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The Factorial Ecology of Johannesburg

TIMOTHY HART

This is to declare that this dissertation is entirely *my own* work and has not been previously submitted as a dissertation or thesis for any degree in any other University.

29/3/14

The Factorial Ecology of Johannesburg

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PREFACE

In recent years, a substantial cross-cultural range of urban factorial ecologies has emerged, revealing some significant regularities in the intra-urban social and economic structure of cities in Western urban-industrial society. Based particularly on studies of a large number of North American cities, three distinct dimensions of residential differentiation are now recognized:

1. Sectoral distribution of economic status;
2. concentric patterning of various aspects of family structure; and
3. nodal clustering of ethnic minorities.

The present factorial ecology of Johannesburg is based on a factor analysis of thirty four social and economic variables pertaining to six hundred and twenty two enumerator's sub-districts for the 1960 census, and sets out to examine two broad interrelated hypotheses. These hold, in the first instance, that the White residential nucleus of Johannesburg is subdivided according to the North American paradigm of economic status, family states and ethnic status, and in the second that these differential dimensions, while spatially distributed according to principles of sectorality, concentricity and nodality, show variations from the American model that are attributable to the unique South African expedient of housing Non-Whites in townships peripheral to the White city.

In seeking to test these hypotheses, the chapters of the dissertation follow a specific sequence. Following the introductory chapter, Chapter 2 traces in broad terms the evolution of the city of Johannesburg, examining especially the settlement behaviour of various racial, cultural and social groups. The chapter concludes by suggesting a tentative model of socio-economic differentiation in Johannesburg and provides, in so doing, a link with Chapter 3. This discusses similar attempts at urban model building in the United States, a discussion which leads ultimately to an evaluation of the merits and shortcomings of factorial ecology. Chapter 4 outlines the sequence of methodological

steps in performing a factorial ecology, attempting at the same time to establish guidelines for future research of this type in South Africa. Interpretation of factor results is undertaken in the fifth and sixth chapters. The former describes the particular socio-economic dimensions that emerge and the latter seeks to evaluate the spatial impact on White residential areas of outlying Non-White enclaves by comparing the spatial socio-economic structure of Johannesburg with that of selected North American cities. The concluding chapter re-examines the hypotheses in the light of the foregoing analysis and finds these substantiated.

This study was initiated in 1971 as one of the first research projects to be undertaken by a member of the newly-formed Urban and Regional Research Unit at the University of the Witwatersrand, Johannesburg. Throughout the preparation of this dissertation contact with members of the Unit staff has proved stimulating and valuable, both by virtue of inter-disciplinary insights obtained during informal discussions and in the form of individual specialized skills that have been available to me from time to time. The director of the Unit, Professor T.J.D. Fair, in particular, has been an ever-approachable source of advice and not a little encouragement.

A debt of thanks is due also to my supervisor, Mr. K.S.O. Beavon, to Yet Chun and John Freedman of the University computer centre, to Mrs. H.D. Marais, who prepared a number of the diagrams contained here and to my wife who typed both the draft and final forms of the dissertation.

The research for this study and the dissertation itself were prepared during the author's tenure of the Corlett Drive Estates Research Fellowship. The author was the first holder of this Fellowship which aims to encourage research particularly in the urban and metropolitan field.

Although the debt to others is great, not only to personal acquaintances, but also to those who have pioneered in the field of factorial ecology, the opinions expressed here remain the sole responsibility of the author.

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CHAPTER 1

BACKGROUND TO THE PRESENT STUDY

Factorial ecology seeks to describe and explain, using factor analytic methods, the areal differentiation of the characteristics and behaviour of human populations (Rees, 1971, p. 220). The greatest research effort in factorial ecology to date has been at the urban scale and a substantial body of cross-cultural urban factorial ecology has emerged. Recent factor analysis of census sub-district information for cities in Western urban-industrial societies has shown that the residential areas of these cities may, in most cases, be differentiated according to the economic status and the family structure and age of sub-district populations. In ethnically heterogeneous societies, such as the United States, urban residential areas have been found to be further differentiated according to the ethnic composition of respective sub-district populations (Timms, 1970; Timms, 1971). A few North American studies have sought to quantitatively examine the spatial distribution of economic and family status (Murdie, 1969; Rees, 1970). These studies have demonstrated the tendency for economic status to be spatially differentiated according to a series of sectors radiating outward from the city centre and for family status to be arranged in a series of concentric zones about the centre.

In South Africa, a Western industrial society with a modern money economy has been superimposed on an indigenous tribal society with an economy based on subsistence (Fair, 1969). The city chosen for study, Johannesburg, has a dual residential structure based on this dichotomous social system. In early Johannesburg, the tribal African was housed in residential areas

peripheral to the White town (Leyds, 1964; Shorten, 1970). The exclusion of Africans from White Johannesburg was a response to the perception held by ruling Whites of the African as a migrant worker, unsuited to urban life and a source of potential friction if allowed to compete with poor Whites for either employment or residential space (Welsh, 1971). In 1923, legislation was passed making the residential separation of Whites and Africans compulsory and in 1950 was extended to include the smaller Asian and Coloured groups[1], who in their turn were moved to peripheral residential areas.

The present city of Johannesburg is composed of two spatially distinct residential sub-systems. These are a peripheral, locationally-controlled Non-White sub-system and a central White sub-system that has been allowed to expand in a relatively uncontrolled manner. The present study concentrates specifically on the White city of Johannesburg, which, it is felt, closely resembles the typical Western industrial city described by earlier urban factorial ecology. In performing a factorial analysis of 1960 census information for White Johannesburg, this study aims to realize two interrelated objectives. These are, in the first instance, to isolate and identify the major axes of social and economic differentiation in White residential areas and to examine the spatial ramifications of this division. Secondly, it is hoped to assess the effect of the controlled peripheral location of Johannesburg's Non-White population on the freely evolving residential mosaic of the White city.

RELEVANT LITERATURE

Relatively few studies exist in South African geographical literature that discuss the complex internal social and

[1] The Natives (Urban Areas) Act of 1923 and the Group Areas Act of 1950 are discussed more fully in Chapter 2.

economic organization that characterizes the White residential areas of South African cities. Three studies of Johannesburg, by Lipworth (1961), Davies (1964) and Cohen and Hart (1973) are particularly relevant in the present context. Both Lipworth and Davies have noted similarities between the spatial disposition of selected social, economic and land use variables in Johannesburg and the models of intra-urban socio-economic organization of Burgess (1925) and Hoyt (1939). Hoyt's sector model, for instance, is seen by Davies as explaining the spatial distribution in Johannesburg of occupations ranked according to social prestige. The value of residential stands in Johannesburg, according to Lipworth, also tends to vary within a sectoral framework. Dwelling type, by contrast, varies with distance from the city centre, giving rise to a series of concentric zones (as envisaged by Burgess) each containing a particular form of housing. These range from high density flat developments adjacent to the central non-residential core, through a zone of old small houses to an outer circle of 'suburban villas' (Lipworth, 1961, p. 31). The zone of old small houses tends to be favoured by migrant groups in Johannesburg, for the reason that housing is inexpensive. Portuguese immigrants, for instance, tend to cluster in residential enclaves that offer both cheap housing and proximity to place of work (Cohen and Hart, 1973).

The findings of Lipworth, Davies, and Cohen and Hart for White Johannesburg accord remarkably well with the results obtained by recent urban factorial ecology in Western industrial societies. The occupational hierarchy about which Davies' study centres, for instance, is an important constituent of the economic status dimension of differentiation often isolated by urban factorial ecology. In Johannesburg the spatial distribution of occupations is found to follow the sectoral patterning shown by Murdie (1969) and Rees (1970) to be typical of the economic status dimension in the North American city. The value of residential stands is not a

common variable in urban factorial ecology, but is economic in emphasis and is also found to be sectorally differentiated (Lipworth, 1961). Lipworth's study demonstrates in addition than an often used indicator of family status, dwelling type, varies concentrically in the manner of family status in North American cities. Ethnic variation is shown to exist in White Johannesburg by Cohen and Hart who find, in common with urban factorial ecology in the United States, that ethnic minorities tend to cluster nodally within a few residential enclaves.

Whereas studies are available that examine aspects of the social and economic differentiation of White residential areas in Johannesburg, none exist that seek specifically to evaluate the effect of the residential segregation of races on the ecology of the White city. In the North American city, racial segregation is not enforced by the central government. Rees (1970) notes that poor Negroes have invaded former middle and high economic status sectors in central Chicago to form, together with poor Whites in the centre, a concentric zone of low status. In Johannesburg, invasion of central areas by Non-Whites is avoided by housing the Non-Whites in peripheral townships. These outlying Non-White enclaves are, however, able to influence the economic status of White areas close to them. Lipworth (1961), for instance, points out that where White residential areas have expanded to abut once-peripheral Non-White townships, the value of residential stands tends to be low. Kuper, Watts and Davies (1958), in a study of the racial ecology of Durban, suggest that even once a Non-White enclave surrounded by White development is relocated to conform with government policy, it will be difficult to remove the stigma attached by Whites to areas formerly occupied by Non-Whites. In some cases Whites of middle and high economic status may refuse to occupy former Non-White areas and these will remain as low status relics in the White residential matrix.

HYPOTHESES TO BE TESTED

In the light of the foregoing discussion the present factorial ecology of Johannesburg seeks to examine two sets of hypotheses. The first set relates to the socio-economic structure of the White residential areas of Johannesburg, suggesting that:

1. Census sub-districts will be differentiated along three axes, reflecting levels of economic status, family status and ethnic status.
2. Economic status will have a sectoral spatial distribution.
3. Family status will have a concentric spatial distribution.
4. Ethnic status will have a nodal spatial expression, within the sector/zone framework.

Secondly, with reference to the influence of outlying Non-White areas on the residential structure of the White city, it is hypothesized that:

1. While large poor Negro groups often gather in the central areas of North American cities, invading and obliterating former middle and high economic status sectors here to form a central concentric zone of low status, the peripheral location of Non-White communities in Johannesburg will obviate this trend, and the sectoral distribution of economic status will tend to be strengthened.
2. White population pockets of low economic status, on land once adjacent to relocated Non-White townships, will be left as relics in the generally expanding White residential matrix.

CHAPTER 2

THE EVOLUTION AND SOCIO-ECONOMIC CHARACTERISTICS OF JOHANNESBURG

INTRODUCTION

Situated in the Southern Transvaal, some 400 km. from the sea and 50 km. from a major river, Johannesburg and most of the towns of the surrounding Witwatersrand urban complex owe their location to economically exploitable gold deposits in the Witwatersrand geological system (Figure 2.1). Rapid urban growth about these nuclei was ensured by a ready response to the seductive appeal of potential riches, together with the mustering of large unskilled labour resources to assist in the extraction and processing of the gold. During the first chaotic years of urbanization on the goldfields, urban populations fluctuated in direct response to technological innovation in the industry, as well as to vicissitudes in the gold market and in labour availability precipitated by local and international armed conflicts.

A modicum of stability followed once the vast extent of the goldfields was fully recognized. As the gold mining industry and the mining settlement began to show promise of permanence, industry complementary to the needs of both was established and this in turn heralded a continuing process of economic diversification on the Witwatersrand (Cockhead, 1970). Dependence on gold mining was greatly reduced after the Second World War, in response to the provision of adequate and integrated electricity and water supplies and also due to the stimulation of local manufacture as a result of the lack of imports during the war (Leyds, 1964).

By 1960, only 6,8 per cent of the economically active population of Johannesburg was employed in the mining industry.



Figure 2.1: The environs of Johannesburg and the location of suburbs.

The city had emerged not as a mining city but rather as the nucleus of South Africa's powerful industrial north-eastern development region (Green and Fair, 1962) and as a commercial centre of national importance (Davies and Young, 1969), dispensing services such as banking, finance and insurance and containing the co-ordinating headquarters of many national and international enterprises.

A BRIEF SETTLEMENT HISTORY OF JOHANNESBURG

The discovery of gold at Johannesburg attracted a heterogeneous group of people from local areas and from overseas. Leyds (1964, p. 25) comments: 'Afrikaners, Uitlanders[1], Indians, Natives, they were all here in 1886'. Observed in Johannesburg's first year, this ethnic mix, although in different proportions, continues to characterize the population of Johannesburg in 1960. An estimate of the population of Johannesburg in 1895 recognizes White, African, Indian and Chinese ethnic groups (Table 2.1), but makes no mention of a Coloured population. The 1904 census, however, showed this group of mixed African, White and Malay origin to be present in considerable numbers, outnumbering the Asian group.

Associated with the White group on the one hand and the broadly defined Non-White group on the other hand, are specific patterns of intra-urban settlement related to the degree of governmental control exercised over the spatial expansion of their respective residential neighbourhoods. The Transvaal government, for instance, even prior to the discovery of gold, insisted that urban Non-Whites reside only in those areas that are close to, but outside the White towns (Leyds, 1964).

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[1] *Uitlander* was an Afrikaans term used to describe members of the group of fortune-hunters attracted by the gold strike from as far afield as England, Australia the U.S.A., Germany, France, Poland and Italy, as well as large numbers from Natal, the Diamond fields of the Cape Colony, and the short lived Barberton goldfield (Chilvers, 1929; Leyds, 1964).

Table 2.1: Compound intercensal growth rates of major ethnic groups in Johannesburg[2] : 1895 - 1960.

INTERCENSAL PERIOD	PERCENTAGE COMPOUND INCREASE			
	ALL GROUPS	WHITES	AFRICANS	COLOUREDS & ASIANS
POPULATION IN 1895[3]	102 000	51 000	45 000	6 000
1895 - 1904	4,8	5,6	3,2	8,5
1904 - 1911	6,3	5,4	8,0	2,9
1911 - 1921	2,1	2,6	1,8	0,6
1921 - 1936	4,0	3,5	4,4	4,6
1936 - 1946	3,8	2,5	5,2	2,2
1946 - 1951	3,6	1,7	5,0	4,4
1951 - 1960	2,5	1,2	3,1	3,2
POPULATION IN 1960	1 137 806	404 143	645 312	64 067

Sources: Leyds (1964); Republic of South Africa (1968).

This policy was at first difficult to apply in a rapidly growing and disorganized town. In 1904, Non-Whites who until then had resided in the town were moved to peripheral Klipspruit (Figure 2.1A) and the former Non-White residential area of Newtown burnt to the ground. The justification offered for this action was that sanitary regulations could be more readily enforced in the resettlement area (Shorten, 1970). The rapid growth of the African population of Johannesburg between 1904 and 1911 (Table 2.1) brought large numbers of squatters to Klipspruit and without supervision this, in its turn, became insalubrious. Only in 1927 was the lack of

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[2] Johannesburg, as here defined, comprises the magisterial district and as such does not include a few areas outside of this district that are economically and socially linked to the city.

[3] 1895 was not a census year, and these figures are simply an early estimate quoted in Leyds (1964).

a supervisory body met with the establishment of a municipal department of Native Affairs. This department began building sub-economic housing in an attempt to realize the object of the Natives (Urban Areas) Act of 1923, which had for the first time made the residential separation of Whites and Africans statutory (Welsh, 1971). This new housing, however, failed to keep pace with the rapidly growing African population of the interwar period, with the result that by 1936 vast slum areas existed, especially around the Western Native Township where the Johannesburg Town Council had initiated a housing scheme some sixteen years before (Shorten, 1970). This situation continued into the fifties despite the establishment of substantial new townships on the south-western outskirts of the main urban complex.

The latter half of the decade 1950 - 1960 saw accelerated migration of Africans to the south-western settlement, joined now in this movement to peripheral areas by Asian and Coloured groups who in the past had remained relatively unscathed by attempts at residential segregation, but who fell now under the umbrella of the Group Areas Act of 1950 (Welsh, 1971). Enshrined now in law, the long established expedient of housing Non-Whites on the urban periphery reached full expression in the sixties with the emergence of the African city[*] of Soweto, and Asian and Coloured settlements such as Riverlea and Lenasia (Figure 2.1).

Unlike the spatially-fragmented Non-White residential areas, White settlement was left relatively free of locational control, and grew in a generally annular manner about the historic town centre (Figure 2.2). Within the

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[*] The term 'city' is used tentatively, since although Soweto had a population of 349 597 in 1960 (Republic of South Africa, 1968) it has no commercial or industrial areas of its own, relying largely on those of Johannesburg for the provision of employment and services. Lewis calls Soweto a 'city within a city' (Lewis 1966, p. 45).

overall pattern of centrifugal expansion, two major axes of accelerated urban growth are evident, one trending east-west along the northern fringe of the mining zone and the other trending north-south.

The emergence of this cruciform structure may be related to the distinct residential space preferences of groups at various levels of the social and economic hierarchy, a stratification that became evident early in the history of Johannesburg as a result of the broad range of cultural backgrounds of the heterogeneous population and their varying ability to exploit the economic and social opportunities offered by the mining industry and the growing town. Two major cultural groups were present that differed significantly in terms of urban acculturation. The *uitlanders* brought with them established traditions of urbanism from Europe, America, Australia and from the more developed parts of South Africa, and prospered in Johannesburg. The Afrikaans-speaking population, by contrast, experienced difficulty in shedding a long standing rural heritage and entered occupations not requiring specialized urban skills, occupations such as the civil service, the police force and the railways (Welsh, 1971).

The wealthy showed a marked disaffinity for the bustling town together with its Non-White and industrial appendages. Footloose as their affluence and later the advent of the automobile made them, the wealthy were able to ensure maximum spatial separation between themselves and undesirable areas, by moving out of the town northeastwards[5] to Doornfontein and its environs (1886 - 1890) and later northwards, toward the magnificent viewsites of Parktown. The land hunger possessed of this elite, together with the perceived desirability of the readily available rural area north of the established settlement ensured the rapid physical expansion of the city in this direction, with the establishment of a series of large, low-density suburbs.

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[5] Mining took place south of the town, while the early Non-White settlement was on its western flank.



Figure 2.2: Proclamation of townships in Johannesburg. The darkest area shading illustrates the spatial distribution of townships declared between 1886 and 1911. Progressively lighter shading is representative of township proclamations in the periods 1912 to 1936, 1937 to 1960 and after 1960. Concentric circles represent distances of five, ten and fifteen kilometres from the historic town centre.

Orthogonal to the northward residential thrust, the second important growth axis trended east and west of the old town, along the northern and to some extent the southern fringe of the gold mining area. In the west, expansion of White urban areas was instrumental in the repeated breakdown of attempts at spatial segregation of racially defined residential areas. Non-White housing, apart from being located according to segregationist ideals, had still to fulfil its primary function of providing a ready labour pool for the gold mining and other industries. Mobility of workers, in the face of compulsory disjunction was ensured by planning Non-White residential areas about the framework of well developed rapid transit routes paralleling the mining belt (Mallows, 1961). Working-class White residential development also took advantage of proximity to mines and transport and because of the larger measure of locational freedom afforded it, often abutted upon or surrounded Non-White areas, which were removed only to be overtaken once more. The process of encompassment and relocation left in its wake a series of low status White neighbourhoods, once perceived to suffer the locational disadvantage of contiguity with a Non-White area, but now standing amidst totally White surroundings.

New townships to the east of the town, by contrast, proved attractive to a number of leading citizens and developed as prosperous areas despite the nearby mines. But where in 1911 the suburbs of Jeppe, Belgravia, Troyville and Fairview (Figure 2.1) contained some 13,4 per cent of the influential[6] residents of Johannesburg, residential blight, together with encroaching light industry, had reduced this number to 2,2 per cent in 1936 and by 1960 had eliminated it completely.

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[6] These figures are based on entries in *Who's Who* publications for the census years of 1911, 1936 and 1960 (Donaldson, 1911; 1936; 1960). Although criteria for inclusion in *Who's Who* may be rather arbitrary, these sources, in the absence of historical income data, provide a useful historical perspective on the movement of elite residential areas. See Johnston (1971, pp. 146 - 147) for a discussion of this technique.

TOWARD A SPATIAL MODEL

Seen in broad spatial terms, the residential structure of Johannesburg is based on two sub-systems. These are a central *laissez-faire* White sub-system and a peripheral, locationally controlled Non-White sub-system. Within the White residential area itself, various socio-economic levels are spatially arrayed in a series of sectors radiating outward from the city centre. Overall, Johannesburg seems to fit the generic view of South African towns proposed by Davies (1963, p. 42):

> ... a tentative model for a South African town would most probably tend to develop a structure resembling the Hoyt model. This model would approach the ideal particularly where the town is developed upon flat land but would possess in addition semi-independent African and, where necessary, Indian and Coloured townships segregated in one or two outskirt localities separated from the remainder of the residential fabric by vacant buffer strip land.

While the phenomenon of outlying Non-White residential satellites in South African towns is predictable in terms of governmental policy, it is difficult to explain the consistencies in internal structure, based as they are on a multitude of location decisions which are influenced by cultural, social and economic considerations. This study now seeks to examine further the internal structure of White residential areas in Johannesburg, using the multivariate analytical approach of factorial ecology.

CHAPTER 3

THE CONCEPTUAL AND EMPIRICAL FOUNDATION OF FACTORIAL ECOLOGY

This chapter will review approaches and concepts relating to the socio-economic structure of cities, focussing particularly on three schools of thought. These are the views on intra-urban socio-economic differentiation put forward by the *early urban ecologists*, the *social area analysts* and the *factorial ecologists*. The review should shed some light on the philosophy and practice of modern urban factorial ecology.

THE EARLY URBAN ECOLOGISTS

Darwin's theory of evolution had a great impact on American sociology in the early twentieth century. The theory's view of nature as being composed of competing yet interdependent organisms within a dynamic evolutionary arena was deemed, by Chicago-based sociologists such as Robert Park and Ernest Burgess, to hold great promise for the scientific description of human society (Reissman, 1964). The city, in particular, was seen as a distinct ecological environment, within which the competitive interplay of humans with humans and the adaptation of humans to the environment could be studied.

The Concentric Zone Model of Ernest Burgess

In developing his well known concentric model of intra-urban socio-economic differentiation, Ernest Burgess (1925) sought to make a spatial statement of the effect of competition for residential locations among the inhabitants of a growing city. The growth of cities, according to Burgess, was the outstanding fact of contemporary

American society[1], and he developed a model based on a system of annular rings to characterize this process. City growth, however, was not viewed by Burgess purely in physical terms, but was thought to bring about changes in social life, and by disrupting this, to create social problems. Urban social pathology then, according to Burgess, could be assessed in terms of the physical growth of the city and communities in which problems were likely to occur located within the concentric growth model (Burgess, 1925).

Burgess described the zones to be expected within the ideal concentric growth model in a number of ways, the interpretation of which has caused confusion among later critics, who have seen Burgess' model as being either economic in emphasis or as referring to variations in family size and organization. Three viewpoints expounded by Burgess are presented in précis form below:

1. *The physical characteristics of zones*

   Zone 1: The central business district.

   Zone 2: The zone in transition — an area being invaded by business and light manufacture.

   Zone 3: The zone of workingmen's homes — homes of workers in industry who desire easy access to work.

   Zone 4: The residential zone — high class apartment buildings and detached dwellings.

   Zone 5: The commuter's zone — suburban areas or satellite cities within thirty to sixty minutes of the city centre (Burgess, 1925, p. 50).

A cross-section through zones two to five reveals an implicit economic gradient in terms of the physical condition of the structures. This ranges from an unstable transition zone, with old functionally obsolete buildings,

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[1] There was a massive influx of European immigrants to Chicago between the years of 1890 and 1910 during which the city grew rapidly. The impact of this migration on the sociological thinking of the time is noted by Burgess in retrospect (Burgess, 1964).

through the houses of industrial workers to high class apartments and detached single-family dwellings. The economic status theme is still evident when Burgess describes the social characteristics of the zones.

2. *The social characteristics of zones*

Zone 1: The C.B.D. — within this or in an adjoining street is the home of the 'homeless migratory man of the middle west'.

Zone 2: The zone of deterioration — a region of 'poverty, degradation and disease, and their underworlds of crime and vice'.

Zone 3: The zone of workingmen's homes — an area populated by factory and shop workers and second generation immigrants. 'It is the region of escape from the slum', a vantage point from which the resident can view the 'promised land' beyond.

Zones 4 and 5: The so-called 'promised land'. (Burgess, 1925, pp. 54 - 56).

Couched in emotive phrases, an increase in the economic as well as the social status of individuals in successive zones is implied together with variation in familial organization, ranging from the homeless single male of Zone 2 to families striving to attain goals embodied in more peripheral areas. A zonal family typology is expounded in greater depth in a later work by Burgess and Locke (1953).

3. *The zonal differentiation of family types*

Zone 1: The C.B.D. — the non-family type. Population made up of homeless men.

Zone 2: The rooming-house region — the emancipated family type. Highly mobile population comprising a high proportion of young people. These are attracted by the career and recreation opportunities offered by the city centre. Family ties are weak.

Zone 3: Immigrant neighbourhoods — small patriarchal family type. Lower class homes of foreign stock. Family structure is of the peasant type with the father the customary head.

Zone 4: Workingmen's area — patricentric family type. An independent population maintaining the patricentric family organization of the rural family.

Zone 5: Apartment-house district — equalitarian family type. Native American middle class inhabitants.

Zone 6: The suburban area — matricentric family type. Upper class native American population in single-family dwelling units. Here the family is organized about the mother since the father works and the mother is at home (Burgess and Locke, 1953, p. 109).

It seems that Burgess did not specifically intend his model to be unidimensional but felt rather that the ramifications of urban expansion had an observable effect on a *number* of levels of social organization, the complexity of this division increasing with successive waves of social disorganization and reorganization (Burgess, 1925). Burgess contributed rather more to the understanding of city growth and its relation to intra-urban spatial and social differentiation than the often criticized concentric zone model *per se*. He recognized, if only implicitly, the multidimensionality of urban socio-economic organization and sought to order this spatially according to ecological principles. Whether in fact the spatial expression of these socio-economic dimensions may be adequately explained within a series of concentric growth zones is a question *to be examined* later in this chapter.

The Sector Model of Homer Hoyt

Hoyt's sector model of residential differentiation is often seen as standing in contradistinction to the zonal scheme of Burgess. It is in fact only an extension that retains many of the latter's features. Hoyt's model owes much of

its apparent disagreement with the zonal model to the fact that Hoyt used a different empirical base and level of generality to those employed by Burgess. Whereas Burgess generalized on the basis of a single (and possibly atypical) North American city, Chicago, Hoyt based his observations on a far wider sample of one hundred and forty two cities. Also, Burgess described the spatial patterning of a number of dimensions of urban social structure, while Hoyt was concerned only with socio-economic differentiation expressed in terms of average block rental.

The following spatial characteristics were noted of various rental categories — in Hoyt's words:

> The highest rental area is in every case located in one or more sectors on the side of the city.
>
> High rent areas take the form of wedges extending in certain sectors along radial lines from the centre to the periphery ... In other cities, the high rent section takes the form of a rectangular or circular area on the periphery of one sector.
>
> Intermediate rental areas, or areas falling just below the highest rental areas, tend to surround the highest rental areas or to adjoin such areas on one side.
>
> Intermediate rental areas on the periphery of other sectors of the city besides the ones in which the highest rental areas are located are found in certain cities.
>
> Low rent areas extending from the centre to the edge of settlement on one side or in certain sectors of the city are found in practically every city (Hoyt, 1939, pp. 75 - 76).

These observations provide a firm base for the generalization, according to Hoyt, that rental subdivisions in United States cities conform to a radial sectoral pattern rather than being defined by a series of concentric zones. Burgess never made any statement concerning rent differentials in the city, but did imply that a general social dimension, socio-economic status, was concentric in its spatial disposition. Apart from this fundamental dissimilarity between the two models, there is some accord as to the processes creating the observed urban residential patterning. Hoyt for instance envisages a growing city with newcomers entering and initiating a shifting and

filtering movem[illegible]tive residents towards the periphery.

> Many of the [illegible]idents move to new and more attractive home[illegible]arther removed from business and industrial sites, while many of the new arrivals enter old neighbourhoods and occupy homes abandoned by previous occupants (Hoyt, 1939, p. 81).

By postulating an invasion and succession mechanism such as this, Hoyt makes concessions to the concentric model. Housing condition, as a function of urban expansion, tends to improve outwards from the city centre. It is to this newer and more attractive housing that the native resident flees in the face of less affluent immigrants, who occupy the recently vacated older housing. Given a growing city then, with immigration and consequent residential filtering, one would expect to find some zonal socio-economic variation within particular sectors. Zonal variation of rental categories is in fact evident in the series of thirty schematic diagrams presented by Hoyt (1939) to illustrate the sectoral variation of residential rents in selected North American cities (Figure 3.1). Of the twenty three cities containing enclaves characterized by the highest rental category, for instance, twenty one have at least one of these enclaves in the outer concentric zone, while only five cities have an area containing the highest rental level in the inner zone. In only one of the thirty cities is a complete high rent sector shown to exist stretching from centre to periphery.

In summary, Burgess' model makes a general attempt at ordering the spatial variation of a number of urban social dimensions. The sector model has a much broader empirical base and seems to represent a better description of the distribution of socio-economic status in cities, while still retaining some characteristics of the zonal formulation, both with regard to spatial patterning and to underlying dynamic processes.

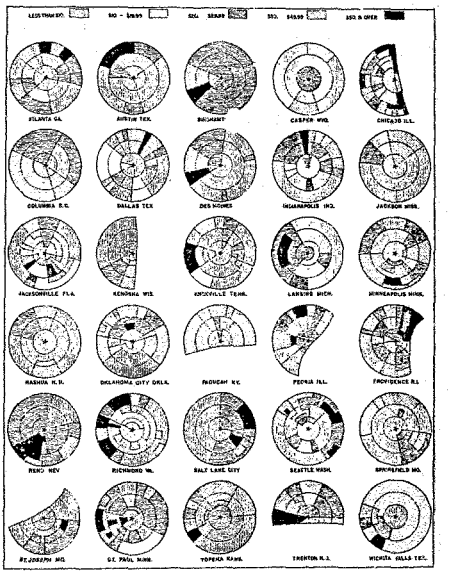

Figure 3.1: Theoretical pattern of distribution of rent areas in thirty American cities. Source: Hoyt (1939).

Criticisms of the Spatial Models of Intra-Urban Differentiation

Two bodies of criticism followed the formulation of the sector and concentric zone models by Hoyt and Burgess. The first group of critics (Davie, 1938; Quinn, 1940) question the use of rigid geometric grids to describe the social and economic organization of American cities. The second group of critics, those expounding the *social values* viewpoint (Timms, 1971, p. 91) overlook the spatial models themselves and attack what they see as an over-extension of evolutionary analogies and question particularly the role of competition in shaping the socio-economic structure of cities. The social values viewpoint is best exemplified in the work of Firey (1945).

In a detailed study of land use in the city of New Haven, Davie notes that certain dominant land uses tend to occupy locations of greatest utility to themselves. Business, for instance, is attracted to the central area, radial streets or strategic intersections. Heavy industry utilizes advantages of transportation to be found along waterfronts or close to railroads. Single-family dwellings are fairly widely scattered but tend to seek areas of residential utility. On the basis of this framework of dominant land uses, subsidiary types cluster in various ways. Two-family dwellings tend to be associated with industry while multi-family residences are close to central business areas. Light industry is freely distributed throughout the city.

Despite Davie's critical frame of reference, his observations and those of Burgess are often congruent. Both, for instance, acknowledge a central business core with adjacent high density residential areas. This core area in its turn is contained within a broad zone of single-family dwellings. Burgess, too, as does Davie, recognizes the existence of outlying shopping nucleations (Burgess, 1925) but sees these as simply representing outlying extensions of the core area.

The spatial component of the Burgess zonal model most difficult to reconcile with empirical observation is that of industrial land use. Burgess never discusses this, but rather implies its existence in the inner zones of the city by placing the zone of industrial worker's homes here. The tendency of heavy industry to locate in suburban or peripheral areas has often been pointed out by Burgess' critics, for example Davie (1938), Hoyt (1964) and Quinn (1940).

Quinn justifies the general zonal model by representing this as an ideal construction within dimensions of *ecological* space, a model which requires elaborate transformation to physical dimensions via functions of time/cost or ecological distance (Quinn, 1940, p. 212). Once he has done this, Quinn is yet unable to explain why Burgess located industry at the hub of the city and agrees that Davie's censure in this respect is valid.

Critics, such as Davie and Quinn, lose sight of the fact, however, that Burgess' aim was not to describe land uses in detail, but rather to locate areas with particular social characteristics and problems within the organizational frame of a uni-nodal growth model. Industrial sites themselves have no residential component, so it is hardly surprising that Burgess concentrated instead on the dormitory area housing industrial workers. Burgess' model is explicitly centred on a single hub, which contains all work opportunities, and seeks to explain the disposition of social types about this dominating axis.

The criticism of the social values school is aimed not at the spatial models themselves, but at the ecological approach that underlies them. The models of Burgess and Hoyt both see affluent urban residents as migrating toward new residential areas on the urban periphery in the face of competition for older central area housing initiated by less wealthy immigrants. Firey (1945) shows, however, that high status residential enclaves often survive social change around them. He argues that long-lived urban

phenomena such as the centrally located high socio-economic status area of Beacon Hill in Boston owe their durability to a *purposeful* maintenance of status despite a general lowering of socio-economic levels in surrounding areas. The force behind this resistance to change is seen by Firey to be the sentimental perception of Beacon Hill itself as symbolizing the cultrally desirable values of high economic and social status. In a similar manner, Italian communities in New Haven resist internal changes of occupational status and external forces as a result of sentimental attachment to the ethnic neighbourhood symbolizing the Italian life style (Myers, 1950).

Summary

Notwithstanding a great deal of critical examination, the innovations of the early urban ecologists have provided a number of valuable insights into the study of the differentiation of urban populations. The ecologists have shown, for instance, how a simple ecological framework can be employed to order the complexities of urban social and economic organization. The spatial models developed out of the ecological approach embodied similar qualities of simplicity, and were severly criticized as being unrealistic. Recent factorial ecological studies (Murdie, 1969; Rees, 1970) have recognized the concentric zone and sector models as *general* principles of urban spatial organization, however, and have found that the two models, in combination, explain much of the social and economic structure of North American cities.

THE SOCIAL AREA ANALYSTS

The conceptual gap between urban ecology and the work of the social area analysts is narrowed considerably if both are considered in relation to the views on urbanization of sociologist Louis Wirth. Like Burgess, Wirth bears witness to a massive shift from rural to urban society, but where Burgess viewed this change within the finite ecological bounds of the city, Wirth suggests that since

a process of graded *transition* between extremes of rural and urban is implied, 'we should not expect to find abrupt and discontinuous variation between rural and urban types of population'. (Wirth, 1938, p. 47). Accepting this viewpoint, the social area analysts see urban social organization as reflecting trends in a broad parent society (Shevky and Williams, 1949).

The initial formulation, by Shevky and Williams (1949), of a technique to isolate urban *social areas* was simply a response to the need for a conceptual framework within which to describe the social characteristics of the population of Los Angeles[2]. Subsequently, the social area approach was applied to San Francisco by Shevky and Bell (1955).

Social area analysis is based on the premise that as a society increases in *scale* it becomes progressively more complex, and a number of changes take place within that society. Shevky and his associates isolate three forms of change resulting from an increase of societal scale (Shevky and Bell, 1955, p. 4).

1. There is a change in the range and intensity of relations. This is evidenced by a changing distribution of skills with less manual productive activity and more directive activity.
2. There is a change in the structure of productive activity. Primary activity decreases and a greater number of relations are centred in the city. There is also a lessening of the importance of the household as an economic unit.
3. The organization of the society becomes more complex. The population becomes more diversified and more mobile.

Each of these social changes is seen to differentiate a population in a particular way. A greater number of

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[2] It is not surprising that a new approach be sought by which to study the decentralized sprawl of this West Coast city, since it stands in complete contrast to the strongly centre-oriented Chicago which so influenced the work of Burgess and his followers.

occupations with varying income earning potential and varying social prestige, for instance, tends to differentiate a population according to *social rank* (Shevky and Williams, 1949, p. 37). An increase in urban-centred activity differentiates a population according to their level of *urbanization* (Shevky and Williams, 1949, p. 41) and greater population diversity and mobility leads to the *segregation* of sub-groups[3] (Shevky and Williams, 1949, p. 47).

Spatially distributed sub-populations are seen by the social area analysts as standing in differential relationship to each of the dimensions of differentiation of social rank, urbanization and segregation. The precise position of a statistically defined sub-population (for example the population of a census tract) on each of the three dimensions is calculated according to an index. Each index comprises a variety of census statistics for a particular census tract. Measures of occupational status, schooling and rent[4], for instance, summed for each tract and standardized by a range of zero to one hundred, constitute the social rank index. *Urbanization* is similarly indexed in terms of fertility, women at work and numbers of single family dwelling units. Segregation is evaluated in terms of measures of spatial isolation (Shevky and Williams, 1949, pp. 34 - 35; Shevky and Bell, 1955, pp. 54 - 58). Based on their scores on each of the social area indices, census tracts are located first within a two-*dimensional social space*[5] defined by co-ordinate axes of social rank and urbanization, and a third dimension added

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[3] Bell prefers the terms *economic status*, *family status* and *ethnic status* (Bell, 1955, p. 45).

[4] This variable was excluded by Shevky and Bell (1955) from their San Francisco study.

[5] This is the term used by Shevky and Bell. Shevky and Williams use the term *attribute space* (Shevky and Williams, 1949, p. 64).

by classifying the tract according to its level of segregation. The *social area type* (Shevky and Williams, 1949, p. 63) of the tract is decided according to its position within a series of arbitrarily defined cells that subdivide the social space diagram (Figure 3.2).

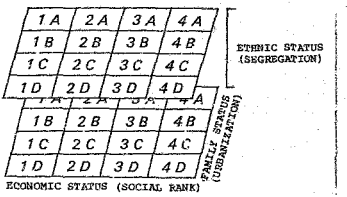

Figure 3.2: Social area cells[6].

Social area analysis, although not explicitly attempting to build a spatial model of intra-urban socio-economic differentiation, has a great deal in common with the work of the early urban ecologists. The social area approach and the concentric model of Burgess, for example, both have a temporal base rooted in the transition of society from rural to urban organization and mutually recognize the existence of many axes of intra-urban differentiation within and as a result of this dynamic frame. The two viewpoints diverge in that Burgess sees urbanization as a *physical agglomeration* process, to which groups of individuals respond differently in an effort to compete effectively. Urbanization in the social area analyst's view is characterized rather

[6] Shevky and Williams use an eighteen cell typology. The thirty two cell typology of Shevky and Bell is illustrated here.

by a concentration of skills and by specialization in response to new opportunities offered by industrial society.

Criticisms of Social Area Analysis

Criticism of social area analysis may be divided into two broad categories. One set of critics question the train of logic used by Shevky to develop his typology, and express doubts concerning the utility of census defined statistics in applying the social area scheme. The other group of critics accept the theoretical framework of social area analysis, and go on to test the model in a number of situations and using a variety of techniques.

In reviewing the work of Shevky and Williams, Ericksen (1949) criticizes the use of census tract data in social area analysis on the basis that the variables selected only reflect *averages* within statistical units. Hawley and Duncan (1957) extend this argument in pointing out that the quest for averages is particularly misleading in areas of considerable internal heterogeneity. Notwithstanding this, Duncan (1955) acknowledges the enormous potential of census data in urban research. Hawley and Duncan also question the range of variables chosen to index dimensions of urban differentiation, pointing out that this seems to be somewhat arbitrary. In examining these variables in some detail, Udry (1964) shows that as supposed indicators of increasing societal scale some variables have little validity since these often do not represent constant trends. For instance, Udry observes that fertility from 1940 onwards began increasing as against the decrease indicative of urbanization postulated by Shevky. In reply Bell and Moskos (1964) point out that fertility is being increasingly explained by the choice of life-style made possible by urban society, a choice between raising a family on one hand, and consumption and social mobility on the other. Whatever the explanation however, the point is that fertility, as of 1940, has come to stand in a different relationship to the overall change it was earlier supposed to index.

Udry further criticizes the logical inconsistency of Shevky, Williams and Bell in defining axes for the

differentiation of urban sub-areas on the basis of trends that are manifestations of the *single* process of increasing societal scale. The argument is that if these axes are not independent, then they do not optimally describe intra-city differentiation and leave other possible dimensions unexplored. More realistic, according to Udry, would be to divide the social area theory into two co-ordinated but not necessarily causally related theories as follows:

(a) A theory of increasing societal scale.

(b) A theory of dimensions of urban differentiation.

It cannot be denied however, that the theory of increasing scale, in concept at least, holds considerable promise as a foundation for cross-cultural social study. It is therefore desirable that the link between theories of increasing scale and urban differentiation be clarified in order to facilitate comparative urban study. An approach to achieving this would be that of reversing the logical order envisaged by Shevky. This is firstly to examine the internal differentiation of cities in different societies, and on the basis of this to establish a scale of social complexity. This phenomenological approach has emerged out of empirically based criticism of social area analysis, and will be evaluated in the section to follow.

Attempts at empirical validation of the social area typology take two basic forms. Some, for instance, employ only the limited range of variables used in the original social area studies, but examine the inter-relationships of these variables using exploratory grouping techniques such as factor analysis. Other empirical tests of the social area scheme use factor and cluster analysis to examine a far broader range of variables.

The first empirically-based critical examination of the social area typology was that of Bell (1955). In this study Bell factor analyzes the original set of social area variables, using census information for Los Angeles and San Francisco in 1940. The factor analysis isolates three groups (or factors) of interrelated variables. The three factors closely approximate the three

dimensions of intra-urban differentiation used by the social area analysts and Bell concludes that economic status, family status and ethnic status provide useful measures of urban socio-economic organization. A similar test of a wider range of United States cities seems generally to support Bell's conclusion (Van Arsdol, Camilleri and Schmid, 1958), with minor variations in cities having large Negro populations. Van Arsdol *et al* seem to agree with Bell however that the three differentiating axes defined by social area analysis, '... are necessary to account for the social differentiation between census tract populations.' (Bell, 1955, p. 53).

This claim by Bell seems a little extravagant since in the above studies the extracted factors only explain the interrelationship of a few selected and not necessarily representative census variables. The fallacy of Bell's argument is revealed by Tryon (1955), whose cluster analysis of thirty three variables for San Francisco uncovers *four* major groups of interrelated census tract attributes instead of the postulated three. It seems then that although the social area analysts isolated major dimensions of population differentiation in North American cities, consideration of a wider range of variables could well reveal further, more city-specific factors related to particular social settings.

THE FACTORIAL ECOLOGISTS

Factorial ecology was born out of critical examination of the provocative social area model, which in its turn has roots in the work of the early urban ecologists. An important background to the development of factorial ecology lies in the extensive marketing and widespread use of computers initiated in the 1950's (Veldman, 1967). The enormous data processing potential of digital computing machinery made feasible the handling of the huge data matrices characteristic of factorial ecologies.

A benchmark in the evolution of factorial ecology is the dyad of papers published by Anderson and his associates in 1961. The first of these examines factorially the

interrelationship of thirteen variables describing fifty four census tracts of the city of Toledo (Anderson and Bean, 1961) and represents a significant combination of the factorial approach employed by Bell and Van Arsdol *et al* and the extension of the range of variables beyond those used by Shevky, as initiated by Tryon.

In the second paper, Anderson and Egeland (1961) seek spatial links between certain dimensions of urban differentiation and the geometrical models of Burgess and Hoyt. In an analysis of variance of spatial patterning in four U.S. cities, they find economic status to have sectoral ramifications and family status to conform to a generally concentric pattern about each of the four city centres.

The methodological innovation of this pair of papers is significant, in that they serve to link a number of conceptual and practical loose ends stemming from both the urban ecological approach and from social area analysis. The multidimensional urban structure implicit in the work of Burgess and formalized by Shevky is made explicit via the objectively analytic powers of factor analysis. Also, specific urban social dimensions are shown to relate in a general way to the spatial views of city structure held by Burgess and Hoyt. Nor is the social area ideal of comparing cities within similar societies abandoned, since objective use of a standardized exploratory technique such as factor analysis is particularly apposite to this approach. In this way, then, it may be possible in time to turn a full conceptual circle by isolating the bases of urban differentiation, comparing these in different cultural situations both in terms of social and spatial characteristics, and on the basis of this background of comparable empirical studies, to attempt to isolate the urban processes so avidly sought by the early urban ecologists half a century ago.

Berry (1971)[7] argues strongly in favour of a

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[7] This article is contained in the Economic Geography supplement (June 1971) entitled *Comparative Factorial Ecology*, a volume focussing specifically on the problems and promise of the comparative approach.

phenomenological comparative strategy of factorial research, and says of factorial ecologies that these,

> ... cannot be evaluated from the scientistic perspective of positivism, for their essence is the idea that meaning in any situation has to be learned rather than posited by aprioristic theory. (Berry, 1971, p. 214).

Studies using the factorial method, and thus suitable for placement within a cross-cultural comparative data bank are legion, with Rees (1972) citing some thirty five factorial ecologies of North American cities and twenty of non-American cities known to him[8].

There is a caveat, however, in that although comparative factorial ecology seems to promise more generality than did the classical ecological and social area approaches, it still has a number of limitations. For instance, Abu-Lughod (1969) points out that the particular selection of input variables will govern the nature of the resultant differentiating dimensions. Cases thus can only be realistically compared if one can uncover latent dimensions, in different situations, with similar meanings (Berry, 1971). It seems that some strategy for the definition of factorial inputs is necessary. There is also the danger, however, that in response to a call for comparability, factorial ecologies will degenerate into 'a stream of witless replications' (Berry, 1971, p. 219), and result in an intellectual dead end. Factorial ecology, according to Smith, (1972) has in fact fallen prey to the pitfalls recognized above. In selection of variables, for instance, criteria for inclusion seem to rely more on readily available census material than on *a priori* conceptualization of the problem being studied, with the result that the results embrace at the outset the conceptual bias of the census. In the pursuit of census based characteristics, according to Smith, factorial ecologies have ignored

> social pathologies such as drug addiction, venereal disease, crime and alcoholism, which are so much a feature of contemporary urban society. (Smith, 1972, p. 45).

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[8] Detailed tabulations of a wide range of factorial studies are contained in Murdie (1969, pp. 32 - 38) and Rees (1971, pp. 223 - 224).

In support of his argument, Smith conducts a factor analysis on a matrix of welfare-oriented variables, extracting a number of *components of social well-being* (Smith, 1973, p. 93). While few geographers would disagree with Smith's concern for the monitoring of social ills and while the points he raises serve to underline some of the shortcomings of the factorial ecological approach, his own analysis serves to emphasize a problem of factor evaluation. It is difficult to imagine how a policy-directing body would establish priorities for social remedial action on the basis of nebulous concepts such as *general socio-economic well-being, mental health* or *social pathology* (Smith, 1973, p. 93), where these factors only have dimension within the space defined by the input variables.

Clearly, the present state of the factorial art is by no means a perfect one. While the social relevance of a great number of studies in human geography could be questioned, a more specific problem to be pointed out by Smith is one of which procedural stance to adopt — to factor from a position of prior theoretical structuring, or to allow the factor technique itself to uncover latent structure. In reality, the current research thrust appears to be taking a course somewhere between these extremes. The recent work of Smith is not, in the first instance, entirely without an exploratory component, since while a frame is established for the selection of relevant variables, no explicit prediction is made as to what factorial dimensions are likely to emerge from these (Smith, 1973). Nor, secondly, is comparative factorial ecology devoid of conceptual base, seeking to explore as it does the cross-cultural socio-economic *relationships* between cities, testing implicitly the sweeping postulate that processes of intra-urban socio-economic differentiation have international generality. In this case criteria for the relevance of variables should seek, not to exhaust the data possibilities of the census, as alleged by Smith, but to satisfy the essential condition of comparability emphasized by Berry and Abu-Lughod. This condition satisfied,

the responsibility for rescuing a factorial ecology from the 'stream of witless replications' rests ultimately with the individual researcher, in his understanding of the potentialities and shortcomings of the statistical tool and his ability to transform sterile factorial outputs into meaningful results.

CHAPTER 4

THE RESEARCH METHODOLOGY

In preparing to execute a factorial ecology, a number of decisions have to be taken. These relate generally to the characteristics of the information to be analyzed, the capabilities of the factor model itself and to the subsequent treatment of basic factor outputs. Each decision must be made with reference to the specific aims of the study (Armstrong, 1967).

The present study has two major research objectives:

1. The *exploratory* analysis of the socio-economic structure of Johannesburg in an effort to isolate and explain fundamental interrelationships within this system.
2. The *comparative* evaluation of this and other factorial ecological studies both in order to identify features common to cities in similar social contexts, as well as to place the unique characteristics of a South African city within a general cross-cultural framework.

With a view to meshing these objectives and the factorial approach, the following points are discussed below:

1. The choice of factor model.
2. The definition of the study area and statistical sub-areas.
3. Selection of variables.

THE CHOICE OF FACTOR MODEL

Before selecting the factor model most appropriate to the objectives of the present study, it is necessary to understand the characteristics of the range of alternative models. Two factor models are most frequently used in

geographical studies. These are *component factor analysis* and *common factor analysis*[1]. Both have the ability to identify composite dimensions of variation underlying a set of interrelated variables and in so doing follow a similar computational sequence:

1. The data matrix, which in factorial ecological studies usually comprises n socio-economic variables describing n sub-areas is converted to a standard score matrix Z, again of order $n \times m$ (i.e. n rows and m columns).
2. Based on Z, a correlation matrix R, of order $m \times m$ is calculated. The correlation coefficients are usually computed according to Pearson's product moment method and express the degree of relationship between each variable and every other variable.
3. The correlation matrix is then factored, yielding an m (variables) by p (factors) *factor loading* matrix F, where the factors represent patterns of variation fundamental to the m variables. Each loading expresses the involvement of a variable in a particular factor.
4. In most factorial ecological studies the option is exercised to mathematically transform or *rotate* (Rummel, 1970, pp. 368 - 422) the factor loading matrix to a solution embodying certain

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[1] Comprehensive texts such as Rummel (1970) and Harman (1967) discuss these models in some detail. Shorter descriptions are given by Cattell (1965), Rummel (1967) and King (1969). Factor analysis terminology can be confusing due to a lack of standard nomenclature. *Component factor analysis* and *common factor analysis*, for example, are terms used by Rummel (1970, pp. 104 - 113) to describe the pair of factor models used most frequently by geographers. Murdie (1969, pp. 70 - 71) uses the terms *principal components analysis* and *principal-axes factor analysis* to describe the same pair of factor models. In Rummel's terminology, which is used throughout this study, the *principal axes technique* is a method of reducing a matrix to its factor dimensions. This technique can be employed in both the component and common factor models (Rummel, 1970, pp. 323 - 348).

specified characteristics. Generally the criterion for this transformation is *simple structure* (Rummel, 1970, pp. 376 - 381). This seeks to maximize the number of high loadings on each factor while reducing to a minimum the number of factors on which any one variable loads strongly. In accounting for the variation of a variable in terms of as few factors as possible, rotation to simple structure pursues the ideal of *parsimony* (Rummel, 1970, p. 381) where it is sought to explain reality in as simple terms as possible.

5. Based on either the unrotated or the rotated factor loading matrix, a *factor score* matrix S may also be extracted. Factor scores index the relative standing of sub-areas on each of the factors. This would be an $n \times p$ matrix.

At step three in the computational sequence the component and common factor models diverge. In the component case, the correlation matrix that is factored contains unities on the principal diagonal. The model assumes, therefore, that every variable will correlate perfectly with itself. In making this assumption, the component factor model fails to recognize that a portion of the variation of a variable may be attributed to influences outside of the sample of variables (Cattell, 1965). In the *common factor model*, the values that are inserted on the principal diagonal are estimates of the amount of variation embodied in each variable that is *common* to all the other variables in the sample. Variation in the sample of variables that is *unique* to individual variables is excluded from the analysis on the grounds that this might have unknown links beyond the scope of the sample.

In selecting a factor model, then, a choice has to be made between two basic factorial approaches to the overall variation contained by a data matrix. These are the component factor approach, in which the entire variance context of the matrix is analyzed and the common

factor approach, which analyzes only the common variance component of the matrix. The present study has dual objectives of exploration and comparison, the realization of which, it is felt, requires the specific capabilities of *both* the component and the common factor models. In pursuing the exploratory ideal, for instance, the component model will account for as much as possible of the patterns of variation contained by the data to be used in the study. The common factor model, by contrast, will isolate and exclude variation that is unique to individual variables. In the absence of a strategy for the standardization of factorial ecological inputs, it is hoped that this *noise reducing* (Berry, 1966, p. 196) quality of the common factor model will produce simple, cohesive factors that in turn will facilitate meaningful cross cultural comparison of factorial ecological results[2].

Specific aims aside, parallel analysis via different factor models will provide valuable practical insight into inter-model relationships. Further, by comparing factor models in this way, the unique variance element retained by the component model and rejected by common factor analysis can be identified and the cause of its uniqueness

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[2] The execution of the component and common factor analyses on which this study is based was facilitated by a computer program contained in Veldman (1967, pp. 222 - 225). This factor analysis design is based on the principal axes method of factor extraction and includes both component and common factor options. The common factor model used is Guttman's (1953) *image* variant. Image factor analysis has the advantage over many other common factor models of being able to define the common variance component of the data sample in precise terms. In the image model the common parts of the data are isolated in the form of regression estimates of each variable regressed on all the others (Rummel, 1970, pp. 113 - 121). A rotation option is also included in Veldman's program. Simple structure is approximated in this case by rotation to Kaiser's *varimax* criterion (Rummel, 1970, pp. 391 - 393). Varimax rotation is frequently incorporated in factorial ecological studies and this option was exercised here in an effort to ensure comparability of the factors of the present study and other factorial eco-

examined, with a view either to expanding the list of variables in the direction of hitherto unrecognized factors, or to simplifying this list by excluding variables shown to be contextually irrelevant.

DEFINITION OF THE STUDY AREA AND STATISTICAL SUB-AREAS

The Study Area

The present study is concerned primarily with the White residential areas of Johannesburg and the study area is delimited accordingly. Basically, the area of study is coextensive with District 555 of the 1960 census, but excludes tracts of rural land in the north of this district and large undevelcped and Non-White areas in the south. Also omitt from the analysis are scattered sub-districts comprising either Non-White residential pockets, such as Alexandra, Coronationville, Newclare, Martindale and Eastern Native Township or urban areas characteristically uninhabited, as exemplified by the Milner Park showground and the marshalling yards of the South African Railways (Figure 2.1). The central and other business districts were retained, together with industrial and mining areas, because these were found to have a superimposed residential component, either in the form of upper-storey apartments, or of dormitory housing attached to mines or large industrial concerns.

Statistical Sub-Areas

In the South African census, urban areas are subdivided at the finest level into enumerator's sub-districts, the populations of which vary, in the case of the 1960 census partition of Johannesburg, between extremes of less than a hundred and more than two thousand. The mean population for 1960 enumerator's sub-districts in Johannesburg is about eight hundred and fifty persons. By contrast, most North American urban factorial ecologies have as units of analysis census tracts with an average

population of about four thousand (Robson, 1969). Not wishing to lose information in a study that is explicitly exploratory, it was decided in the case of the present study to retain, as far as possible, the detailed coverage of the study area offered by the enumerator's sub-district system of six hundred and fifty eight units. Aggregation of sub-districts was necessary only to supplement the small residential populations of sub-districts in industrial or commercial areas. Spatial synthesis to this end reduced the number of statistical units to six hundred and twenty two.

SELECTION OF VARIABLES

A problem confronting the user of census material is one of selecting pertinent variables from an often confusing array of dispassionately displayed population characteristics. The strategy adopted here seeks primarily to assemble a body of variables that will complement both the exploratory and the comparative functions of the present study. In order to qualify for inclusion in the present study variables have to satisfy three conditions:

1. They must be clear and unambiguous[3] in definition, in order to establish a stable and comprensible base for the interpretation of explanatory factors.
2. The variables should index as efficiently as possible the overall variation in the research domain.

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[3] An example of ambiguity among variables is provided, albeit deliberately, by Carey (1966) in his factorial analysis of housing patterns in Manhattan. Variables in this study are retained in their raw form, with no attempt made to control for acknowledged population differentials between census tracts. As a result, each variable, in addition to measuring what its nomenclature suggests, represents also an indirect index of population size. With size fluctuation being reflected over a wide range of variables, it is hardly surprising, if somewhat misleading, that Carey should extract a confluent factor emphasizing this demographic feature.

It is deceptive, in an exploratory study, to supplement a list of variables with sets of variables *known* to be strongly covariant (such as male and female, employed and unemployed), since such sets would tend to add undue weight to a single variance perspective — a perspective that could be expressed in a more balanced manner by *one* of the covariant variables.

3. To facilitate meaningful international comparison, the sample of variables should mirror, as closely as the census will allow, the selection adopted by other factorial ecologies.

Exact cross-cultural replication of individual variables is made difficult in that national census bureaux tend to be insular in their approach to data collection, doing little to ensure that the data they assemble is comparable with census information collected in other countries. This handicap is compounded in that even among factorial ecological studies based on a common census system (that of the United States), a consensual datum for comparative urban factorial research has yet to be formulated. There is, however, a general recognition of three fields of intra-urban interest, loosely coincident with the social area constructs of socio-economic status, family status and ethnic status, a conceptual structuring that may be called on to guide the choice of surrogate measures in cases where duplication of variables is impracticable or, in a specific cultural context, misleading.

The variables on which the present study is based are thirty four in number* and may be divided into major groups of social and economic character. Also included is a pair of variables indexing sub-district location in relation to the city centre and relative spatial

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* The South African census does not publish information at the enumerator's sub-district level. The data used in this study had to be extracted from the raw listing (stored on computer tape) of census information for each individual in Johannesburg. At the time of writing the 1970 census tapes were not yet available.

concentration of sub-district populations (Table 4.1). All, with the exception of the distance variable, are expressed in terms of a ratio (usually a percentage) in an effort to neutralize inter-district variations of area and population.

Table 4.1: Variables used in the present study.

NUMBER	DESCRIPTION
1	ROAD DISTANCE FROM PEAK LAND VALUE INTERSECTION
2	GROSS POPULATION DENSITY
	SOCIAL VARIABLES
3	PERCENTAGE NON-WHITE
4	PERCENTAGE FEMALE
5	PERCENTAGE LESS THAN FIFTEEN YEARS OLD
6	PERCENTAGE MORE THAN SIXTY FIVE YEARS OLD
7	PERCENTAGE MARRIED
8	PERCENTAGE MARRIED BEFORE THE AGE OF TWENTY ONE[$]
9	PERCENTAGE BORN IN SOUTH AFRICA
10	PERCENTAGE BORN IN THE BRITISH ISLES
11	PERCENTAGE BORN IN SOUTHERN EUROPE
12	PERCENTAGE WITH EDUCATION UP TO STANDARD EIGHT
13	PERCENTAGE WITH POST-SCHOOL EDUCATION
14	PERCENTAGE DUTCH REFORMED
15	PERCENTAGE ENGLISH PROTESTANT
16	PERCENTAGE ROMAN CATHOLIC
17	PERCENTAGE JEWISH
18	PERCENTAGE AFRIKAANS-SPEAKING
19	PERCENTAGE WITH ONE OR TWO CHILDREN[$]
20	PERCENTAGE WITH MORE THAN FIVE CHILDREN[$]
	ECONOMIC VARIABLES
21	PERCENTAGE IN HOUSES
22	PERCENTAGE EMPLOYERS
23	PERCENTAGE UNEMPLOYED
24	PERCENTAGE IN PROFESSIONAL, TECHNICAL AND RELATED OCCUPATIONS*
25	PERCENTAGE IN ADMINISTRATIVE, EXECUTIVE AND MANAGERIAL OCCUPATIONS*
26	PERCENTAGE IN SALES OCCUPATIONS*
27	PERCENTAGE IN TRANSPORT AND COMMUNICATION OCCUPATIONS*
28	PERCENTAGE CRAFTSMEN, PRODUCTION WORKERS AND LABOURERS*
29	PERCENTAGE IN SERVICE, SPORTS AND RECREATION OCCUPATIONS*
30	PERCENTAGE IN THE MINING AND QUARRYING INDUSTRY*

31	PERCENTAGE IN THE MANUFACTURING INDUSTRY*
32	PERCENTAGE IN THE COMMERCE AND FINANCE INDUSTRY*
33	PERCENTAGE EARNING BETWEEN R1 200 AND R2 000 PER ANNUM*
34	PERCENTAGE EARNING MORE THAN R5 000 PER ANNUM*

Note: All variables, in keeping with the overall focus of this study, apply to Whites, with the exception of the third variable, which reflects the *Non-White* population of White sub-districts as a percentage of all races. Unless otherwise indicated, all percentages have as their base the total White population of the sub-district. *Deviant cases* are the following:

* - Percentage of the economically active White population.
θ - Percentage of the White female population.
φ - Percentage of the White married population.

Two variables have unique meaning in the South African context and, although discussed in an earlier chapter, require clarification here. These are the variables *percentage Non-White* and *percentage Afrikaans-speaking*. Despite legislatively enforced residential segregation, a large number of Non-Whites occupy, in White areas, dormitory quarters attached either to an industry or to a private White residence. By including the Non-White variable it is hoped to *uncover not* the cohesive ethnic neighbourhood of the North American city, but rather to illustrate the broad spatial dispersion of this work-oriented population, as it is related to the socio-economic fabric of the White city. Since its foundation, Johannesburg has supported two major White cultural groups, each outwardly characterized according to the language spoken by its members. In the early years, the *schism went deeper* than superficial linguistic differences, however, with the English-speaking group adapting to and exploiting the new mining settlement of Johannesburg far more readily than did *rural Afrikaners attracted* to the town from surrounding farms. It is intended, by inclusion of a variable indexing the relative number of Afrikaans-speakers per sub-district, to determine the nature of this cultural duality, and to establish whether, in modern

Johannesburg, it still constitutes a major principle of socio-economic differentiation.

INTERPRETATION OF THE FACTOR RESULTS

The four factor matrices[5] generated by this analysis will complement each other in the following interpretive sequence: In Chapter 5, after comparison of component and image factor loading matrices to identify unique variance components, the major dimensions of intra-urban differentiation will be explained, not only on the basis of variable loadings, but also according to insights provided by the spatial configuration of factor scores, as this is related to recognized on-ground features. The spatial organization of the factors thus rationalized will then be examined, with a view to comparison with similar studies, via the technique of analysis of variance (Chapter 6).

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[5] These are the loading and score matrices produced by the component and image factor models used here.

CHAPTER 6

INTERPRETATION OF FACTORS

COMPARISON OF COMPONENT AND IMAGE FACTOR SOLUTIONS

In its exploratory concern with the entire variance content of the data matrix, the component factor model extracts eleven factors or *dimensions*[1]. These range from a primary dimension explaining some 36 per cent of the variance contained by the data matrix to a dimension explaining some 2 per cent of the total variance. Following the separation of common and unique variance elements, by contrast, only five image *factors* are necessary to describe patterns of common variation within the data sample. The proportion of the total variance explained by each of these factors ranges from 36 *per cent* to 5 per cent[2].

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[1] The term *dimension* is used by Rummel (1970, p. 113) to differentiate factors extracted by the component factor model from those produced by the common factor or image factor models.

[2] A number of factor techniques, including the principal axes technique used here, extract factors or dimensions measuring decreasing proportions of variance. The number of factors to be extracted may be specified, making it possible to stop factoring when *minor* factors emerge that are largely measures of random error. A common criterion for the number of factors to be extracted is the *eigenvalue-one* criterion (Rummel, 1970, pp. 362 - 364). Here, factors are extracted that have *eigenvalues* greater than unity and which account, in consequence, for a greater proportion of the total variance than would a single variable. The eigenvalue-one criterion was employed in the present study and was found in the image factor case to produce a parsimonious five-factor solution, with each of the factors lending itself to easy interpretation. The same criterion was used in the common factor case to ensure comparability of the factor outputs of the two models.

The five factors and the first five dimensions are remarkably similar, both in terms of the variables loading on them and the magnitude of these loadings. An index of factor similarity that is sensitive to both variable loading *pattern* and variable loading *magnitude* is the *coefficient of congruence* (Kummel, 1970, pp. 461 - 462). Coefficients of congruence vary between limits of +1,0 and -1,0 with each of these values representing perfect similarity and perfect negative similarity respectively. Congruence coefficients for each of the five factor-dimension pairs are presented in Table 5.1. Dimension 1 and Factor 1 are highly congruent. The dimensions and factors comprising the remaining factor-dimension pairs are less similar but still display a high degree of congruence. Since the factors and dimensions compared measure similar portions of the overall variation contained by the data matrix and the factors are concerned only with common variance, the remaining six dimensions must, by subtraction, contain the major portion of the

Table 5.1: Coefficients of congruence between factor and dimension loadings.

FACTOR-DIMENSION PAIR	COEFFICIENT OF CONGRUENCE
DIMENSION 1 & FACTOR 1	0,99
DIMENSION 2 & FACTOR 2	0,98
DIMENSION 3 & FACTOR 3	0,90
DIMENSION 4 & FACTOR 4	0,98
DIMENSION 5 & FACTOR 5	0,83

unique variance. With the unique variance elements thus explicitly isolated, the noise reducing potential of the image factor model may be exploited, without the accompanying loss of a substantial and possibly locally significant portion of the data.

THE IMAGE FACTOR ANALYSIS

Factor 1

The loadings of variables on Factor 1 are given in Table 5.2. The minimum level at which these loadings are considered to express the character of the factor has been set, as is common practice in factorial ecology (Murdie, 1969; Rees, 1970), at ±0,4.

Table 5.2: Principal loadings on Factor 1.

POSITIVE LOADINGS			NEGATIVE LOADINGS		
NO.	VARIABLE	LOADING	NO.	VARIABLE	LOADING
PL1	% EMPLOYERS	0,853	NL1	% MAR. UNDER 21	-0,878
PL2	% ADMIN. & EXEC.	0,836	NL2	% CRAFT. & PROD.	-0,875
PL3	% PROF. & TECH.	0,806	NL3	% AFRIKAANS SP.	-0,832
PL4	% IN COM. & FIN.	0,792	NL4	% ED. TO STD. 8	-0,831
PL5	% POST SCH. ED	0,765	NL5	% DUTCH REFORM.	-0,810
PL6	% EARNING R5000+	0,748	NL6	% 5+ CHILDREN	-0,806
PL7	% JEWISH	0,744	NL7	% R1200-R2000	-0,771
PL8	% SALES OCC.	0,705	NL8	% TRANS. & COMM.	-0,766
PL9	% BRITISH BORN	0,663	NL9	% S. AFRICAN	-0,713
PL10	% 1&2 CHILDREN	0,582			
VARIANCE EXPLAINED BY FACTOR 1 = 36% OF TOTAL					

With most of the principal loadings reflecting occupation, together with levels of education and income, Factor 1 appears superficially to have the characteristics of the *socio-economic status* dimension recognized in most other studies of urban factorial ecology (Rees, 1972, p. 286). Socio-economic differentiation in Johannesburg, however, can be related to the culturally-based economic duality that has been characteristic of the city since its infancy. Relative wealth (PL6) in 1960, for instance, as in the late nineteenth century, appears to remain in the hands of the English-speaking sector of the population as represented by Jewish (PL7) and British-born (PL9) elements, while the South African-born (NL9), Afrikaans-speaking (NL3) group tend still to occupy less remunerative

(NL7), blue-collar[3] (NL2, NL8) employment.

Whereas it is recognized that cultural variations in economic status arose out of an initial lack of urban expertise on the part of rural Afrikaans immigrants in Johannesburg, it is remarkable that, despite several decades of urbanization, this dichotomy is still so clearly defined. Even in the social sphere, urban life has had less impact on Afrikaners than would perhaps be expected. Despite the initial disruption of rural Afrikaans kinship systems as a result of urbanization (Welsh, 1971), for instance, traditions of early marriage (NL1) and large families[4] (NL6) have been perpetuated in Johannesburg, as has the strong adherence to the Dutch Reformed Church[5] (NL5) observed by Trollope (1878) in the Transvaal of pre-gold mining times.

Notwithstanding that the above interpretation invites analogy between the town of the gold rush days and the modern city, it would be misleading to extend this parallel too far. Where, for example, wealth in old Johannesburg depended largely on individual enterprise and practical experience in the extraction and exploitation of minerals, it is formally educated (PL5) people, occupying professional (PL3), directive (PL1, PL2) and sales (PL8) occupations, mainly in the tertiary sector (commerce and finance, PL4), that are the most affluent today

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[3] Davies (1964, pp. 24 - 25) discusses the broad stratification of South African census occupational categories into white and blue-collar groups, placing the classes *craftsmen and production process workers* and *workers in transport and communication* under the latter heading.

[4] In contrast to the small families of the English-speaking sector (PL10).

[5] The Dutch Reformed Church as here defined consists of three branches: the Nederduitse Gereformeerde Kerk, the Nederduitse Hervormde Kerk and the Gereformeerde Kerk. These three churches account for over eighty per cent of the Afrikaans-speaking White population of Johannesburg in 1960 (Republic of South Africa, 1966).

The residential location requirements of groups at various levels of the socio-economic scale here defined are likely to differ widely according to desired standards of physical and social environment. Whatever these aspirations, however, they are increasingly restrained, with decreasing socio-economic status, by economic considerations. The domiciliary ideals of the high status section of the population, for instance, are allowed relatively free rein and find, in 1960, well defined spatial expression in the northern sector of the city (Figure 5.1), amidst a long established English-speaking peer group, and taking advantage of expansive and picturesque surroundings far divorced (both spatially and visually) from the southern mining, industrial and Non-White residential belt[6]. Lower socio-economic strata, in turn, because economically unable to penetrate enclaves occupied by superior status levels, have progressively more restricted fields of choice in which to exercise their own residential preferences until, in the case of the lowermost socio-economic group, location alternatives are confined to land commanding the least overall attraction. This, in Johannesburg, comprises sectors radiating east and west of the central business core in close spatial association with that same mining, industrial and Non-White residential area that seems so repellent to the wealthy.

In broad terms, then, the residential location process, as it is related to socio-economic status and its cultural overtones, is seen here as being strongly controlled by income[7]. Within the limits set by income,

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[6] Whereas mining and industrial activity occupy most of this belt, areas of permanent Non-White residence are to be found mainly in the west, beyond the border of White Johannesburg (Figure 2.1).

[7] This view is shared by Rees (1970, pp. 311 - 313) who sees income as being the most important determinant in a housing purchase decision involving not only socio-economic considerations, but also requirements related to marital status, family size and life style. The effect of these on residential location in Johannesburg will be discussed later in this chapter.

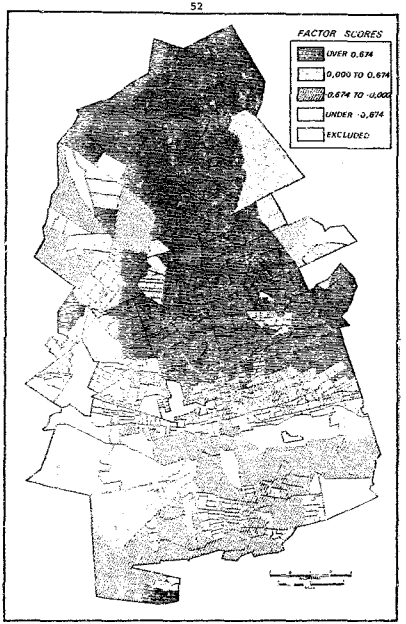

Figure 5.1: Factor 1: Socio-economic status. Normally distributed factor scores are divided into four categories here, such that each category contains approximately the same number of sub-districts.

other residential whims (such as the desire to live among social peers) may be exercised to a greater or lesser degree. In addition high status residential development in Johannesburg has tended to shun unsightly gold mining areas, together with the secondary industrial and Non-White townships accompanying them. On the basis of these observations, and considering the historical location of the original mining settlement in relation to the reef, a generalized spatial model of socio-economic differentiation in Johannesburg is developed (Figure 5.2).

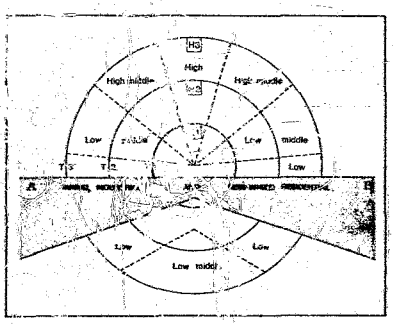

Figure 5.2: A spatial model of socio-economic differentiation in Johannesburg

The concentric circles T1, T2 and T3 represent the outer limit of urban development at three moments in time. Cell H1 represents a residential enclave on the periphery of the urban area at time T1. The peripheral location of this enclave north of the town centre ensures maximum separation between it and the transverse mining, industrial and Non-White residential belt AB. Consequently, in terms of the foregoing discussion, H1 is the most desirable of residential locations contained by T1 and therefore potentially available only to those able to bid competitively for occupance in the face of strong demand. The most successful bidders are likely to be those at the head of the socio-economic hierarchy, ensuring that H1 becomes a district reflecting the high socio-economic status of its population.

As the competitive bidding for residential land is repeated over time, the locus of similar enclaves (H2, H3), satisfying the condition of remoteness from AB, forms a sector of high status orthogonal to AB and expanding to the fringe of the contemporary developed area. At each time stage, intermediate socio-economic groups will occupy the best interstitial locations economically available to them, generating a series of sectors, each similar in spatial form to the high socio-economic status quadrant, and ranging from high-middle status adjacent to the high status sector to low status abutting AB. Areas south of the centre, being traversed by the mining-industrial-Non-White belt, suffer a constant locational disadvantage relative to the northern areas, and thus cannot attain similar status levels.

Although this simple, if somewhat deterministic, model explains the basic elements of the spatial variation of socio-economic status in Johannesburg, a more detailed district-by-district examination of the four factor score categories (Figure 5.1) reveals a number of deviations from the ideal pattern of Figure 5.2. Whereas most high socio-economic status areas, for instance, are included in, or are close to, the broad sector extending northwards from the centre to the periphery of the study area, one

isolated high status pocket is found at the southern extremity of the city — a part of the suburb of Mondeor (cf. Figures 5.1 and 2.1). Although spatially closer to the mining, industrial and Non-White residential zone than suburban areas of similar age to the north, Mondeor has the topographic advantage of being situated in a pleasant valley which obscures from view the mine workings and sand dumps[8] so typical of the remaining southern suburbs.

Influences other than physical environment must, by contrast, be sought to explain anomalous lower status residential intrusions into an otherwise remarkably homogeneous northern high status sector. Striking examples of such intrusion are the insular Norwood-Orange Grove complex in the east, and the peninsular penetration of Parkhurst in the west (cf. Figures 5.1 and 2.1). Proclaimed between 1903 and 1904 Norwood[9], Orange Grove and Parkhurst were forerunners in the spate of township development that took place in the northern sector between 1902 (Houghton, Orchards, Abbotsford) and 1905 (Westcliff, Sydenham, Waverley, Highlands North, Birnam), a period during which more than twenty new residential districts were established in this area. Unlike surrounding contemporary developments, however, Norwood, Parkhurst and Orange Grove were deliberately designed to attract buyers of intermediate socio-economic status, by creating small residential stands[10] and by offering attractive credit facilities to purchasers (Smith, 1971). In the survival of these lower status enclaves amidst a high status norm, the marketing policy of early township

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[8] Apart from the visual ugliness of the gold mines, a further disadvantage is nuisance from sand blown from mine dumps (Hart, 1968), a problem largely alleviated by the sheltered site of Mondeor.

[9] Residential stands were offered for sale in Norwood in 1902 (Smith, 1971).

[10] Predominantly 50 x 100 feet. This stand size of approximately 0,05 ha. allows gross population densities of around 50 persons per hectare.

developers appears, at least partly, to have overridden postulated considerations of locational advantage. It is significant to note, though, that higher status levels obtain in these northern anomalies than, for example, in the southern suburb of Regents Park, proclaimed in 1905, and characterized by similarly small residential stands.

While sub-districts of high-middle status (the second level on the socio-economic scale) cling generally to the immediate perimeter of the high status sector, as expected, the lower levels are far more fragmented in spatial disposition, with a number of low status cells, in particular, lying beyond the immediate compass of the mining-industrial-Non-White residential zone supposed earlier to underpin all low status residential development. The situation of most of these outliers can, however, be related to decentralized industry and, in one case, to an isolated Non-White township. For example, in the north-east, low status districts abut the long-established[11] Non-White settlement of Alexandra, and small concentrations of light industrial activity occur in Kew and Wynberg. Similarly, South Hills, on the south-eastern boundary of the study area, is flanked by the industrial estates of Steeldale and Electron. The municipal gasworks of central western Johannesburg, too, has low status environs in the suburbs of Sunnyside and Cottesloe.

In summary, it seems that the sectoral pattern of socio-economic differentiation in Johannesburg is subject to modification in certain areas of the city. Deviations from the sectoral pattern are attributed to variations in topography, to variations in the policy of township developers toward the subdivision of residential townships and to the location of isolated pockets of industry and Non-White residence. With these local anomalies considered

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11 Alexandra falls beyond the jurisdiction of the Johannesburg City Council and is not included in the study area. The location of Alexandra relative to Johannesburg is shown, however, in Figure 2.1. The township of Alexandra is the oldest extant Non-White residential district in the Johannesburg area, with its establishment dating back to the turn of the century (Wilson, 1972).

however, it still seems valid to regard the spatial differentiation of socio-economic classes in Johannesburg as being governed largely by the desire to maximize, within the bounds of economic feasibility, the distance between chosen residential location and areas occupied by Non-White residential townships, industry and mining.

Factor 2

Table 5.3: Principal loadings on Factor 2.

POSITIVE LOADINGS			NEGATIVE LOADINGS		
NO.	VARIABLE	LOADING	NO.	VARIABLE	LOADING
PL1	% UNDER 15	0,900	NL1	POPULATION DENS.	-0,630
PL2	% NOT EC. ACTIVE	0,867	NL2	% OVER 65	-0,625
PL3	% IN HOUSES	0,832	NL3	% MARRIED	-0,621
PL4	DIST. FROM PLV1	0,653			
PL5	% S. AFRICAN	0,511			
PL6	% ED. TO STD. 8	0,412			
VARIANCE EXPLAINED BY FACTOR 2 = 14% OF TOTAL					

Enumerator's sub-districts are ranked by this factor along a scale reflecting the predominance of one of two[12] age groups representative of early and late stages in the human *life cycle*. Positive factor loadings, for instance, characterize districts at one end of the scale as having a youthful population, with the under - fifteen age group prominent (PL1), while at the opposite end, census subdivisions reflect atypically large numbers of married[13] (NL3) persons over the age of sixty five (NL2).

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[12] A detailed multi-level age breakdown was not included in the list of variables in an effort to satisfy the conditions, outlined in Chapter 4, of efficiency and unambiguity. At the same time, it was felt that a single measure of central tendency, such as median or mean age per sub-district, would lack precision and would tend to mask the role, particularly, of age categories at the two extremes of the life cycle.

[13] Included under this general notation are the post-marital states of divorce and widowhood.

Associated with each of these opposed life cycle stages is evidence of differential dwelling type and location preference[14]. The young, for example, tend with few exceptions to occupy single-family detached dwelling units (HL3) in areas peripheral to the central business core (PL4), while the older group, less well represented in suburban houses (Table 5.4), opt in many cases for residence in central high density (NL1) flat and apartment[15] complexes (Figure 5.3).

Table 5.4: Proportional representation of age groups by dwelling type : Johannesburg, 1960. Figures in *italics* indicate the difference between the proportional representation of individual age groups in houses and flats, and the division characteristic of the population as a whole. Signs give the direction of the deviation.

DWELLING TYPE	PERCENTAGE OF TOTAL POPULATION	PERCENTAGE OF AGE CATEGORY				
		0-14	15-19	20-24	25-64	65+
HOUSES	75	86 *+12*	78 *+3*	62 *-13*	71 *-4*	59 *-16*
FLATS & APARTMENTS	20	11 *-9*	13 *-7*	28 *+8*	25 *+5*	30 *+15*

Source: Republic of South Africa (1966).

Whereas the interrelationship of character of housing and age of residents suggests the existence of age-specific residential requirements among the population of Johannesburg, stage in the life cycle is not necessarily the only determinant in dwelling-type selection. It may be valid to suppose, for instance, that the life style needs of young children are best satisfied in the spacious environment of outlying suburbs, but it is unrealistic to credit

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[14] Many American urban factorial ecologies have isolated a similar *stage in the life cycle* factor relating housing type and age indicators (Rees, 1972, p. 287).

[15] Apartments, in the 1960 census definition, differ from flats mainly in that they contain no independent cooking facilities (Republic of South Africa, 1966). In this discussion the term *flat* is used to include both types.

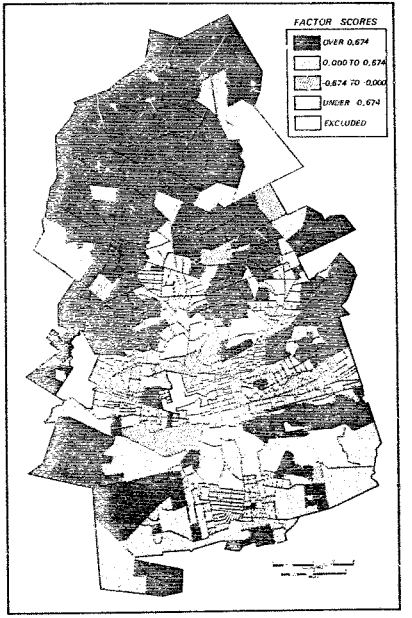

Figure 5.3: Factor 2: Stage in the life cycle.

this school-going (PL6), economically inactive (PL2) group with the *decision* to locate in these surroundings instead of in a crowded flat area. This choice is made *and effected*, rather, by an older parental group, who may or may not share this preference for the suburbs, but whose decision is weighted by the perceived housing needs of the *family*[16].

Family responsibilities, of course, are unlikely to influence the location decisions of all age groups equally. The over-sixty five group for instance, free in most cases of dependent children, are able to give free reign to their own residential ideals and may decide, as often seems to be the case in Johannesburg, to relinquish the now wasted space of the suburban residence in favour of the compactness, the *personal security* (due to proximity to other units) and the accessibility to central business and recreational functions, offered by a flat. This locale is often preferred too by their newly independent offspring[17] for similar reasons of accessibility, but probably also due to the freedom of daily movement allowed by an easily managed household, and the locational mobility made possible by short-term rental contracts.

In general terms, then, choice of dwelling type is seen here as being governed by two determinants: In the first instance, alternatives are seen to be evaluated on the basis of housing *requirements peculiar* to persons of various ages. These requirements are, in turn, either modified or reinforced according to the second determinant of commitment of the individual to the residential

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[16] Unterhalter (1968) shows that childless couples and couples with adult progeny predominate in the Johannesburg high-rise flat complex of Hillbrow-Berea. In cases *where young children* are found in flats, their parents usually are seeking alternative accommodation, regarding themselves purely as sojourners in their present place of residence.

[17] Notice in Table 5.4, for example, the markedly greater representation in flats, relative to that of other groups, of not only the 65+ group but also the 20 - 24 age category. Unfortunately the gross census age grouping of 25 - 64 tends to obscure the points at which this flatward trend is reversed and then reinitiated.

commonweal of a family. Further, the discussion thus far has seen personal sympathy with a family group as fluctuating predictably according to temporally well defined life cycle phases. This deterministic linking of life and family cycles is perhaps somewhat simplistic[18]. Nonetheless, it serves, in combination with recognized dwelling type preferences, to make possible the formulation of a cyclic model of intra-urban movement between types of housing in Johannesburg (Figures 5.4 and 5.5).

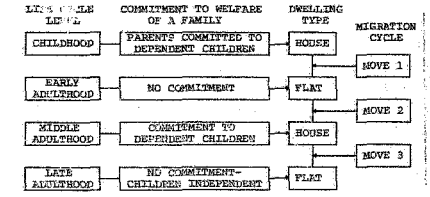

Figure 5.4: The relationship between stage in the life cycle, commitment to the welfare of a family and inter-dwelling migration in Johannesburg.

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[18] It has been suggested that in an economically developed society, independent individuals may elect to live outside of the family system, pursuing a life style devoted to a career or simply to self indulgence (Bell, 1958). Although a group explicitly rejecting families doubtless exists in Johannesburg, evidence shows that after the age of twenty, most young White adults soon initiate families of their own. Of the 1960 population for instance, unmarried persons account for 9% per cent of the age group fifteen to nineteen, dropping sharply to 56 per cent for the twenty to twenty four category, 22 per cent for the twenty five to twenty nine group and only 11 per cent of ages thirty to thirty four (Republic of South Africa, 1966). It is significant to note in addition that the 1960 census classifies 74 per cent of Johannesburg families as being characterized by one or both spouses plus dependent children, with the remaining 26 per cent being simple husband-wife dyads (Republic of South Africa, 1970a).

The concept of inter-dwelling migration can be examined spatially. Superimposed on a stylized spatial representation of the growing city of Johannesburg, where new suburban development is continually pushing the urban fringe outward, and where high density residential land uses are invading the old spacious suburbs close to the city centre, this migration cycle may be seen to maintain, despite urban expansion, a concentric array of zones differentiated according to the age of their respective populations (Figure 5.5)[19].

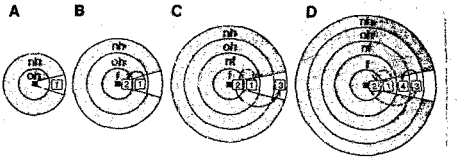

Figure 5.5: A spatial model of life cycle differentiation in Johannesburg (symbols explained in text).

Where urban growth stages A, B, C and D cover one human life span[20], locations 1, 2, 3 and 4 are residential

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[19] Most concentric models of urban land use have at their base the assumptions of a mono-nucleated city, with accessibility to the centre declining at the same rate in all radial directions from it. While it is recognized that Johannesburg satisfies neither of these assumptions perfectly, the broadly concentric land use pattern noted by Lipworth (1961), and the variation in population age structure from centre to periphery isolated by this factor, serve to justify the use of a concentric framework as an explanatory device here.

[20] The rate of growth suggested by the model, although primarily illustrating an argument, is not entirely unrealistic if it is realized that the city of Johannesburg has attained its present size over a period little longer than the life expectancy of any of its White inhabitants.

areas within a particular sector of the city satisfying the sequential life cycle requirements of one socio-economic group. At the first point in time, A, I is a residential enclave within a zone of new peripherally located houses, occupied by representatives of the contemporary generation of children, together with their parents. As these children mature to early adulthood (stage B) and become independent of their parents, they make the first move in the migration cycle, to a residence in the flat area (f) that has now invaded the former zone of old houses (oh). The second move in the cycle occurs at stage C, when this group reach middle adulthood and have young children of their own. This transmigration passes through zones of new flats (nf) and old houses and is directed toward the current zone of new houses (nh). Finally the late adulthood move (move 3) back to a flat (f or nf) is initiated when the new generation of young adults leave home (stage D).

Clearly, it is unrealistic to assume that none of the residents of a socio-economic sector will ever cross its bounds to live elsewhere in the city, just as it is mistaken to suggest that the entire population will follow the same pattern of inter-dwelling movement as they age. Some may, for example, change their place of residence only once, and others four or more times. Some may become more affluent and wander beyond the limits of one socio-economic sector. But this movement, in *aggregate*, provided that it follows the general tenets of the migration model developed above, will tend, against the background of immobile residents, to maintain concentric zones in which specific age groups predominate. Central flat areas, for instance, whatever their basic stable population, will always contain strong young adult and independent late adult elements, owing to continuous immigration of non-family and emigration of family groups — families who are received, in turn, by outlying zones of low density detached housing.

While the spatial principles of life cycle differentiation in Johannesburg may be illustrated within geometric

bounds, however, the finer distribution of scores for Factor 2 shows significant departures from the ideal concentric pattern. A central cluster of non-family flat dwellers is, for instance, clearly demarcated by extreme negative factor scores and accords with the model. At the same time, scattered suburban outliers of similar character are also evident, coextensive with such decentralized flat complexes[21] as Killarney, Rosebank, Highlands North Extension 2 and the south-eastern tip of Houghton in the north, Cottesloe[22] in the west, and the mixed business and flat core of the suburb of Rosettenville in the south (cf. Figures 5.3 and 2.1).

These isolated high density flat pockets owe their anomalous existence in the midst of suburbia to location decisions made by property developers, backed since the 1930's (City of Johannesburg, 1971), by residential zoning patterns laid out in the local government's town planning scheme. More significant in this context, however, is the observation that despite considerable differences in distance from the central city between the distal flat islands and the central flat complex, both areas contain populations of similar age structure. This seems superficially to suggest, in modification of the opinion expressed earlier in this chapter, that it is the physical character of flats, more than access to the

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21 The Johannesburg City Engineers Department (Forward Planning Branch) draws a distinction between flat *areas* and *complexes*, with the latter defined as comprising townships in which all residential land is zoned for flat development (City of Johannesburg, 1971). The term *complex* is used here to imply, a spatial concentration of flats.

22 Cottesloe is not a true flat complex, because although containing a number of multi-unit dwellings, many of these are in fact barracks, one set of which is incorporated in an institution for the aged and another housing elements (in 1960) of the South African Army. The expansive district containing Maritzoro in the far north, too, is misleading. This is not a cluster at all, being largely undeveloped and with such dwelling units as do exist scattered widely over its area.

shopping and recreation facilities and employment opportunities of the central business district, that attracts the independent, non-family age groups that tend to occupy them. It is, however, misleading in a modern technologically advanced city to equate distances and access, just as it is mistaken to suppose that all shops and offices are in the C.B.D. Many of the outlying flat areas, in fact, enjoy the dual advantages of proximity to a major decentralized business district, such as those at Rosebank and Rosettenville, while being served at the same time by a major radial transport artery, providing a rapid motor commuting link with the city centre.

There appears, then, to be little foundation to the argument that access to a business centre is a minor factor in attracting to flats the distinctive flat-dwelling population. Further examination of the distribution of intermediate factor score categories (*Figure 5.3*) makes it possible to postulate that business district accessibility is a more important location determinant than housing type for some of the independent non-family persons supposed to be typical flat dwellers. Spatially, these middle categories spread outward from the centre of the city along main radial roads in a series of finger-like intrusions into the outer zone of young families, and include both sub-districts containing mixed flats and houses and a number that have no flat component at all. The latter sub-districts have, therefore, no physical distinction from districts in the zone of detached dwellings, yet they house relatively more old and young independent people than do the outer areas. This differential attraction cannot be explained in terms of type of dwelling and depends rather, it seems, on differential access to radial transport routes and hence to the central business district.

The radial routeway system, with enhanced access to the C.B.D. appears, then, to be the major modifying influence on the ideal concentric pattern of life cycle differentiation in Johannesburg. If the map of factor scores was transformed and travelling time and cost

substituted for distance, a much closer approximation to perfect concentric distribution of life cycle stages would probably result.

Factor 3, Factor 4 and Factor 5

The census variables describing Factors 3, 4 and 5 all relate to ethnic origin, religious affiliation and in some cases to occupation. The factors bear, therefore, a resemblance to the *ethnic status* dimension frequently demonstrated by factorial ecological studies in other parts of the world (Rees, 1972, p. 286), and collectively may be said to reflect the ethnic structure of White residential areas in Johannesburg. The ethnic status factor triad differ one from the other, however, not only in terms of the particular ethnic group that they isolate, but also according to the spatial distribution of each within the census sub-district matrix covering the city. In recognition of these differences, the factor loading structure of each factor will be discussed individually and the determinants of residential location for the three ethnic groups examined and compared thereafter.

The first of the three ethnic factors arrays enumerator's sub-districts along a scale characterized at one extreme (Table 5.5) by sub-districts containing a relatively large number of persons born in southern Europe (PL2),[23], adhering to Roman Catholicism (PL1) and employed in the manufacturing industry (PL3). At the opposite end of the scale, sub-districts have a high relative proportion of Dutch Reformed Church affiliates (NL1).

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[23] Countries included in this variable are Portugal, Spain, France, Italy and Greece. Of these, Portugal, Italy and Greece have contributed by far the largest numbers of immigrants to South Africa.

Table 5.5: Principal loadings on Factor 3.

POSITIVE LOADINGS			NEGATIVE LOADINGS		
NO.	VARIABLE	LOADING	NO.	VARIABLE	LOADING
PL1	% ROMAN CATHOLIC	0,767	NL1	% *DUTCH REF.*[24]	-0,384
PL2	% BORN IN S. EUR	0,639			
PL3	% IN MANUFACT.	0,530			
VARIANCE EXPLAINED BY FACTOR 3 = 7% OF TOTAL					

Southern European migration to South Africa, although by no means absent before this time, accelerated in the post World War Two years to reach a peak in the late 1960's (Table 5.6). In 1960, the southern European population of Johannesburg was only some 14 000 in number (Republic of South Africa, 1966) yet evidence was already present of spatial clustering of this group (Figure 5.6), particularly in suburbs such as Orange Grove in the north, Troyville and Bezuidenhout Valley in the east and La Rochelle in the south (cf. Figures 5.6 and 2.1).

Table 5.6: Southern European immigrants[25] entering South Africa: 1924 - 1967.

PERIOD	NUMBER OF SOUTHERN *EUROPEAN* IMMIGRANTS	AVERAGE YEARLY IMMIGRATION
1924 - 1939	3 179	199
1940 - 1947	2 371	296
1948 - 1955	11 340	1 418
1956 - 1959	7 087	1 772
1960 - 1963	8 864	2 216
1964 - 1967	29 688	7 422

Sources: Republic of South Africa (1964, 1967, 1970b).

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[24] This is the highest negative loading on this factor. Although it falls below the arbitrary significance threshold, it is included here to illustrate the negative side of this factor.

[25] The small group of immigrants born in Spain are not included in this table, as the sources from which it is derived include this group in a broad and ill-defined *other European* category.

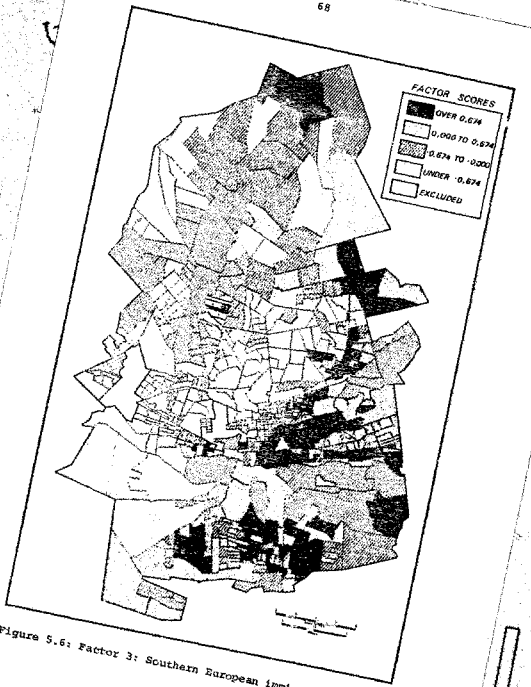

Figure 5.6: Factor 3: Southern European immigrant population.

Factor 4, in contrast to the preceding factor, does not isolate a recent immigrant community, but differentiates sub-districts rather on a cultural-religious basis (Table 5.7) with districts at one extreme reflecting the relative predominance of either Jewish (PL1) or Afrikaans-speaking (PL2) inhabitants, and the other extreme being characterized by sub-districts containing a high relative porportion of English Protestants (NL1) and persons born in Britain (NL2).

Table 5.7: Principal loadings on Factor 4.

POSITIVE LOADINGS			NEGATIVE LOADINGS		
NO.	VARIABLE	LOADING	NO.	VARIABLE	LOADING
PL1	% JEWISH	0,528	NL1	% ENGLISH PROT.	-0,851
PL2	% AFRIK. SP.[26]	0,250	NL2	% BRITISH BORN	-0,430
VARIANCE EXPLAINED BY FACTOR 4 = 6% OF TOTAL					

Small numbers of Jews entered South Africa between 1800 and 1880, but the greatest immigration occurred between the years of 1880 and 1910, when some 40 000 arrived in this country. Most Jewish immigrants settled in either Johannesburg or Cape Town and were quickly assimilated into these urban societies (Saron, 1965). The Afrikaans-speaking community is in most cases South African-born, and in common with the Jews, has elements of the community who have lived in Johannesburg since the turn of the century. But where the Jewish group are often only distinct from the majority English-speaking population of Johannesburg in terms of religion, the more obvious differentiating characteristic of language sets Afrikaans-speakers apart from the greater number of the city's inhabitants.

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[26] This variable does not qualify for inclusion here, but is presented to avoid confusion of Jewish and Afrikaans neighbourhoods, both of which are characterized by high positive factor scores in Figure 5.7.

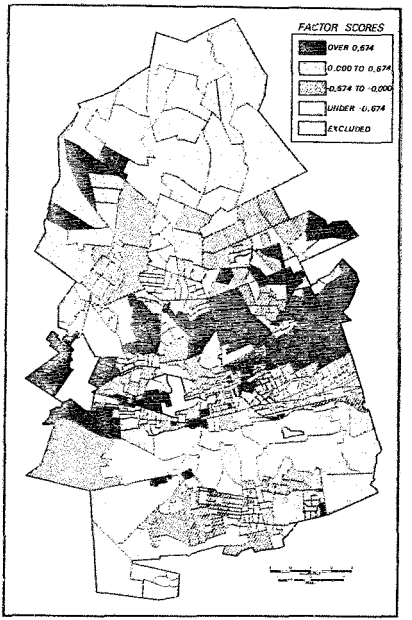

Figure 5.7: Factor 4: Jewish and Afrikaans population.

Although spatially separated one from the other, both groups seem to favour a residential location close to the C.B.D. and the industrial and mining belt, forming a broad band of Jewish and Afrikaans settlement dividing the English Protestant residential areas into northern and southern components (Figure 5.7).

The third ethnic status factor, Factor 5, classifies sub-districts in White residential areas according to the porportionate number of Non-Whites that are resident in them (Table 5.8).

Table 5.8: Principal loadings on Factor 5.

POSITIVE LOADINGS			NEGATIVE LOADINGS		
NO.	VARIABLE	LOADING	NO.	VARIABLE	LOADING
PL1 PL2	% IN SERV. OCC. % NON-WHITE	0,632 0,565	NL1	% FEMALE	-0,503
VARIANCE EXPLAINED BY FACTOR 5 = 5% OF TOTAL					

A portion of the Non-White population of Johannesburg occupies dormitory quarters attached to their place of employment within the White city. Districts in which the largest numbers of Non-Whites reside in this manner, according to the factor loadings, are those in which there are numerous Whites in service occupations (PL1). Spatially, these areas tend to be coextensive with the industrial and mining belt (Figure 5.8), where barrack-like compounds house migrant miners and industrial workers, or they are located within high socio-economic status White areas, where the Non-Whites are employed as domestic servants[27].

Census sub-areas with the smallest Non-White component are those with relatively large White female populations (NL1)

[27] The 1960 census report on Metropolitan Johannesburg (Republic of South Africa, 1966) gives no relevant information for Coloured or Asian groups, but shows that, of the 648 740 Africans residing in Metropolitan Johannesburg, some 5,8 per cent are housed in barracks attached to mines or industrial concerns and 21 per cent are found in White urban and sub-urban areas.

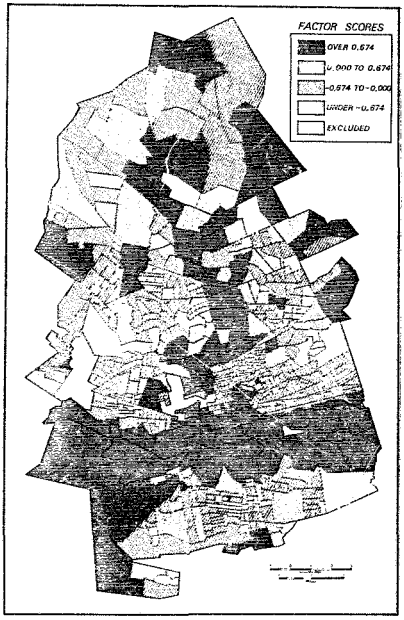

Figure 5.8: Factor 5: Non-White population.

and are often characterized, in addition, by flats and high residential densities. Independent unmarried and widowed women are probably attracted to compact dwelling units, which require minimal upkeep and are therefore unable to support domestic Non-White staff complements of the size that is required to maintain single family detached houses set amidst expansive grounds.

In general, the ethnic groups isolated by Factors 3, 4 and 5 show a tendency to cluster within distinct residential enclaves. The location of these nodes of settlement differs from one ethnic group to the other, governed in the first instance by the range of residential locations potentially open to each group and, in the second, by the manner in which the residential ideals of each are exercised within this field of choice.

Cohen and Hart (1972), for instance, see the specific residential requirements of poor immigrant Portuguese in Johannesburg as being satisfied in the suburb of La Rochelle (Figure 2.1), where housing is *relatively cheap and access* to the work opportunities of the C.B.D. is good. Similar residential needs seem to be typical of a large proportion of the southern European group, who have invaded old suburbs characterized by small residential stands and houses, close, in most cases, to both the central business district[28] and the zone of industry and mining. Anomalies are, however, evident in the north-eastern sector of the city, where southern Europeans have gathered about the outlying industrial estate of Wynberg (cf. Figures 5.6 and 2.1), and in the far north where market gardening probably accounts for high relative numbers of southern Europeans in a sparsely populated semi-rural district. The multinodal character of southern European settlement in Johannesburg is not necessarily indicative of a lack of community

[28] A general tendency for foreign-born persons to reside in central areas is indicated in that the variable *percentage born in South Africa* loads positively on Factor 2 (Table 5.3), as does *distance from the peak land value intersection*.

cohesion but may possibly reflect, rather, the location of the individual national or even intra-national[29] groups that comprise this broad and somewhat arbitrary classification.

By virtue of their habitation of a broad zone paralleling the mining axis and abutting the central business core, it could be argued that, like the southern Europeans, the Jewish and Afrikaans communities value proximity to places of work. While this may be true of elements in the Afrikaans group of low socio-economic status, the generally high socio-economic status of the Jews makes minimization of commuting costs an unlikely determinant of residential location. The relative affluence of this group also diminishes the role of housing cost as a limiting factor in the selection of a dwelling site, while such considerations restrict a large portion of the Afrikaans-speaking population of Johannesburg to residential areas immediately adjacent to the mining-industrial belt, close to the western border of the city (Figure 5.7). In the absence of the economic constraints that so profoundly influence southern European and Afrikaans settlement patterns in Johannesburg, the Jews have a wide range of dwellings and locations open to them, yet still elect to live within a restricted residential area in the northern sector of the city. The present basis for this decision is probably a desire to reside among an established peer group, but the reason why early Jewish pioneers chose to colonize this area is obscure. The initial attraction of the area lay, possibly, in its relative nearness to existing Jewish community facilities in the central area, in the picturesque and expansive residential stands that it offered, and the high social status that was perceived to characterize the northern suburbs.

Patterns of Non-White habitation in White areas reflect,

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[29] Cohen and Hart, for instance, show that 58 per cent of the sample of Portuguese interviewed in La Rochelle come from the north-western region of Portugal (Cohen and Hart, 1972, p. 88).

simply, the location of places of employment able to offer to Non-Whites rudimentary dwelling facilities on site. Many of the inhabitants of these dormitory quarters are permanently domiciled elsewhere, and leave their families for long periods in order to exploit the economic opportunities and cheap (if not free) housing offered in White Johannesburg. The major portion of the Non-White population of Johannesburg, however, is housed in townships on the city's periphery. These are relatively permanent and socially coherent and represent, in contrast to the amorphous overlay in White areas, the only real Non-White communities.

SUMMARY OF FINDINGS

Based on an image factor analysis, three basic factorial dimensions emerge to describe the socio-economic structure of White residential areas in Johannesburg. These are broadly congruent with dimensions of economic status, family status and ethnic status described by a number of factorial ecologies elsewhere, but show minor variations from the standard triform model. These deviations are attributable in some instances to unique conditions pertaining to Johannesburg, and in others to limitations in the range of variables used in this study.

Socio-economic status in Johannesburg is shown, for instance, to include with measures of income, education and occupation, the cultural duality between English and Afrikaans-speaking inhabitants of the city. Stage in the life cycle does not include any specific reference to families, a short-coming in the data, and is supplemented by additional information to demonstrate the links between family status and stage in the life cycle. Ethnic status in White Johannesburg is divided into three components, with two isolating well defined southern European, Jewish and Afrikaans communities, and the third an unconsolidated component of the Non-White population occupying dormitory dwellings in the White city.

The spatial differentiation of socio-economic status, stage in the life cycle and ethnic status are shown to follow organizational principles of sectorality, concentricity and modality respectively. In addition, socio-economic sectors are shown to be strongly influenced by the location of the transverse belt of mining, industrial and Non-Whits residential land use, with the lowest status areas being those immediately adjacent to this zone. These low-status sectors, in turn, are shown to house poorer ethnic groups such as the southern Europeans and the Afrikaans-speaking community, and the mining area itself a population of migrant Non-White miners and industrial workers.

THE COMPONENT FACTOR ANALYSIS

Among the six minor dimensions shown at the beginning of this chapter to isolate unique variation among the thirty four variables used in this study, only one has more than one variable loading significantly on it (Table 5.9).

Table 5.9: Principal loadings on Dimension 6.

POSITIVE LOADINGS			NEGATIVE LOADINGS		
NO.	VARIABLE	LOADING	NO.	VARIABLE	LOADING
PL1	% IN MINING IND.	0,880			
PL2	% NON-WHITE	0,660			
VARIANCE EXPLAINED BY DIMENSION 6 = 5% OF TOTAL					

High positive scores on this dimension isolate enumerator's sub-districts that contain high relative numbers of White inhabitants in the mining industry (PL1), as well as large numbers of Non-Whites. In almost every case, these districts lie within the mining belt (Figure 5.9).

The important feature of this dimension, however, is that, in being excluded from the image analysis as unique variance, it has explicitly isolated a dimension of variation that is *superimposed* on the overall socio-economic

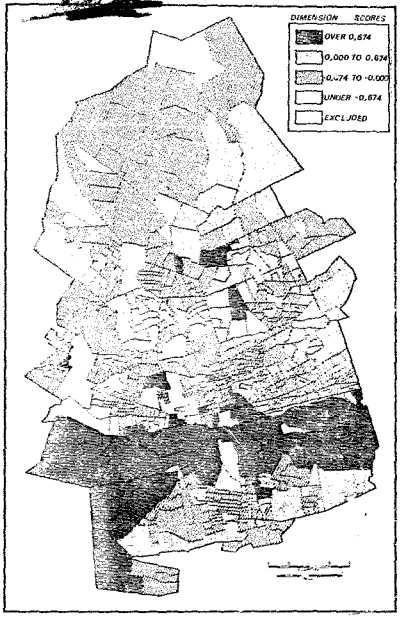

Figure 5.9: Dimension 6: Persons employed in the mining industry.

structure of Johannesburg, but which strongly influences the spatial organization of other aspects of residential differentiation.

CHAPTER 6

QUANTITATIVE EXAMINATION OF SECTORAL AND CONCENTRIC RESIDENTIAL PATTERNS IN JOHANNESBURG

In Chapter 5, it was concluded that socio-economic status in Johannesburg is sectorally distributed and stage in the life cycle concentrically arrayed. This conclusion is, however, based purely on visual inspection of the relevant factor score maps. A few recent studies have attempted to eliminate this subjective evaluation of spatial patterns and have developed a method, based on two-way analysis of variance[1], whereby the relative importance of either sectoral or concentric principles of spatial organization can be quantitatively evaluated and a statement made on the probability that the spatial relationship of a variable to any one of these patterns could have occurred by chance.

The most sophisticated applications of the analysis of variance method to the evaluation of intra-urban socio-economic patterns are those of Murdie (1969) and Rees (1970). Rees' statistical examination of the spatial variation of socio-economic status and family status in Chicago is of particular significance because it incorporates two objectives. It evaluates, in the first instance, statements concerning socio-economic patterning made earlier in the study and compares these findings, in the second instance, with the results obtained in other studies using similar techniques. In this way, Rees is able to suggest, albeit tentatively, a modification to the common sector-zone model, based on variations in the size of urban Negro populations. He finds in North America, for example, that

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[1] Analysis of variance is discussed in some detail by, amongst others, Croxton and Cowden (1955, pp. 706 - 720) and more simply by Gregory (1963, pp. 133 - 150).

the larger the city, and therefore its Negro population component[2], the stronger becomes a subsidiary variation of socio-economic status by concentric zone and of family status by radial sector. Rees explains the concentric variation of socio-economic status in Chicago (the largest city in Rees' sample) in terms of a process of racial succession, where low-status Negroes have invaded former middle and high status sectors in the central city to form, together with poor whites in the centre, a concentric zone of low status.

The present chapter uses the analysis of variance method to examine spatial socio-economic patterns in Johannesburg. Based on the experience of Rees it is suggested in this chapter that Johannesburg, by virtue of the location of Non-White communities in areas peripheral to the White city, will not, despite its large Non-White population, have developed an equivalent zone of low status at its centre. Stated differently, it is postulated that, by housing Non-Whites in urban fringe areas, the sectoral structure of the White city is strengthened.

METHOD OF EVALUATION

A matrix of 30 cells was superimposed on a map of Johannesburg, each cell having a location co-ordinate expressed in terms of one of six sectors (labelled 1 to 6) and one of five concentric zones (labelled A to E) as indicated in Figure 6.1.

The location of the sectors was decided somewhat arbitrarily, but determining factors in this choice were the strongly trending east-west mining belt and the northward-reaching high status sector. By virtue of their relatively insignificant residential component and physically determined location, it was decided to exclude gold mining areas from the analysis itself. The concentric zones were defined so as to

[2] Rees assumes that, since all the cities in his sample are in the north of the United States, and one in Canada, it is safe to equate total population and size of the negro community.

include within each zone approximately the same number of sub-districts, and so to take account of declining population densities toward the urban periphery.

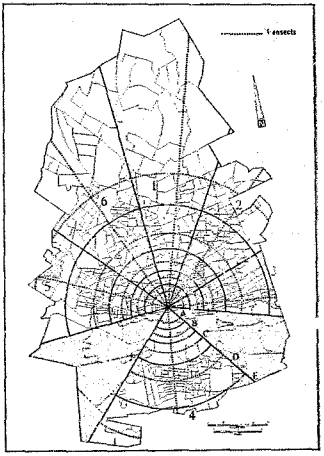

Figure 6.1: Matrix of sectors and zones in relation to 1960 census enumerator's sub-districts.

The analysis of variance sets out to establish, across six hundred and seven sub-districts, the relative proportions of the overall variation of socio-economic status and stage in the life cycle that can be attributed to differences between

sectors, betw[illegible]s and to variation within cells.

In practice, this is achieved by calculating, for the overall case, the sum of squared sub-district deviations from the overall mean, and in the between-sectors case, the sum of deviations from the mean of each sector, squared and summed across all sectors. A similar procedure is followed for the between-zones case. The within-cells sum of squares is defined as the sum of squared deviations from the mean of each cell, summed for all cells. The residual sum of squares is made up of the difference between the overall sum of squares and the combined sum of squares of the other three sources of variance. Each sum of squares is converted to an estimate of variance by division according to an appropriate number of degrees of freedom, and ratios between variance estimates compared with values on 'Snedecor's F distribution' (Gregory,1963. p. 140) to ascertain whether the greater variance estimate differs significantly from the lesser.

INTERPRETATION OF RESULTS

The results of the analysis are presented in Tables 6.1 and 6.2 below:

Table 6.1: Analysis of variance of zonal and sectoral socio-economic patterns in Johannesburg.

SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM	VARIANCE ESTIMATE
TOTAL	604	606	
BETWEEN SECTORS	350	5	70,00
BETWEEN ZONES	17	4	4,25
WITHIN CELLS	148	577	0,26
INTERACTION	89	20	4,45

$F = \frac{\text{BETWEEN SECTORS}}{\text{INTERACTION}} = 15,73$ (significant at the 0,01 level)[1].

[1] Significance at the level of 0,01 means that there is a no more than one per cent probability that a ratio of the observed order could have occurred by chance.

$$F = \frac{\text{BETWEEN ZONES}}{\text{INTERACTION}} = 0,96 \text{ (not significant)}.$$

Table 6.2.: Analysis of variance of zonal and sectoral life cycle patterns in Johannesburg.

SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM	VARIANCE ESTIMATE
TOTAL	621	606	
BETWEEN SECTORS	56	5	11,20
BETWEEN ZONES	400	4	100,00
WITHIN CELLS	153	577	0,27
INTERACTION	12	20	0,60

$$F = \frac{\text{BETWEEN SECTORS}}{\text{INTERACTION}} = 18,67 \text{ (significant at the 0,01 level)}.$$

$$F = \frac{\text{BETWEEN ZONES}}{\text{INTERACTION}} = 166,67 \text{ (significant at the 0,01 level)}.$$

The F-ratios of Table 6.2 show that, in Johannesburg, family status varies significantly by sectors and zones. A comparison of the two ratios reveals, however, that concentric zonal variation, as suggested in Chapter 5, is the dominant principle of spatial *life-cycle organization*. The secondary sectoral variation of life cycle can probably be explained in terms of the observed tendency for life cycle categories normally characteristic of inner urban areas, to penetrate outer zones in finger-like projections following major radial transport routes.

Socio-economic status, by contrast, is overwhelmingly sectoral in spatial organization*, in support of the sectoral model of socio-economic status developed in the previous chapter, and lending substance to the argument that sectoral

* Johnston (1970) argues that analysis of variance, *in the* form used by Murdie and Reer, and employed here, is insensitive to zonal variations of socio-economic status within sectors. Harr (1971) shows that, while Johnston's criticism is valid, a restructured analysis of variance framework overcoming the problem of sensitivity to zonal fluctuations still reveals sectorality to be the dominant principle governing the spatial variation of socio-economic status in Johannesburg.

patterning is strengthened in Johannesburg by removal to the urban periphery of poor Non-White communities.

With no process of racial succession breaking down middle and high status sectors in the central area of Johannesburg, these should remain clearly defined. A series of concentric socio-economic transects (Figure 6.2. b) show that within the innermost zone (Zone A) little sectoral fluctuation of status occurs. This zone, however, includes most of the non-residential central business district and is not representative of patterns of residential differentiation. The second concentric transect (B) on the other hand, situated only some two kilometres from the peak land value intersection, demonstrates a marked variation of socio-economic status by sector, corresponding with the well defined sectors illustrated by more peripheral transects.

Superficially, then, it seems that the statement that the spatial separation of Non-White communities from White residential areas has tended to strengthen their sectoral socio-economic structure is valid. This is not the case, however, because it is by no means certain that Non-Whites, if free to locate residentially in the White city, would be attracted to the central area at all. Probably, owing to their low socio-economic status, they would elect to live close to places of employment within residential areas perceived by higher status Whites to be undesirable. While, then, a body of Non-Whites might invade old, blighted central residential areas, close to the work opportunities of the C.B.D., others possibly could equally choose to occupy the mining fringe. In this way, while sectors are broken down at the centre, the low-status sectors paralleling the mining-industrial belt would be strengthened.

A more tangible consequence of residential segregation as it is practised in Johannesburg stems from the tendency of the White city to expand outward to engulf once-peripheral Non-White residential enclaves, such as Newtown, Vrededorp and Sophiatown. Both the Newtown and the

Sophiatown[5] communities have been relocated, but the influence of these (particularly Sophiatown) on White residential areas is still being felt. This is illustrated by the series of radial socio-economic status

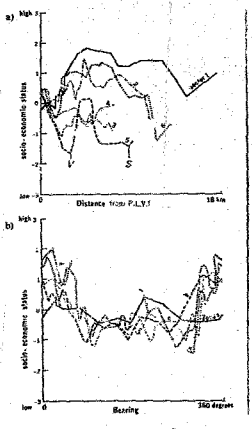

Figure 6.2: Radial and concentric socio-economic status transects. Factor scores on the socio-economic status factor are the basis for the vertical scale in both graphs.

[5] The Newtown community was moved in 1904 and the populations of the huge Sophiatown, Martindale and Newclare complex between 1954 and 1960 (Sherten, 1970).

profiles (Figure 6.2. a). Here, the lowest status levels for Whites are shown to exist in sector 5, corresponding with the locations of Vrededorp (V) and Sophiatown (S) respectively.

While the effect of residential segregation on the spatial form of socio-economic differentiation in White Johannesburg is speculative, then, the policy of housing Non-Whites on the periphery of the White city has one very definite consequence. A process of successive engulfment of once-peripheral Non-White areas by White residential expansion has left in the Western sector of Johannesburg a series of nodal low-status White residential pockets, perceived to suffer the locational disadvantage of proximity to Non-White areas, and contrary to the sectoral principle of socio-economic status variation.

CHAPTER 7

CONCLUSION

This analysis of the factorial ecology of Johannesburg has concentrated specifically on isolating dimensions of socio-economic differentiation of the White population, as these are evidenced in the 1960 census, and on describing the spatial differentiation of White residential areas in terms of each of these dimensions. Reference to Non-Whites is made only insofar as the location of Non-White residential enclaves is seen to affect spatial socio-economic patterns in the White city.

SUMMARY OF THE FINDINGS OF THE STUDY

The findings of the present study may be summarized in the form of a statement on the validity or otherwise of the hypotheses listed in Chapter 1:

1. Census sub-districts in the White residential areas of Johannesburg are differentiated along three axes according to socio-economic status, stage in the life cycle and ethnic status.

These axes are broadly congruent with dimensions of economic status, family status and ethnic status described by numerous other factorial ecologies, but display minor deviations attributable to local conditions. Socio-economic status includes, for instance, reference to the English-Afrikaans cultural duality. Stage in the life cycle does not include any reference to families. This is due to inadequate data and the link between family status and stage in the life cycle is illustrated by additional information. Ethnic status isolates minority southern European, Jewish and Afrikaans groups, as well as an element of the Non-White population of Johannesburg occupying dormitory dwellings in the White city.

2. Socio-economic status shows a strongly sectoral pattern of variation.
3. Stage in the life cycle has a predominantly concentric distribution.
4. Ethnic status reaches its highest levels within nodes distributed throughout the city.

The location of socio-economic sectors, and of ethnic and cultural groups such as the southern Europeans and the Afrikaners is strongly influenced by the east-west trending mining and industrial belt. Sectors of lowest status are those adjacent to the mining zone, and low socio-economic status ethnic groups occupy these industrial fringe areas.

With reference to the second set of hypotheses, it is not possible to make a definite statement as to the effect of the peripheral location of Non-Whites on the overall distribution of socio-economic status in the White city. However, it is demonstrated that once-peripheral Non-White townships engulfed by the White city have created around them localized nodes of low-status White residence. These low socio-economic status nodes are left as relics in the generally expanding White residential matrix even after the Non-White areas are relocated to conform with government policy.

SYNTHESIS

To synthesize the findings of this study, a model of socio-economic differentiation in Johannesburg may be developed. For simplicity each factorial dimension is dichotomized as illustrated in Table 7.1.

Table 7.1: Simple dichotomization of socio-economic dimensions.

FACTOR 1 SOCIO-ECONOMIC STATUS	FACTOR 2 STAGE IN THE LIFE CYCLE	FACTOR 3 SOUTHERN EUROPEAN IMMIGRANTS	FACTOR 4 JEWISH AND AFRIKAANS POPULATION	FACTOR 5 NON-WHITE POPULATION
HIGH (H)	YOUNG (Y)	MANY (M)	MANY (M)	MANY (M)
LOW (L)	OLD (O)	FEW (F)	FEW (F)	FEW (F)

A spatial framework for these dimensions may be obtained by superimposing the idealized sector and concentric models developed in Chapter 5 to describe the spatial differentiation, in Johannesburg, of socio-economic status and stage in the life cycle respectively. Symbols are then inserted according to their actual spatial distribution in the city (Figure 7.1).

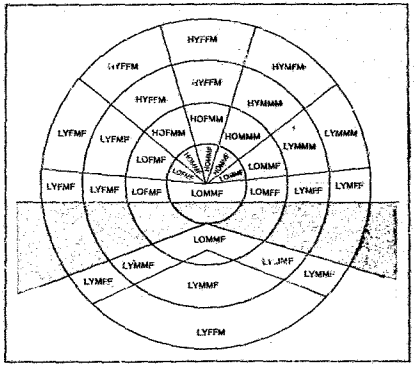

Figure 7.1: A spatial model of the socio-economic structure of Johannesburg. Letters in cells refer to the dichotomized factors of Table 7.1. Each cell contains five letters illustrating the character of the cell in terms of each of the five factors.

Each cell of the model may now be described according to the relative standing of its population on each of the factors. A cell designation HYFMF, for instance, describes a spatially defined group characterized by relatively high

socio-economic status, relative youth, few southern European immigrants, many Jews and few Non-Whites. Each cell population here is assumed to be homogeneous and may be described as a community defined, not according to ethnic characteristics only, but in terms of five social and economic attributes. In reality, of course, it is unlikely that the overall socio-economic structure of a city could be described in terms of so few homogeneous communities, or indeed that perfectly homogeneous communities exist at all. It is also unlikely, even if *relatively* homogeneous groups are considered, that they will be contained by cells defined in terms of super-imposed geometric sectors and concentric zones. In Chapter 5, for instance, numerous spatial deviations from the ideal sector and concentric zone models were noted when the actual distribution of socio-economic status and stage in the life cycle was traced. These spatial anomalies were attributed to variations in topography and access, as well as to decisions made by planners and developers.

But if criticism in detail is not allowed to obscure the modest claim of this model to be no more than a schematic representation of the principal findings of this factorial ecology of Johannesburg, then it can possibly be seen as a conceptual guide to further urban research in South Africa. In this way, perhaps, a further step toward the development of a model of the South African city may have been achieved.

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