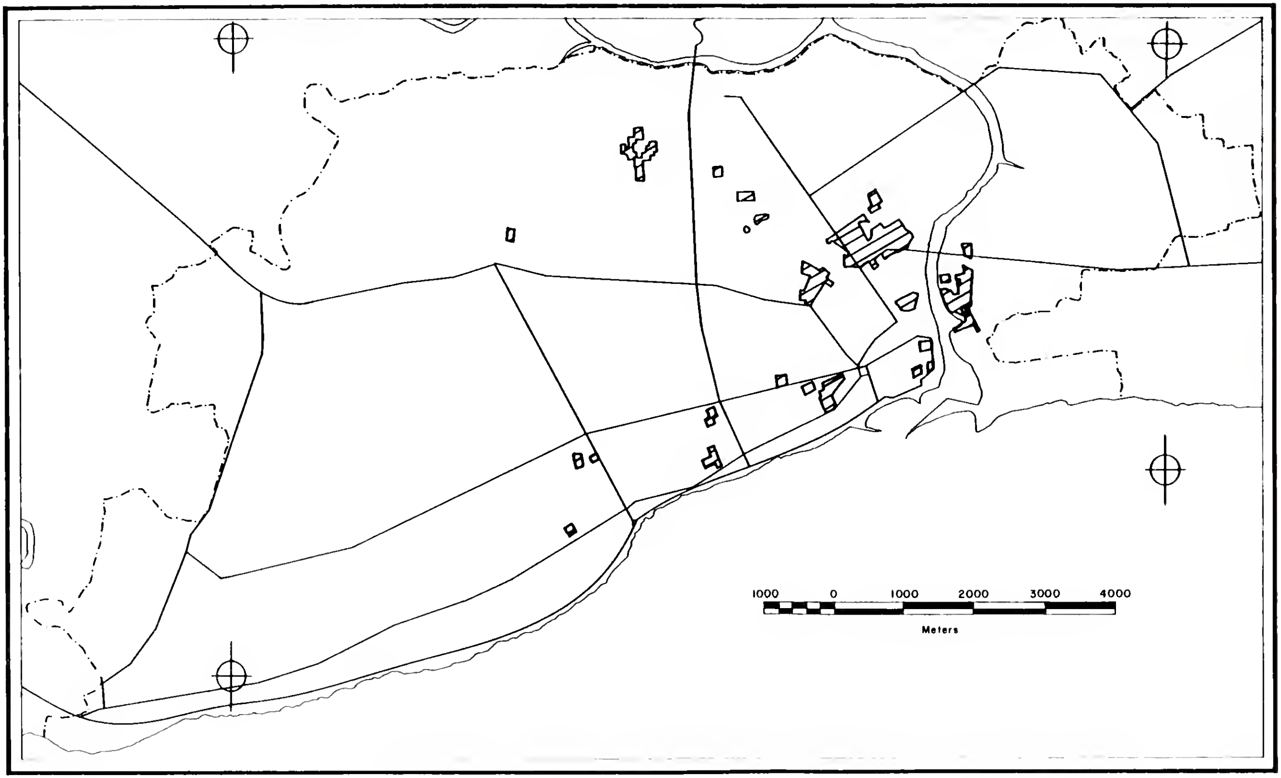

Figure 6-2: Medium-Income Residential Land Use, 1948

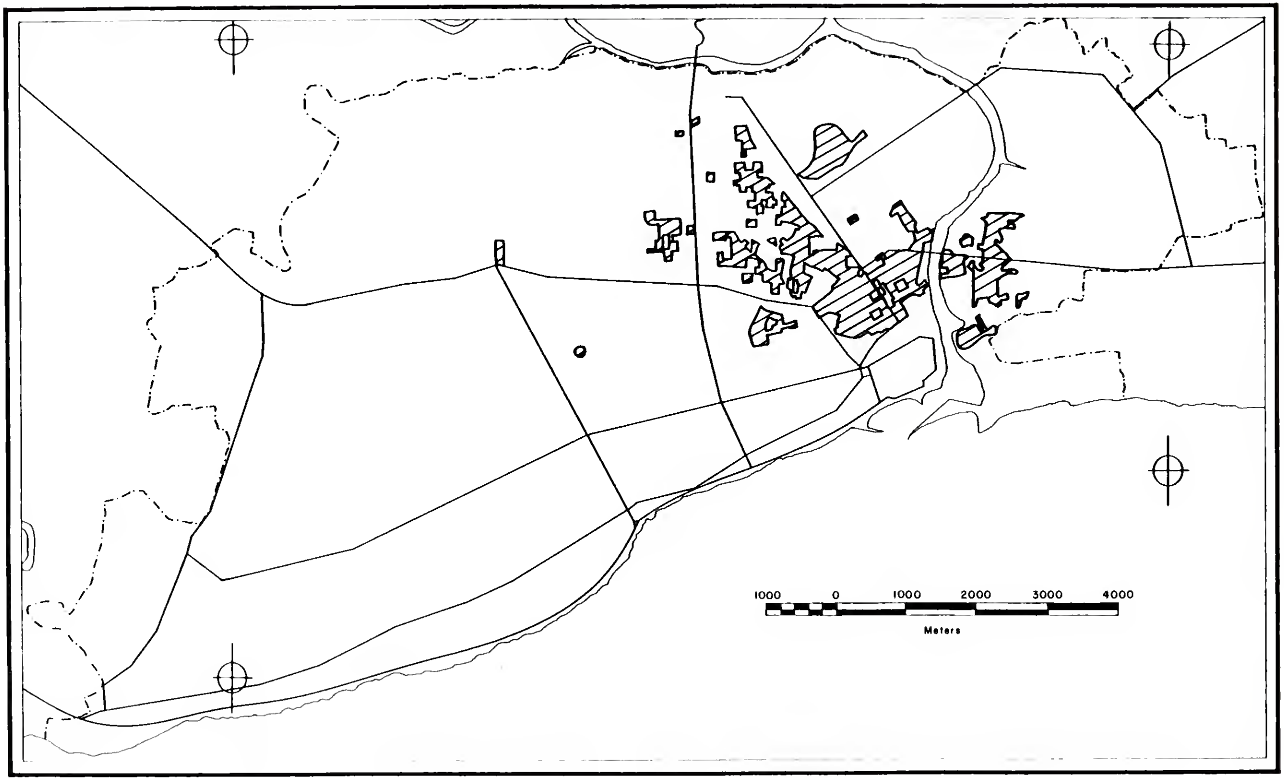

Figure 6-3: Low-Income Residential Land Use, 1948

communities involved were M. Social, Villa Consuelo, El Ensanchito, and Villas Agrícolas, as well as Villa Duarte on the east bank of the Ozama River.

Separating low- and high-income residential land uses was a large mass of other land use (Figure 6-4) transsected by Avenidas San Martín and 30 de Marzo which included the commercial city center and the air force base. There were narrow strips that extended northward along the river where the harbor facilities lay, and to the west at the coast where recreational facilities were built along Avenida G. Washington. Additional parcels of other land use were found to be widely scattered at the city's edge. Consequently, the average distance of other use was greatest, and the major portion of other land use is best described as a wedge that extended out from the colonial center between major transportation-communication corridors to the city limits.

High-income land was another wedge that extended out from the CBD, bounded on the south by the sea and a narrow strip of other land use along Avenida G. Washington (the main route out of the city toward Haina and the provincial capital of San Cristóbal). This was a prime location for cooling sea breezes and broad vistas, both of which still attract the well-do-do to this area.

Low-income residential land use, although not as exclusive as high-income use, aggregated between Avenidas Duarte and San Martín, in a third sector which began at the edge of the central business district and incorporated most of the developed land between the two main transportation routes to the countryside. The extension of low-income housing to the eastern bank of the Ozama River was indicative of a trend of outward expansion.

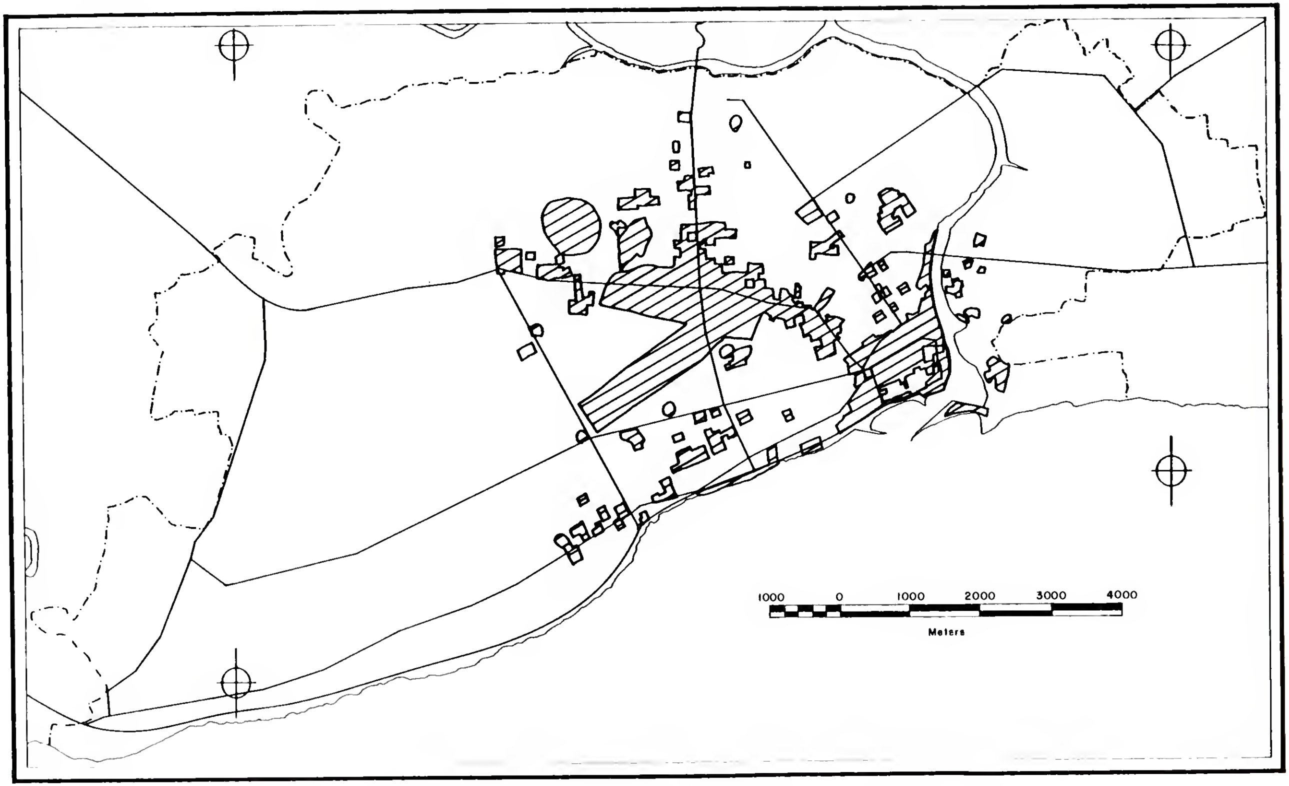

Figure 6-4: Other Land Use, 1948

The land use patterning of the 1948 city is best explained in the context of the traditional Latin American city where the well-do-do prefer to live in or near the center. A small middle class was the most recent socioeconomic group. They located in new communities built on open land at the city's edge. The low-income residential land use did not include marginal settlements, indicating that massive rural-to-urban migration was not yet a significant phenomenon. Consequently, in part due to the little population in-migration, Santo Domingo did not exhibit zonal land use patterns. There was no indication of deterioration and decentralization that would accompany such population change in an industrializing city.

1974 Land Use

By a quarter century later, Santo Domingo had undergone considerable growth, and change was apparent in the land use maps. The city area, as delimited from the aerial interpretation augmented by field survey information, was 91 square kilometers, an increase of 74 square kilometers, with developed land stretching from east of the Ozama River to the Haina River in the west, and from the river floodplain of the Isabela River to the Caribbean.

A comparison of the statistics in Table 6-1 reveals that much of the land use expansion after 1948 occurred in middle- and upper-income residential and other land use. The most common land use was open space, followed by other use, while the low-income residential land use covered twice the area of high-income residential land use.

The importance of the shift in land use is seen in the evaluation of the land use change models. Open space increased from 7 to 30 percent, an indication of the horizontal spread of uncontrolled development that left much undeveloped land dispersed throughout the urban area. Open space was concentrated in the area to the west of Avenida General A. Duvergé. In the built-up city, other use (which includes public, commercial, and industrial activities) decreased substantially as a proportion of the urban area as well as of the developed area. Other important changes were the increased proportion of middle-income residential land use while both low-income and high-income residential land use either remained stable or decreased slightly.

Figure 6-5 shows a continuation of the dispersed pattern of other land use. The removal of Andrews Air Force Base shifted the general location of the sector of other land use which now extended further northwestward along Avenida J. F. Kennedy and Avenida M. Gómez. A second strip of other land use was found at the western edge somewhat parallel to the city limit and accessible to the Herrera-Haina highway that connects the port with the industrial zone.[1]

The high-income residential land use as shown in Figure 6-6 has the highest concentration of the three income groups. It is a zone of homogeneous land use beginning at the 1948 area of high income and continuing beyond Naco to Arroyo Hondo. A suburbanization process must have occurred, probably in the 1960s, when high-income residences were constructed on open land beyond the city limits. In part, this expansion was encouraged with the relocation of the airfield which left a large expanse of land for redevelopment. Other high-income residences

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[1]Today, this route is completed and connects with a by-pass highway which allows rapid transit around the city and on to the international airport 30 kilometers to the east.

Figure 6-5: Other Land Use, 1975

Figure 6-6: High-Income Residential Land Use, 1975

continued to appear in proximity to the older high-income communities located along the limestone terraces and now accessible to the CBD due to the construction of several new avenues.

The medium-income residential land use is shown in Figure 6-7. The immediately obvious pattern is linear, an indication of the importance of transportation to the residents in the area along broad west-east avenues. High-income and medium-income residential land uses are frequently contiguous. Middle-income was more prevalent, however, and the further west, the more recent was the appearance. These uses comprise the bulk of development west of Avenida A. Lincoln in an area where open land predominates.

Low-income land use is insulated from these residential uses and is concentrated in a wedge (Figure 6-8) which includes the eastern portion of the city beyond Avenida San Martín as well as most land beyond the eastern bank of the river. Although a few scattered squatter neighborhoods are found among the newer middle-income and high-income neighborhoods, the major low-income area in the west is beyond the Herrera-Haina highway, near the industrial zone. Another, major low-income area is at the far eastern extreme of the city and includes such marginal settlements as Puerto Rico, Katanga, Las Palmas, and Villa Faro. These extreme locations underscore the recent appearance of peripheral low-income housing.

Land Use Change, 1948-1974

In an Anglo-American city, filtering brings about a change in the socioeconomic character of residential land use. Population growth forces housing change at or near the periphery of homogeneous areas to

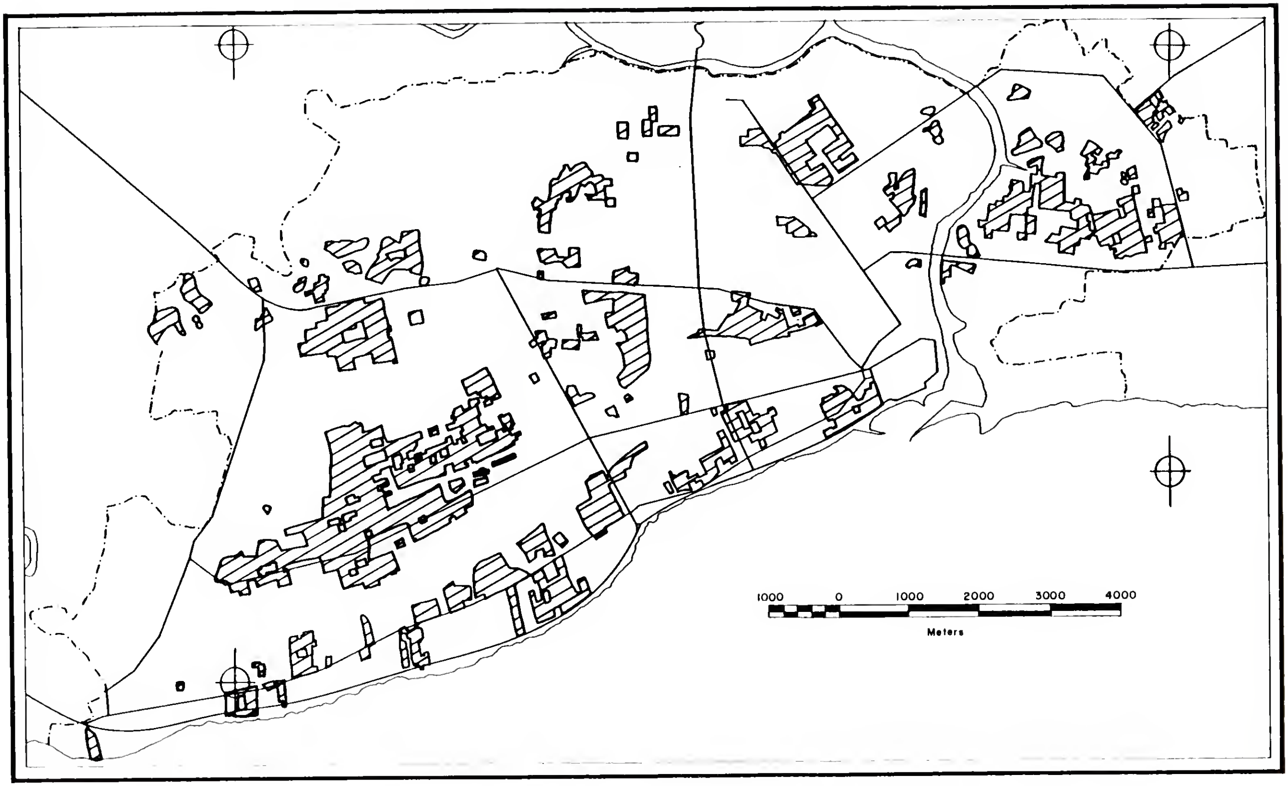


Figure 6-7: Medium-Income Residential Land Use, 1975

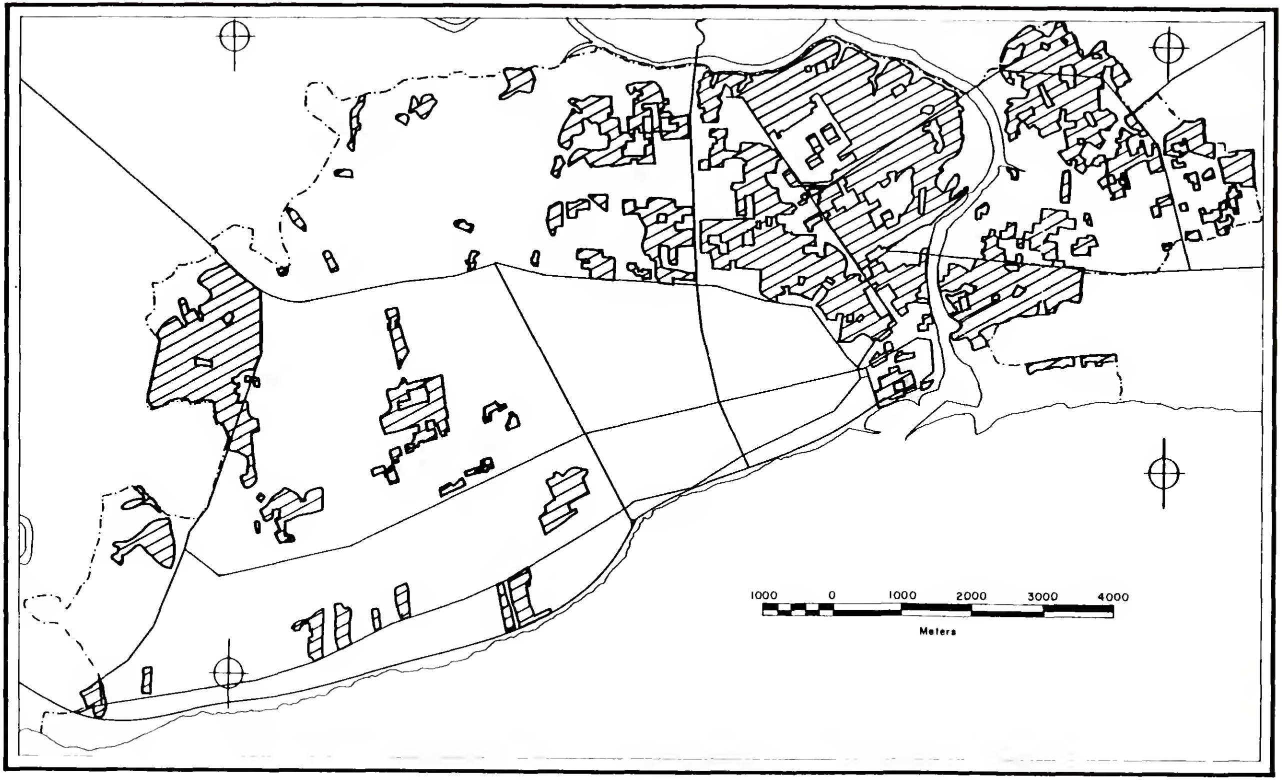
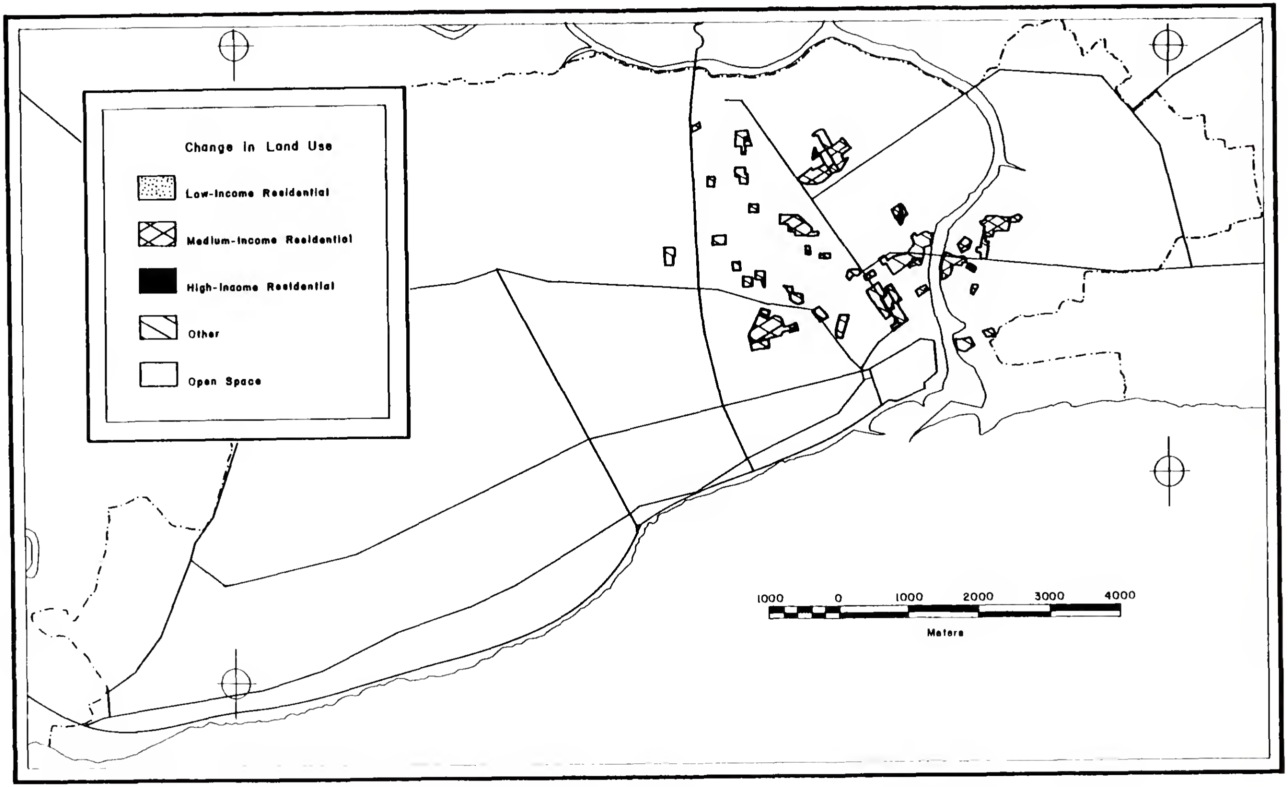


Figure 6-8: Low-Income Residential Land Use, 1975

accommodate an influx of new residents. Newcomers may be the more fortunate, often young population of a lower socioeconomic group. Their financial situation and life-cycle stage are different and cause a change in the resident character of the community. The resulting transition area will gradually be transformed into another, often lower socioeconomic-level neighborhood. The housing stock is usually remodeled to accommodate the lower income of the newcomers, resulting in higher densities.

Those who resided in what has become a transition zone may vacate their homes for better housing in another area. Others, displaced from their old neighborhoods, may seek similar neighborhood conditions nearby where there has not yet been a change in the socioeconomic character of the neighborhood.

The land use change maps, Figures 6-9, 6-10, 6-11, and 6-12, reveal that all land uses underwent change over the 1948-1975 period. As Table 6-2 indicates, open space was the most stable land use. Other use experienced the greatest conversion. This nonresidential land became low-income housing in the eastern portion of the city and medium-income residences in the western part. Table 6-2 shows the average distances of the land which changed in use. The least change occurred at approximately 1,000 meters and 2,500 meters from the city center (Figure 5-1). The land included in the airfield ranged in location from 1,400 to 4,000 meters from the city center and accounted for much of the change in land use beyond 2,500 meters. The average distances of the three residential and the other land uses grouped within the 1,000 to 2,000 meter range. The filtering process should have been



Figuge 6-9: 1948 Low-Income Residential Land Use Changed in 1975, by Use

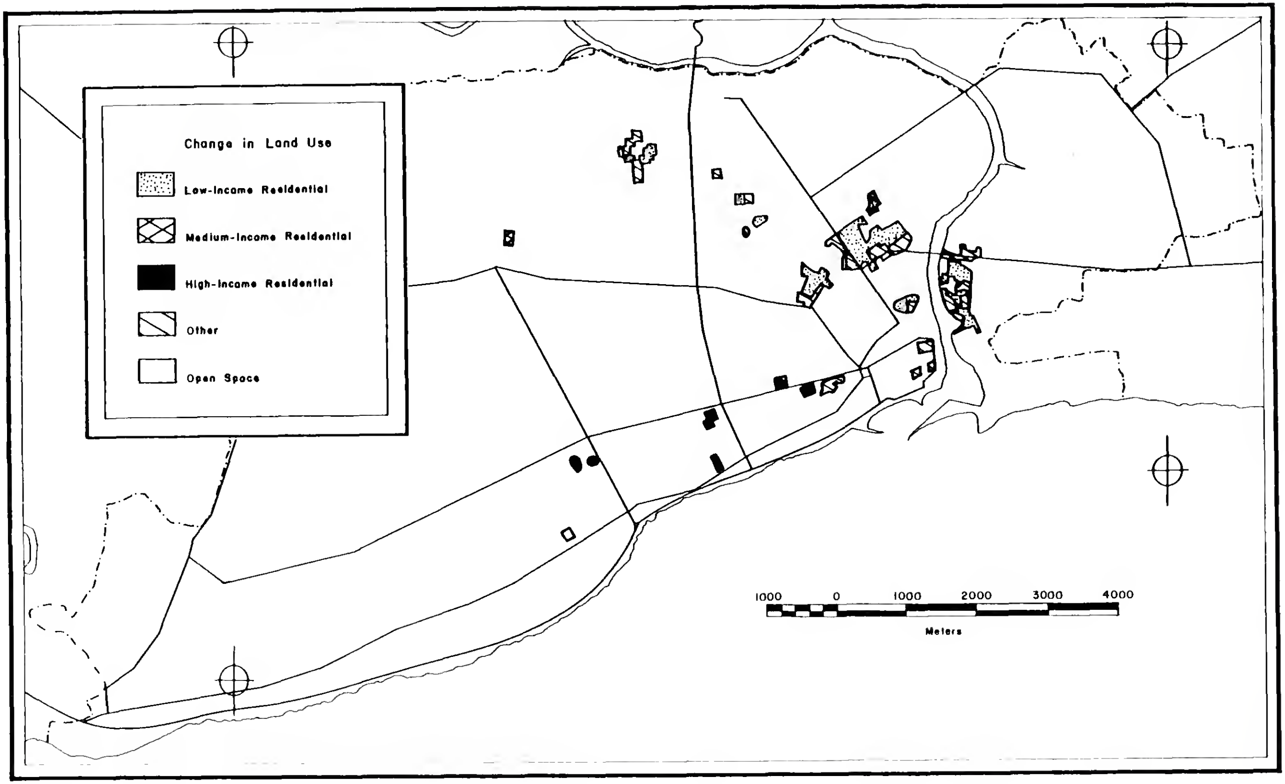


Figure 6-10: 1948 Medium-Income Residential Land Use Changed in 1975, by Use

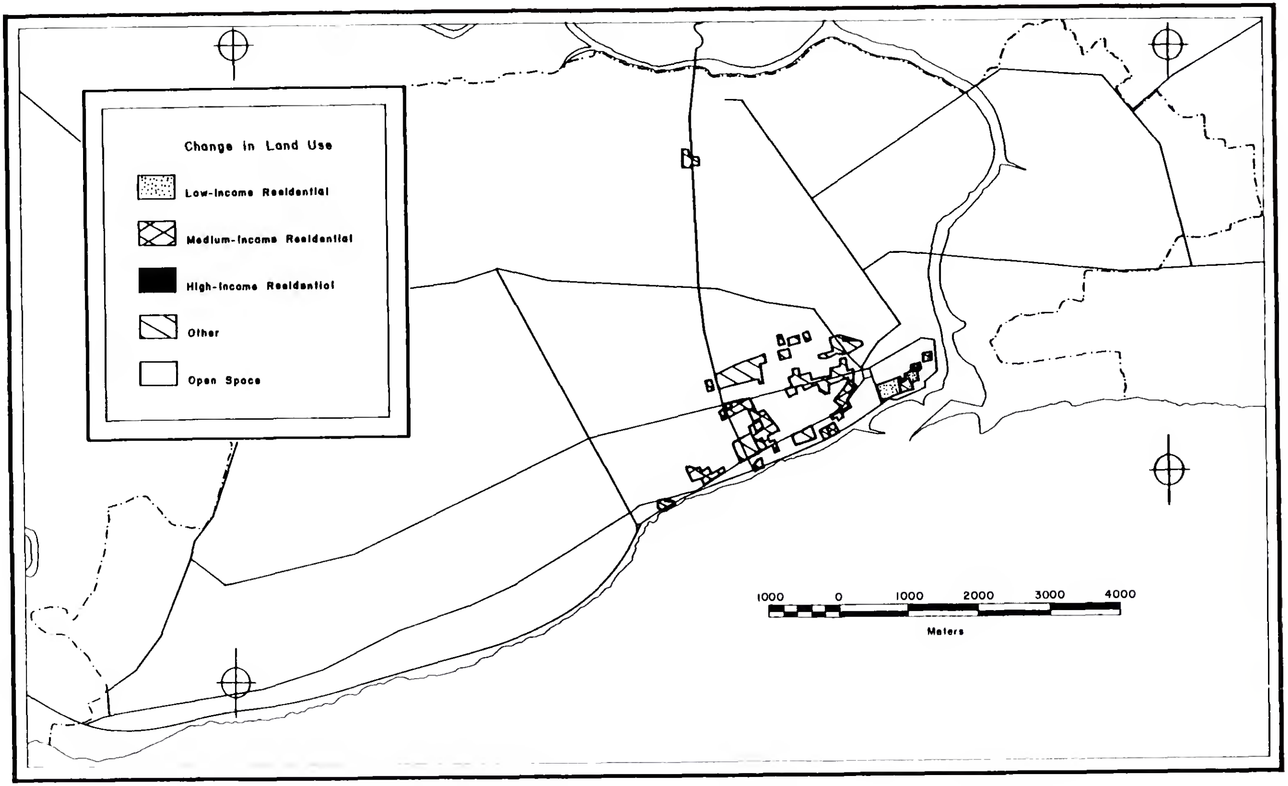


Figure 6-11: 1948 High-Income Residential Land Use Changed, 1975, by Use

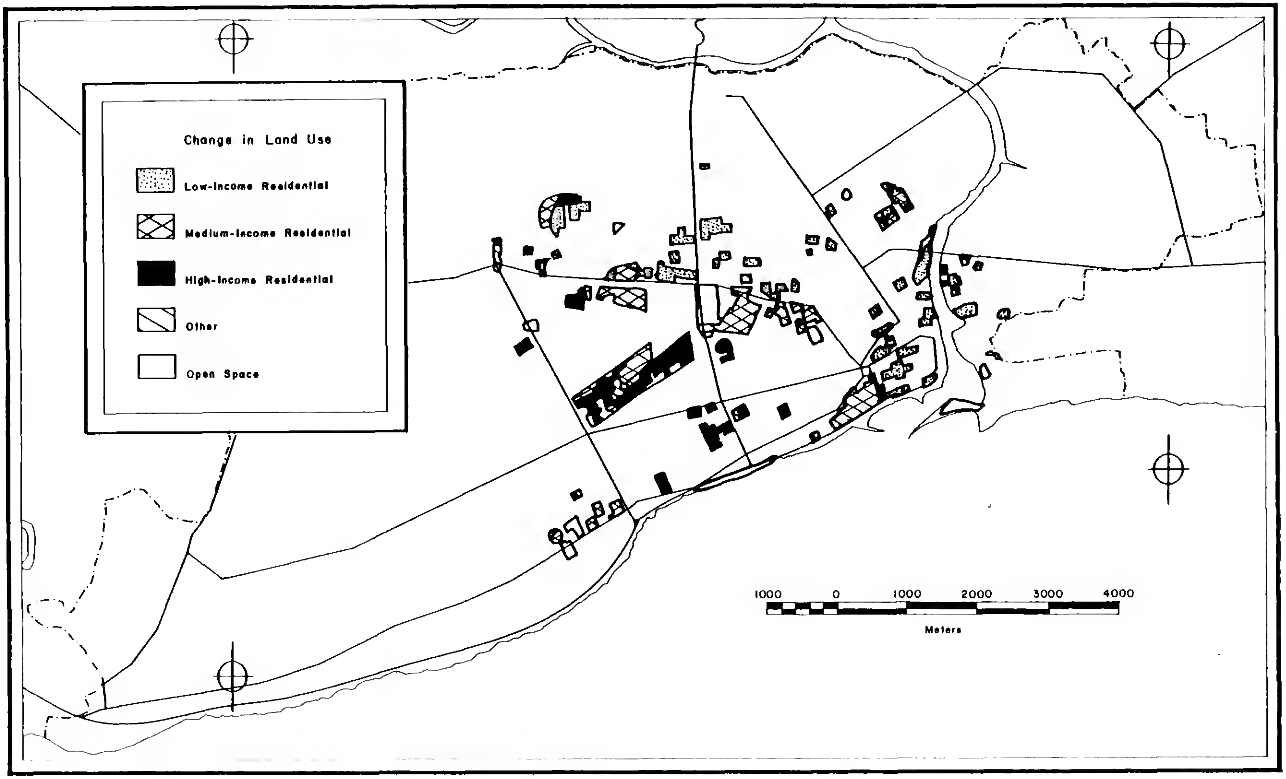


Figure 6-12: 1948 Other Land Use Changed in 1975, by Use

Table 6-2: Stable Land-Use Patterns and Distances from City Center, Aerial Photography for 1948-1974 Period

Aerial Photographic Interpretation	Low-Income Residential	Medium-Income Residential	High-Income Residential	Other Uses	Open Space
Area in Hectares	229	10	114	114	14
Mean Distance in Meters	1,954	1,688	1,268	2,430	908
Range, Minimum, in Meters	412	565	316	0	100
Range, Maximum, in Meters	4,220	4,313	2,801	5,281	2,262
Percentage	29.0	1.3	14.5	53.5	1.8
Cumulative Percentage	29.0	30.3	44.7	98.2	100.0

most prevalent within this range. High-income land use, shown in Figure 6-11, had the lowest average distance among the hectares which changed to other residential land uses.

Only 8 percent of the low-income land existing in 1948 was converted to other uses, much of it into nonresidential use or middle-income residential use. Less than 1 percent of middle-income housing changed to another use. The greater growth of this land use compared with low- and high-income residential use may explain the very small proportion of middle-income land that changed to another use. The demand for housing ensured the continued occupancy of existing middle-income housing. Figure 6-12 supports this interpretation, for much of the other land use was converted to middle-income housing.

In general, low-income residential patterns have displayed a sector configuration. One sector is contained between Avenida San Martín and the Caribbean coast at the eastern side of the city and begins at the commercial center. Low-income housing tends to be located in areas of the city with the least desirable conditions such as on the floodplain and steeply sloping banks of the rivers. Low-income residential land use is usually near other land use, especially commercial use which has employment opportunities for unskilled and semi-skilled workers.

Another sector of other land use separates the low-income from middle-income sector. It extends from the city center to the Puente de Pontones at the terminus of Avenida M. Gómez and along Avenida J. F. Kennedy. A second concentration of other land use, mostly industrial and institutional, is at Herrera and just south of the low-income area that lies at the city limits.

A part of the 1948 middle-income residential area was lost to low-income use as a result of filtering. The most apparent feature of current middle-income housing is its dispersion over a wide area in the western two-thirds of the city. It is probably too soon to refer to this as a sector, although the extensive open land that is also found here indicates that, with continued growth, this will assume a sector configuration transsected by major communication and transportation corridors linking the distant neighborhoods with the central employment area.

Finally, high-income residential land demonstrates a zonal pattern. This curved, compact area lies on the west side of the city just beyond what had been the approximate limit of the city in 1948. But this zone is undergoing change. Extending out from the zone is a newer high-income area which is bounded to the north and south by middle-income communities. Continued growth probably will extend this into a sector configuration that will parallel the coastal terraces.

In Hoyt's model of urban expansion, it is the elite who seek out the higher elevations that offer superior weather and view far from noxious industrial pollution and commercial congestion. They seek seclusion, space, and the best environment. In Santo Domingo this pattern exists. The well-to-do have built fine residences along the higher elevations near the sea and in the northwest in Arroyo Hondo, where secluded sites in canyons have become fashionable. Once ensconced, the elite have drawn to them the best municipal services. This is evident in the zoo and parks which have been established near the high-income areas. Naco has a fine shopping mall modeled after centers found in wealthy sections of Anglo-American cities. The entire high-income area is undergoing extensive highway and street improvement.

There is evidence that filtering of the better homes in the urban center is occurring. Along Avenida S. Bolívar, large, palatial homes have been converted into apartments and professional offices, and along Avenida G. Washington and Avenida Independencia, other fine houses have been remodeled for middle-class use.

To some extent, there is evidence that the middle-class is locating near the high-income residential communities. It has occurred out in the western part of Santo Domingo, but there has been a typically Caribbean modification. Drawn by the accessibility that the high-income urbanites enjoy and the many open spaces, the very poor have squatted in small enclaves that often appear to merge with elite neighborhoods.

It seems that the middle class is leading the change in contemporary patterns of land use in Santo Domingo. It is the most recent group to benefit from economic prosperity, increasing in number and demanding new housing that has contributed to the building boom of the 1970s. While the 1948 urban picture is viewed as a Caribbean capital with a two-class society, the well-to-do in the center city and the less fortunate scattered about the periphery, the contemporary city is being transformed for the benefit of the middle-income as well as the upper-income residents.

The land use maps therefore revealed that both ecological models are in evidence in Santo Domingo, although the sector model is most prevalent. Since urban ecological theory suggests that the models may reflect stages of modernization, it is possible to examine the city within such a paradigm.

CHAPTER SEVEN
RELATIONSHIPS AMONG LAND USE CHANGE, HOUSING, AND POPULATION

Evolutionary Theory of Urban Change

In 1948, high-income use was the nearest of the residential types to the central business district. Decentralization was initiated by the middle-income residents whose homes now are scattered about the western part of the city. There appears to be little obsolescence or abandonment of the housing stock, and a transition zone so commonly found in Anglo-American cities is not present in Santo Domingo. The massive in-migration of thousands of Dominicans to their capital has obscured most of a zonal pattern, and only the high-income residential area displays the vestige of an earlier suburbanization process. The city experienced a surge in automobile registrations which increased fourfold over the 1960s.

Davis (1969) hypothesized that a city during its stage of industrial take-off will have an inner zone dominated by low-income residential use with increasing socioeconomic level in the communities located farther from the central business district. Santo Domingo does not reflect this gradient change entirely, but there has been a shift from an inner zone of high-income to one of low-income land use.

The land use mapping identified both zone and sector patterns, the latter much more in evidence. Urban evolutionary theory proposes that the rapidly growing city will not exhibit a zonal configuration because of the active processes of axial and central growth which rapidly induce neighborhood heterogeneity and obscure a zonal pattern. Sector patterns are not excluded, however.

If the land use models were not explanations of city land use, then the proportions of each land use that would be relegated to the models (as overlain on the city land use map) would be similar to the proportions of land use in the city as a whole. The 1975 field sample of housing was evaluated to determine whether the allocation of residential land by type for zones and sectors resulted in significantly different groupings. The chi-square test for low- and medium-income use was significant. From the land use maps, it was concluded that, of the two models, the sector pattern best described the distribution of these two residential land uses.

High-income residential land use also was found to exhibit a significant difference between the two models, but the 1948 pattern was zonal and included the most concentrated land use of the three types. By 1974, however, a western extension of the high-income land use was distorting the zone, and middle-income sectors to the north and south are likely to direct the expansion of high-income use into a west-to-east sector in the future.

The present sector pattern suggests that Santo Domingo has entered an industrialization stage of development. With continued modernization, a minor suburbanization trend should increase to reinforce the spatial patterns that are now established. The sector model is not entirely fulfilled here, however, for the Third World phenomenon of marginal settlements is generating a fringe zone of low-income land use that will have impact on the future spatial evolution of the city.

Santo Domingo has not undergone a long period of modernization. As the process continues, it is likely that the land use proportions will change significantly. Presently 70 percnet of all land is residential. In an Anglo-American city that has sustained a much longer period of modernization, the proportion of residential land use is about 50 percent, although the general range is from 40 to 80 percent where the stage of development is ignored. Santo Domingo has been unencumbered by city limits that could hinder horizontal growth. Therefore, it has not been necessary to renovate existing housing stock to accommodate growth resulting from the in-migration of new population and the urban natural increase. Furthermore, the increasing demand for housing discourages demolition and slows decay of the stock which is being maintained to accommodate the need for all kinds of housing.

Because of the general absence of development controls, there has been a wide dispersal of nonresidential use. It has encroached on residential use in high- as well as medium- and low-income areas. In Anglo-American cities which have been developed under the restrictions of zoning and building codes, the proportion of homogeneous nonresidential land is greater.

Housing Conditions

Much of the land use expansion since 1948 has been in middle- and high-income housing and in other land use. The bulk of population growth has been among low-income people, but their housing does not display the proportional increase in area. About 17 square kilometers of land have been designated low income. It is assumed, therefore, that densities must have increased within the low-income areas.

The highest gross residential densities determined by field surveys of typical blocks by the National Statistics Office were in the marginal settlements along the Isabela River. There, on the steep slopes of the riverbank, 600 or more people were found to be residing on an average hectare of land. In less poverty-stricken, low-income communities, densities of 400 to 500 persons per hectare were encountered. The colonial city and the low-income areas to the north and east, in San Carlos and Las Minas, had densities that ranged from 300 to 400 persons per hectare. Most other areas in the city had relatively low densities, less than 100 persons per hectare.

It has been estimated that there were 200,000 families residing in the city in 1975. The average urban family had five members. The estimated number of dwelling units would have been 116,000 based upon an average of 1.72 families per unit, or 8.6 persons per dwelling unit, estimated by the National Statistics Office.

The field survey of land use included the number and kind of structures for each sampled hectare. Table 7-1 contains the results

Table 7-1: Residential Land Use Determined from 1974 Aerial Photographic Base and 1975 Field Survey of Housing Based on 50-Percent Criterion, 511 Cells Included

	Low-Income Structures	Medium-Income Structures	High-Income Structures	Totals
Total Structures	4,076	2,052	694	6,822
Total Hectares	227	198	86	511
Residential				
Single-Family	1,496	1,332	520	3,348
Multiple-Family	872	188	4	1,064
Apartment	844	422	168	1,434
Improvised	864	110	6	980
Institutional	66	18	22	106
Commercial	286	94	34	414
Industrial	6	6	0	12
Open Space	208	168	82	458
Structures—Walls				
Concrete	946	1,422	664	3,032
Cement Block	1,668	490	46	2,204
Wood	1,614	184	22	1,820
Palm	28	0	0	28
Galvanized Steel	96	42	0	138
Brick	18	26	22	66
Limestone—Colonial	36	12	2	50
Structures—Roof				
Concrete	1,076	1,448	594	3,118
Galvanized Steel	3,266	576	76	3,918
Asbestos	42	0	0	42
Tile	6	54	80	140
Yagua-Cana	2	0	0	2
Floors				
One	4,004	1,694	428	6,126
Two	360	390	280	1,030
Three	46	46	32	124
Four or More	8	14	12	34
Landscaping	292	1,020	578	1,890
Recently Painted	672	1,124	452	2,248
Driveway-Carport	610	1,318	646	2,574
Louvered Windows	948	1,372	494	2,814
Grated Windows	970	1,064	442	2,476
Fenced	830	1,090	554	2,474
Professional-Commercial Use	550	274	74	898
Street				
Congested	750	310	150	1,210
Sidewalks	2,192	1,736	630	4,558
Curbing	2,814	1,866	688	5,368
Pavement—Good	1,394	1,302	574	3,270
Pavement—Poor	1,358	358	102	1,818
Clean	268	772	370	1,410

of the random selection of 140 streets. The 4,976 low-income structures included in 227 hectares of the survey sample were almost always one-storied. The average number of residential structures per hectare, computed from Table 7-2 is 17.96. Using this average, it is possible to compute an average of 9.6 households per residential structure in Santo Domingo's marginal settlements. This implies that the average residence sheltered 48 persons. The density of population per hectare of low-income residential land use would be 862 persons, a higher figure than that estimated by the National Statistics Office in 1970-1971. Yet, the slow increase in low-income land use evidenced in the maps and the massive in-migration of rural and urban Dominicans support the conclusion that city densities in these marginal areas should be higher.

Population Estimate

Based upon the estimated 800 persons per hectare and the area in low-income land use defined in the land use maps, it is estimated that there were 200,000 low-income residents in the city.

There were, as shown in Table 7-1, a total of 6,822 surveyed residential structures in the city in 1975. The number of dwelling units in each structure, estimated from the field survey, was one per single-family house, four per multiple-family structure, three for each apartment, and four per improvised home (Table 7-3). There were 511 hectares of residential land and 642 hectares of developed land included in the survey. For the estimated 15,826 dwelling units

Table 7-2: Average Number of Structures by Land Use and Type of Structure, Based on Merge of 1974 and 1975 Data Bases, 511 Hectares Included

	Average Low Income	Average Medium Income	Average High Income	Density Low Income	Density Medium Income	Density High Income
Total Structures	17.96	10.36	8.07	8.0	4.0	1.4
Total Hectares	227	198	86	511	511	511
Residential						
Single Family	6.6	6.7	6.0	2.9	2.6	1.0
Multiple Family	3.8	0.9	0.0	1.7	0.4	0.0
Apartment	3.7	2.1	2.0	1.7	0.8	0.3
Improvised	3.8	0.6	0.0	1.7	0.2	0.1
Institutional	0.3	0.1	0.3	0.1	0.0	0.0
Commercial	1.3	0.5	0.4	0.6	0.2	0.1
Industrial	0.0	0.0	0	0.0	0.0	0
Open Space	0.9	0.8	1.0	0.4	0.3	0.2

per hectare, the average number of units per hectare was 24.68 for the field survey data.

Table 7-3: Estimated Dwelling Units, Field Survey

Type of Residence	Number per Residence	Total Number
Single Family	1	3,348
Multiple Family	4	4,256
Apartment	3	4,302
Improvised	4	3,920
Total		15,826

From the aerial photography, it was established that 6,377 hectares were developed in 1974. At a rate of change of 0.065 based upon the growth over the 1948-1974 period, the projected 1975 area of developed land would have been 6,792 hectares. If this area is multiplied by the average number of dwelling units in a hectare, 24.65, the estimated number of units in the city totals 167,430. The National Statistics Office estimate of 4.8 persons in the urban family is used to compute an estimated 803,664 persons in the city in 1975. A 1975 estimated National District population of 922,528 adjusted for the noncapital population is 756,473 persons residing in Santo Domingo. The 6-percent difference between the two city totals is not extreme.

The total number of residential structures in Santo Domingo is low compared to that of Anglo-American cities of similar size. In a city of one million in the United States, the average is four persons per residential structure, less than half of the average in Santo Domingo. Furthermore, since almost 60 percent of the residential housing in Santo Domingo is low income, and less than one-half of all poor families can qualify for housing that meets minimum standards, actual density in marginal settlements must be considerably higher.

In Bogotá, Quito, Lima, and Santigo density was found to range from 675 inhabitants per hectare to 9 per hectare. In San José, Costa Rica, the 1970 Census of Population and Housing reported the city contained 87,404 dwellings housing a population of 458,154, an average density of 185 inhabitants per hectare. Densities of over 1,000 persons per hectare are not uncommon in large cities, even reaching 3,000 persons per hectare in extreme cases. Therefore, these estimates for Santo Domingo are not unreasonable and may accurately reflect the housing situation.

Table 7-4 presents estimated population for Santo Domingo by socioeconomic level of housing. It is possible that 85 percent of all poor in the city live in improvised, multiple-family dwellings. The low-density housing is reserved primarily for the more affluent. Even the middle-income residents live in higher density housing than would be found in Anglo-American cities. While they constitute one-quarter of the city's population, only 36 percent of middle-income inhabitants occupy single-family housing. The well-to-do, who comprise 7 percent of the population, occupy most single-family housing and the luxury high-rise apartment buildings.

Table 7-4: Estimated 1975 City Population, by Socioeconomic Level of Residential Land Use

Residential Structure Type	Low Income	Medium Income	High Income
Single Family	79,134	70,459	27,507
Multiple Family	184,505	39,779	846
Apartment	133,936	66,968	26,660
Improvised	182,813	23,275	1,270
Totals	580,388	200,481	56,283

Density of residential structures (see Table 7-5) does not vary inversely with distance from the CBD. Since high-income land use is closer to the central business district than middle-income land use, the density gradient holds true only for low- and high-income areas. There is evidence to support the contention that single-family housing tends to follow the gradient of Anglo-American cities.

Housing Typology

Several national censuses of housing have reported the types of construction materials used in the buildings in the city. Of 6,146 structures that were counted in 1930, more than one-half were wooden, the remainder concrete. Although the number of structures had doubled by

Table 7-5: Field Survey of Land Use, by Area, with Distance from Land Use Type to City Center, 1975

Land Use Type	Area in Hectares	Distance from CBD in Meters		
		Average	Minimum	Maximum
Low-Income Residential	2,076	4,672	316	11,992
Medium-Income Residential	1,374	5,292	282	11,992
High-Income Residential	983	4,751	282	11,986
Other Land Use	1,944	4,555	0	11,412
Open Land	2,768	6,936	100	12,212

1945, 60 percent of all structures were wooden and 34 percent concrete or cement block. Ten years later, wooden structures had increased to 64 percent (Repûblica Dominicana, 1960). An important part of the field survey was to assess some of these general conditions of the structures surveyed in 1975.

Table 7-6 contains the results of the field sample for a random subsample of one-half of the sites. An important change had occurred when these are compared with the previous census results. The use of impermanent materials decreased significantly. The threat of storm devastation and insect infestation must be, at least in part, responsible for the improvement in housing conditions.

One-half of the average hectare of residential land is developed in single-family residences, almost 40 percent multiple-family housing, and only 14 percent improvised. The latter proportion is low in

Table 7-6: 1975 Field Survey Totals and Percentages for All Land Uses

Structure	Total for the Field Survey	Percentage for All Structures
Single Family	2,099	44.05
Multiple Family	659	13.83
Apartment	911	19.12
Improvised	582	12.21
Total Residential	4,251	89.21
Institutional	66	1.39
Commercial	343	7.20
Industrial	105	2.20
Total Other Uses	514	10.79
Total Developed	4,765	100.00
Open Space	359	—
Concrete Walls	2,065	43.34
Concrete Block	1,362	28.58
Wood	1,071	22.48
Palm	42	0.89
Galvanized Steel	79	1.68
Brick	41	0.87
Colonial	32	0.68
Concrete Roof	2,150	45.12
Galvanized Steel	2,334	48.98
Asbestos	22	0.47
Tile	98	2.09
Cana-Yagua	31	0.66
One Floor	3,856	80.92
Two Floors	683	14.33
Three Floors	116	2.43
Four or More Floors	29	0.62
Landscaped	1,267	26.59
Recently Painted	1,512	31.73
Driveway/Carport	1,732	36.35
Louvered Windows	1,845	38.72
Grated Windows	1,587	33.31
Fenced Lot	1,636	34.33
Commercial/Professional Use	590	12.38
Congested Street	894	18.76
Sidewalks	3,003	63.02
Curbing	3,474	72.91
Good Paving	2,184	45.83
Poor Paving	1,136	23.84
Clean Surroundings	990	20.78

comparison with Latin American cities, but it may be the result of the local popularity of the inquilino, or rental within a rental, that permits two or more nuclear families to live within an extended family kinship group in the same house.

There is a high proportion of commercial establishments in residential areas. On the average, 2.57 structures are commercial in the residential hectare. These are most commonly the neighborhood grocery stores and small businesses which are operated out of the home.

About 40 percent of the residences have evidence of automobile use; yet there are extensive paving, curbing, and sidewalks throughout the city. The general absence of congestion and the reasonably good repair of streets suggest that automobile use is relatively recent and not yet as prevalent as that found in cities that have undergone a longer period of modernization.

The analysis of the results of the 37 variables in relation to the land use models and the land uses was too complex to be cartographically evaluated. Correlation analysis was used to reduce the numerous variables to a few which would be most useful in explaining land use patterns and housing conditions.

The initial correlation coefficient matrix indicated that some of the original field variables were not important. Low correlation coefficients were found for other land use, open land, tile roofing, two and more floors, commercial-professional use, congestion, and apartment structures. Additional variables from the land use maps which did not have sufficiently high coefficients to be included in the analysis were high-income land use and the six sectors. These were other variables that had only a few coefficients above 0.50. These were paving, distance to the CBD, middle-income land use, and all zones. The variable list was reduced to exclude most of these. The final group included single-family housing, a combined apartment and multiple-family category, improvised housing, concrete, cement block, and wood wall construction material, concrete and galvanized steel roofing, one floor, landscaping, recent paint, a driveway or carport, louvered and grated windows, fencing, sidewalks, curbing, clean appearance, density of residential structures, and the three land use designations.

Although the low correlation coefficients meant that there was much unique variance, both principal component and common factor analysis were employed in order to assess the relative advantages of one over the other approach. With rotation, four factors were produced by both techniques, and, in general, the variable loadings were similar. As generated by the common factor program, they are

Factor 1 - High-Income Housing;

Factor 2 - Low-Income Housing;

Factor 3 - Middle-Income Housing;

Factor 4 - High-Income Land Use.

Factor 1 is based upon the high loadings for single-family housing, concrete walls, concrete roof, landscaping, recent paint, driveway/carport, louvered and grated windows, fencing, and clean surroundings. These were interpreted as meaning that the factor included single-family housing, permanent and more expensive construction materials, housing that was kept up, was neat in appearance and was in good repair, evidence of automobile ownership, protected property, clean surroundings, low-density neighborhood, and a tendency for the land use to be middle-income or high-income.

Factor 2 is based upon improvised housing, concrete block walls, wooden walls, galvanized steel roofing, one floor, high density, and low-income residential land use. These variable loadings were interpreted to mean the housing tended to be improvised, of temporary, less expensive building materials, one floor, in high density neighborhoods located in low-income residential areas, and showing little or no improvements or evidence of good repair.

Factor 3 loadings that were used for the interpretation included concrete walls, concrete roofing, sidewalks, curbing, and a tendency for multiple-family housing to be selected. These were assumed to indicate that housing tended to be multiple family, or permanent and more expensive construction, and with sidewalk and curbing improvements.

Factor 4 included only two loadings of importance. The land use was high income rather than middle income. This suggested the unique influence that high-income residential land use seemed to exert on the survey results, and may indicate the Anglo-American, middle-class values of the researcher.

It is apparent from the factor analysis that high-income and low-income residential land use were the most distinct of the variables. Since these are the land uses longest in evidence, it is to be expected that selective change would have resulted in homogeneous characteristics of the residents. The low-income areas tend to repel other uses, while only the well-to-do are usually able to afford homes in the exclusive, expensive communities. Heterogeneity of land use is best explained by rapid change which has not allowed this selection process to have progressed far.

It is surprising that housing type, i.e., single-family, multiple-family, apartment, and improvised, did not differentiate more completely by land use. It is true, however, that single-family housing is a feature of high-income neighborhoods, and that multiple-family housing concentrates in low-income areas. The housing mixture of different socioeconomic levels is probably a characteristic of Caribbean cities where a quiet, suburban single-family residence is not as high a priority among achievement-oriented urbanites.

There is evidence that housing quality is improving in the city. Solid, hurricane-resistant structures are necessary in Santo Domingo because of its location in the storm track.

Automobile use is still limited. However, the number of registrations of automobiles is increasing, most of the city streets are paved and in good repair, and urban sprawl is making some sort of transportation necessary for completing daily living acitvities. The wide dispersal of other land use activities, however, suggests that employment, shopping, recreational, and other city functions are decentralizing, too, enabling people to find housing near their jobs. The important exception, of course, is the many thousands of marginal settlement residents who have been relegated to the urban fringe. These people are often tied to unskilled and semi-skilled work opportunities that are most commonly found in the commercial center.

There is little evidence that urban infrastructure has preceded or paced new housing construction. Using the middle-income residential land as the example, it has increased in proportion to the other land uses. But neither paving, curbs, nor sidewalks is significantly associated with this land use. Factor 1 indicates that infrastructural variables were most closely related to high-income residential land use.

The factor analysis supports the gradient thesis. Housing sites become larger and the number of structures per hectare decreases with socioeconomic level. Density has a high loading only on Factor 2.

The failure to establish a relationship among land use and socioeconomic level of residents and the land use change models may be due to several reasons. The land use maps indicated that a zonal configuration is not an adequate model for explaining land use change in Santo Domingo. Sectors, however, do seem to explain some variation in residential land use. Perhaps it is again the problem of choosing too many sectors to discriminate among the uses. Factor 1, which is high-income residential land use, does not correlate with either the zonal or sector models, however, it spite of both being indicated in the high-income land use patterning. The field variables probably were not specific enough to identify socioeconomic differences among residential land uses.

CHAPTER EIGHT
SUMMARY AND CONCLUSIONS

It is clear that Santo Domingo is experiencing decentralization. From the 1948 conditions of a concentrated commercial center surrounded by residential neighborhoods of homogeneous socioeconomic level, the city has increased fivefold in area and ranges twice as far from the CBD. All land uses have dispersed more widely within this much larger area, and this is particularly true for commercial, industrial, and institutional land uses. Outside the 1948 limits to the city, land uses have become mixed, obscuring zonal patterns. The sectors even become blurred toward the western portion that lies beyond Avenida A. Lincoln.

The urban transportation network has changed extensively. The single span across the Ozama River has been replaced by three bridges which link the lower-income residential and the industrial east with the western two-thirds of Santo Domingo. A modern, divided highway has been constructed that now routes long-distance vehicles around the built-up city, improving the east-west accessibility. Automobiles, trucks, and buses, the principal transportation in the city, are increasing in number. The major avenues have been extended and the north-south connecting routes in the western, less developed urban area are in place.

Congestion is extreme in the colonial center. The routing of traffic along narrow, crooked streets has reached the capacity of the Parque Independencia, Calle Conde, Avenida Mella, and others to carry people on their daily errands to and from the old city. The renovation of much of the ancient city created much needed government office space, and the resulting increased activity has made parking difficult in the crowded area that contains the main post office, several major banks, national offices, major department stores, as well as historic buildings which draw hundreds of patriotic Dominicans into their capital city each day.

During the past decade, there has been extensive relocation of important government offices. The National Statistics Office now enjoys space several times larger than the cramped quarters it once occupied in a colonial building in its new location in a modern high-rise structure that has been built on land beyond the old city. There is a huge complex newly constructed at the intersection of Avenida 27 de Febrero and the Haina-Herrera Highway that accommodates several national fiscal and diplomatic departments. Not far away is the industrial area of Herrera which includes its own airfield.

Most of the industry in the city is small firms, 60 percent of which lies scattered throughout the city. The other 40 percent is found clustered in seven major industrial areas, and over one-half are sited beyond the 1948 limits to the city.

The rapid expansion of residential use has involved nearly all urban areas. Density has increased within the older urban places, but development has been scattered, leaving extensive open space in the west and east. The middle-income land use especially is found widely dispersed. Low-income residential communities tend to exhibit higher densities and compactness. They are found more often in small enclaves of marginal housing in the west rather than the older, established low-income areas that have spread out to the east of Avenida Duarte. High-income neighborhoods, showing the greatest homogeneity, are grouped in two main areas, each of which is expanding to the west and away from the city center.

The decentralizing land uses now are being preceded by the extension of the street network. The national government's commitment to street improvement in the capital is evident everywhere. The city's citizens enjoy paved roads linking together all communities including those at the urban fringe. Although many of the marginal settlements' streets are unpaved, the longer-established areas have been included in the program to modernize the transportation network.

Another indication of the modernization process is the shift in residential land use patterns. The city can no longer be described as traditional. The two-class society has been replaced by a more complex socioeconomic class structure manifested in the wider array of housing types. The extremely poor, often recently arrived, are sheltered by family members who have been living in the city. They may have homes in the densely occupied neighborhoods just to the north of Avenida Mella and along the Ozama River, or in the many marginal communities scattered about the city. But within the extremes of distance that are found for the poor housing locations, the socioeconomic gradient is changing toward that found in much of the industrialized world.

At least for now, residential land use is becoming more heterogeneous than in the past. The overall land mix is wide-ranging, even confused in the most rapidly growing areas. The dispersal of non-residential use, unfettered by zoning restrictions, has essentially eliminated vestiges of the traditional city that were exhibited in homogeneous zones and sectors. Clearly, exclusivity still exists, but the rapid development of open land beyond Avenida M. Gómez involves all income levels, while the eastern third of the city includes housing for the very poor to the middle class.

Although there is evidence to support the sector model of land use change, the present conditions have not progressed sufficiently to conclude that sectoral growth will reflect the city's morphological patterns through the remainder of the century. Industrialization and urbanization doubtless have been forces for this change. The latter has probably had the greatest impact on the present spatial form. Yet, the large marginal settlement areas have not been anticipated in the model. Continued resettlement of the inner-city poor in the fringe-area communities is resulting in a ring of low-income housing in several key locations. Since the city's future expansion is limited by inaccessible, poorly drained, or steeply sloping land to the northwest, and the seacost lies to the south, future horizontal expansion must range east and west. The Haina River and the port city are now at the urban fringe. Beyond them lie extensive publicly owned sugarcane fields that have been largely unprofitable. In the future, they are apt to be annexed. Impeding this anticipated western growth of middle- and high-income residential communities are the industrial area of Herrera and the margin settlements. Clearly, the former has less likelihood of being eliminated. The national policy of relocating inner-city poor to the marginal settlements in this area is contributing to their spread across open land ostensibly owned by the university. Eventual conflict among these groups will exacerbate politically sensitive issues.

One alternative is to encourage new industry to locate in the east. New employment opportunities are needed there. The present extensive, low-income residential areas must continue to grow, and the resulting potential labor supply would be an enticement to industry. The concerns of the few who now deplore the current levels of pollution are largely ignored. But the dispersal of manufacturing and heavy industries away from the water resources in the west will become necessary as modernization intensifies.

Residential filtering has not been widespread. There is a shift in socioeconomic level in housing in the city center, a change that is based on a development pattern of sprawl including strip development along the major avenues and the construction of low-density communities for the middle and upper classes. Until further horizontal expansion stops, either through public policies or the fiscal limitations of the municipality to extend infrastructural services, average urban densities are not apt to increase by much. It is assumed, therefore, that as inner-city housing is abandoned for the new housing being built in the west, filtering will occur, and the pace of this process will be tied to the general economic prosperity. Inner-city structures already exhibit the deterioration of many years' use and the influx of poor migrants who crowd tenements and the colonial buildings that have been converted from single- to multiple-family residences. After centuries of use, some of these structures only now are showing recent neglect brought about by the loss of high- and middle-income occupants. Suburbanization is depleting the inner city of its well-to-do and, unless the tourist industry rejuvenates the area's financial base, the old urban core is going to experience the decay that has devastated inner-city neighborhoods in U.S. cities.

The city needs some mechanism for identifying conflicting land use and controlling for future incompatibility in land use. Especially during the rapid growth period that is accompanying this second state of the modernization process, Santo Domingo's land use mixtures must be controlled. Some present situations caused by the lack of control of growth are astounding, even frightening. There are numerous places where multi-storied, commercial buildings and high-rise apartment buildings are being erected between single-family homes in middle-class neighborhoods. There are such dangerous conditions as a propane gas field that lies within a residential community, only meters away from occupied homes. Even though this study shows that, over time, the process of selective location tends to separate incompatible land use mixes, nevertheless, development must be directed for the sake of public health and safety.

Since most major construction projects involve government investment, urban growth can be regulated with the assistance of national planning. This entails collaboration among a number of offices, some competing for political power and scarce finances. But, until the important questions about land use control are debated and collaborative decisions are made, alternatives to present trends are going to be difficult to identify and implement.

As necessity will eventually dictate, a comprehensive development plan will become a central issue, and the first requirement will have to be the determination of the extent of the problem. A survey of existing conditions, including a census of housing and nonresidential structures, is needed. This study indicates that certain exterior features of structures coupled with remote sensing information can be used inexpensively to identify land use patterns. The analysis of the field variables indicates that further revision would be needed but, that with the addition of some other measures of occupancy, it should be possible more accurately to determine the spatial location of residential land uses. Although the research produced factor scores for each of the surveyed hectares, the limitations to this study did not allow their mapping. It is proposed that with modifications to the methodology, computer-generaged maps of residential land uses would be relatively simple, and such cartographically aggregated information is an efficient means of creating the data base for a comprehensive plan for development.

In conclusion, it is hoped that the residents of Santo Domingo will seize the opportunity to avoid some of the mistakes that now confound the citizens of many modern cities, that they will see the wisdom of employing the urban theory which is applicable to their problems in order better to understand the change that must come. There are cross-cultural processes which land use change theory incorporates into explanations of the urban environment. This study is offered as an attempt to demonstrate that land use change in Santo Domingo over the recent decades, and during a critical time in its evolution, is measurable, understandable, and its consequences over the short range predictable. It is further hoped that any utility this study's results may offer the city's inhabitants will in some small way repay them for the many rewarding months that were spent in their fine city. We all wish to protect and enhance its qualities.

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Howard M. Tupper was born in New England but lived and traveled in the United States, Central America, and Europe during most of his youth, graduating from the Nürnberg American High School, Germany, in 1959. After studying psychology at the University of Maryland, Mr. Tupper served for seven years as a public health advisor in the U.S. Public Health Service. In 1970, he resumed schooling at the University of Florida, graduating with the degree of Master of Education with a major in social sciences. There followed several years' training as a population geographer at the Center for Latin American Studies. After acquiring a certificate of completion of urban studies from the Center for Urban and Regional Studies, Mr. Tupper was admitted to the Ph.D. candidacy in geography in 1975. That same year, he began a year's residency in Santo Domingo to research conditions in that city.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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