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THE DISTRIBUTION AND ARRANGEMENT OF URBAN STRUCTURE AND SPATIAL CHANGE

By

Kingsley Edwin Haynes

A dissertation submitted to
The Johns Hopkins University
in conformity with the requirements
for the degree of
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Baltimore, Maryland

1971

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ABSTRACT

Montreal's urban structure for 1951 and 1961 was defined by factorial analysis. As hypothesized Socio-economic Status, Family Status, and Minor Ethnic Status were among the most important factors to be identified. An oblique analysis proved these factors to be "naturally" orthogonal. After the temporal stability of the composition of similar factors in each time period was established and an indication of factorial homogeneity and reliability was obtained, spatial change in urban structure was identified by the subtraction of factor scores for identical areas measured on compositionally similar but temporally separated factors. Two spatial characteristics, distribution and arrangement, were then examined with regard to urban structure (1951 and 1961) and change.

Distribution deals with the relative concentration or dispersion of residential characteristics in urban space. A factor analysis of the same variables as used to characterize urban structure but

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transformed to location quotient measures was carried out for 1951 and 1961. As hypothesized a set of factors representing increasingly restricted urban distributions were identified. Analysis indicated these factors were also "naturally" orthogonal and compositionally stable through time, 1951-1961. A measure of factorial homogeneity and reliability also was obtained. Distributional change was identified by subtracting factor scores for identical areas measured on compositionally similar but temporally separated factors. These distributional characteristics of Montreal's urban space in 1951 and 1961 and their change were related to urban structure.

An intercorrelation analysis of structure and distribution factors for 1951 and 1961 was carried out. As hypothesized the most closely related structure and distribution factors were those with similarity in variable and transformed variable composition. This was true despite the shifting of key urban structure variables to different variable associations in the distributional analysis, eg., one of the major ethnic variables shifted from an urban structure socio-economic association to an urban distributional segregation association. A multiple-partial coefficient was calculated in order to examine the relationship between spatial change

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in urban structure factors and urban distribution factors. These results indicate that the most important distributional change factor in explaining change in urban structure is the Male Labour Force Factor. Since this factor had already been linked to suburban characteristics these results support an early hypothesis concerning the importance of suburbanization in Montreal's urban structure between 1951 and 1961.

Arrangement deals with the spatial pattern of structure factors in 1951 and 1961 and their change in urban space. The classical patterns of sectorial arrangement of Socio-economic Characteristics, of the zonal or ring arrangement of Family Characteristics, and of multiple-nuclei arrangement of Minority Characteristics are tested. The original factor scores for a given factor are correlated with a set of smoothed or filtered scores typical of a particular arrangement pattern. A set of correlations are produced indicating the similarity between the original distribution of factor scores and each set of filtered scores typical of a particular pattern. When change is examined partial correlation is used to control for initial levels. A Z transformation of these

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correlations is utilized to identify significant differences. As hypothesized Socio-economic Status is sectorial and Family Status is zonal in their static distributions, 1951 and 1961. However, the pattern of Socio-economic change is nucleated and the pattern of change in Family Status could not be distinguished. As expected Minor Ethnic Status is nucleated in its static and change characteristics. The overall importance of nucleation in the pattern of urban structure is a dominant finding. One heuristic result implies that where other studies, which did not utilize a nucleation measure, identify factors as inconclusive in their zonal versus sectorial pattern character this study classifies these factors as nucleated.

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CHAPTER I

INTRODUCTION

Purpose

The study of urban structure and urban change is a rapidly growing branch of many fields. It encompasses a wide range of both particular and general work. The purpose of this study is to examine some spatial characteristics of urban structure and urban change

The type of urban structure to be analyzed here is ecological. That is, it deals with the spatial distribution of interrelated social variables of the city in the tradition of Park, Burgess and McKenzie.[1] In that context structure is defined as a population's

---

[1] R.E. Park, E.W. Burgess, and R.D. McKenzie, The City (Chicago: Chicago University Press, 1925). Summaries of this tradition can be found in A.H. Hawley, Human Ecology (New York: The Roland Press, 1950), G.A. Theodorson (ed.) Studies in Human Ecology (Evanston, Illinois: Row, Peterson and Co., 1961), and L. Reissman, The Urban Process (New York: The Free Press, 1964).

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residential characteristics for various areal elements of the city as opposed to other physical characteristics of urban structure such as commercial, institutional and industrial land-use.[1] It is the spatial characteristics of change in this urban ecological structure that will be a focus of this research.

A vast literature exists on this type of urban structure and the research tradition of urban ecology that is associated with it. Since a number of excellent reviews of this literature are available, only a brief review will be attempted here. Some important sources for reference and review can be found in Hauser and Schnore's The Study of Urbanization,[2] Murdie's study of Toronto,[3] Berry and Horton's

---

[1] Leo F. Schnore, "On the Spatial Structure of Cities" in P. H. Hauser and L. F. Schnore (eds.) The Study of Urbanization (New York: J. Wiley & Sons, 1965), p. 361.

[2] Ibid.

[3] R.A. Murdie, Factorial Ecology of Metropolitan Toronto, 1951-1961. (Chicago: Dept. of Geography, Research Paper No. 116, University of Chicago, 1969.

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book on urban systems[1] and Dogan and Rokkan's edition of Quantitative Ecological Analysis.[2]

Approach

Within the tradition of the 'Chicago School' of urban ecology and the framework of recent developments in social area analysis, this study examines two spatial characteristics of urban structure. These characteristics deal with the distribution and arrangement of that structure. Distribution is defined as the relative concentration or dispersion of a given phenomenon in urban space, while arrangement is defined as the patterns created by such phenomenon. Hypotheses relating to distribution are tenuous and exploratory while hypotheses relating to arrangement are reasonably well-defined in theory and via previous empirical research.

In order to carry out this analysis the primary variable, urban structure, is defined. The definition of this variable is carried out along the methodological line of previous research

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[1] B.J.L. Berry and F.E. Horton (eds.) Geographic Perspectives on Urban Systems: Text and Readings, (Englewood Cliffs, N.J.: Prentice-Hall, Inc., Forthcoming).

[2] M. Dogan and S. Rokkan. Quantitative Ecological Analysis in the Social Sciences. (Cambridge, Mass: M.I.T. Press, 1969).

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for the comparative purposes of validation in both time (1951 and 1961) and space (Montreal). The relationship between urban change and its spatial character (distribution and arrangment) is also examined with the aforementioned context.

The urban area selected for this study is Montreal. With a metropolitan population of two and a half million, it is the largest city in Canada. More important, is that even gross measures of the city indicate the last decade, 1951-1961, was a period of rapid change. For example, Montreal registered one of the highest growth rates in North America for a city of its size, 43.37% (1951-1961).[1] At the same time, urban population density declined from approximately 12,000 per square mile to 9,500 per square mile.[2] This was the largest decline in urban density for any Canadian city.[3]

---

[1] Dominion Bureau of Statistics. Census of Canada, 1961, Bulletin 1.1-6.

[2] Canadian Federation of Mayors and Municipalities. First Canadian Urban Transportation Conference: Study Papers (February 9-12, 1969), p. 67.

[3] Ibid.

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Time

In part, it is hoped that the rapidity of change will make up for the limited time span of this study. However, the most important consideration for the choice of the time periods of this study was simply that the Canadian Census did not begin small area data collection until 1951. Another useful aspect of this time span is the collection of the 1956 and 1966 "mini" Census. As a consequence, trends set during the decennial period 1951-1961 can be checked (1956) and extended (1966), when the relevant variables or their surrogates are available. The decade 1951-1961, therefore, provides possibilities of monitoring and extending rates of change, not available for other periods.

Location

Montreal is located on an island in the St. Lawrence River just downstream from the junction of the Ottawa River. The only physiographic barriers to urban development are the river itself and Mont Royal. Mont Royal is a low upland feature with a

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prominance disproportionate to its actual elevation due to its high relief in an otherwise lowland area. It is located to the northwest of the city's Central Business District (CBD) and has been completely engulfed by the city except for a large park preserved on its promentory. As a consequence of previous urban expansion and the extension of the associated transportation networks, this ridge has not been a major barrier to urban growth in recent years.

Although a major commercial center for English speaking North America, the dominant culture, as designated by language, is French. The city is an important bicultural center (French and English) with a large and recent immigrant population from various origins primarily the United Kingdom, Eastern and Southern Europe. This cross-cultural aspect of Montreal adds an important dimension to this study since most previous work, of the type attempted here, has been carried out within a basic uni-cultural framework[1]

---

[1] An important exception to this is F.L. Sweetser. "Factorial Ecology: Helsinki, 1960" Demography, Vol. 2 (1965), pp. 372-385, the non-time oriented work by G. Cliffe-Phillips, J. Mercer and Y. Young, "The Spatial Structure of Urban Areas: Montreal" (unpublished paper Urban Studies Center, Univ. of Chicago), April, 1969 and the preliminary urban factorial ecology research by B. Greer-Wootten for a study on the relationship between migration and social area structure in Montreal (unpublished report to the Committee for Social Science Research, McGill University, 1969).

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most commonly that of the United States.[1]

Context

Sociology, economics and land-use theory together with geography have provided the framework and previous empirical research upon which this study is based. Within sociology the 'Chicago School' of human ecology in the 1920's identified space as a primary object of concern in urban analysis and recent work by human ecologists have maintained a strong emphasis on spatial patterns and change in those patterns.[2] The process by which urban space is organized among alternate uses was seen as a problem of competition. Human ecologists

---

[1] Other non-North American studies of this type include D.T. Herbert "Social Area Analysis: A British Study" Urban Studies, Vol. 4 (1967) pp. 41-60; D.T. Herbert "Principal Components Analysis and Urban Social Structure: A Study of Cardiff and Swansea", (Swansea, U.K.: Dept. of Geography, University College Swansea, 1967), mimeographed; P.O. Pedersen "An Emprical Model of the Population Structure: A Factor Analytic Study of the Urban Population Structure of Copenhagen" Proceedings of the First Scandinavian-Polish Regional Science Seminar (Warszaga: Polish Scientific, 1967); F.L. Jones "A Social Profile of Canberra, 1961" The Australian and New Zealand Journal of Sociology, Vol. 1 (Oct., 1965), pp. 107-120.

[2] L.F. Schnore. Op. Cit., p. 348.

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were divided over the competitive mechanism by which this allocation of urban space took place. Even the two early leaders in the field, Park and Burgess, were divided as to whether Social Darwinism or the classical market forces of economics provided the basis of the competitive mechanism.[1] Park and Burgess produced the concentric-circle or zonal pattern as the static theoretical model of urban spatial structure with each zone composed of specific land use characteristics. The dynamics of this model is generated by one of the two competitive mechanisms noted above and the spatial form of change was postulated to occur in ring-like expansion from the center of the system. Rings shifted outward in the typical patterns of invasion and succession.[2]

Land economists and land-use theorists have lent support to the concentric zone hypothesis but also generated some alternate hypotheses of urban spatial patterns that deserve consideration. Alonso identi-

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[1] G. Sjoberg, "Theory and Research in Urban Sociology" in The Study of Urbanization, Op. Cit. p. 164.

[2] Park, Burgess and McKenzie, Op. Cit., pp. 47-62.

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fied a theoretical basis in economic theory for the concentric zone hypothesis when he pointed out the relationship between commuting costs and the decline of land values from the CBD.[1] When this is linked to the life-cycle demand for land and children as outlined by Wolpert a strong case can be made for this theoretical spatial model of urban structure.[2] On the other hand, land economists and land-use theorists, particularly Hurd and Hoyt, were among the first to suggest an alternative sectorial hypothesis of urban spatial structure.[3] Their empirical support lies in the importance of transportation in modern society both at the individual and aggregate levels. Furthermore, the fact that the spatial forms of urban transportation structure tend

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1 W. Alonso. Location and Land Use. (Cambridge, Mass.: Harvard University Press, 1964).

2 J. Wolpert. "Behavioral Aspects of the Decision to Migrate." Papers and Proceedings of the Regional Science Association. Vol. 15, (1965), p. 159.

3 R.M. Hurd. Principles of City Land Values. (New York: Real Estate Association, 1903), pp. 59-63. H. Hoyt. The Structure and Growth of Residential Neighborhoods in American Cities. (Washington, D.C.: Federal Housing Administration, 1939).

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to be radial is not without significance. In this model the higher value land, accessible to transportation is seen as going to the highest bidders, the wealthy, while the less accessible land in the interstices of the transport net is filled in with the poor. Hoyt postulated that the pattern of dynamics in this model occur via a shift of the wedge or sectors outward from the CBD.[1] Wingo's work on transportation and land-use lends strong theoretical support for the critical role of transportation in sorting residential land-use in a city.[2]

The final model of urban spatial structure has a hybrid theoretic origin. Harris and Ullman noted early that the city might be more accurately represented as a set of clusters rather than simply one center represented by the CBD.[3] Berry has indicated the relationship between this multiple

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[1] Ibid.

[2] L. Wingo. Transportation and Land Use. (Washington, D.C.: Resources for the Future, 1961).

[3] C.D. Harris and E.L. Ullman. "The Nature of Cities". The Annals of the American Academy of Political and Social Science, Vol. 242, (November, 1945), pp. 7-17.

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nuclei hypothesis and a hierarchy of centers that would be postulated by a central place theory of internal urban structure.[1] The economist Hoover noted that the agglomerative forces that create the city in the first place can be seen as primary generators of nucleation and spatial differentiation within the city and that these mechanisms operate in the social as well as the commercial sphere.[2] This is reflected by clustering within the residential structure of the city. Gans in his famous sociological study notes that sub-centers are of variable importance to the various ethnic and structural communities that compose the city.[3] All these researchers would seem to agree that there is some merit in viewing the city as a set of multiple nuclei rather than as a single centered structure.

---

1 B.J.L. Berry. "Cities as Systems within Systems of Cities". Regional Development and Planning, J. Friedmann and W. Alonso (eds.) (Cambridge, Mass.: M.I.T. Press, 1964).

2 E.M. Hoover. "The Evolving Form of the Metropolis" in Issues in Urban Economics ed. by H.S. Perloff and Wingo Jr. (Baltimore, Md.: The Johns Hopkins Press, 1968), pp. 262-264.

3 H.J. Gans. The Urban Villager. (New York, N. Y.: The Free Press, 1962).

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The dynamics of multiple nucleation are less clear because it encompasses two views of the multiple nuclei. One is commercial while the other is social. While these views are not independent of each other, they are also not coincident. Since this study uses data on residential characteristics the social view will be followed. Invoking theories of neighborhood change and urban succession it would be expected that socially isolated groups nucleated at one point in time become less nucleated as they spread through the urban structure in a diffusion-like process over time.[1] However, this diffusion process refers to specific groups of individuals and not areas. It seems reasonable to expect that this would be true for areas provided that the groups so diffused were not replaced by new minorities. In the case of replacement, however, the multiple-nuclei sub-areas could be

---

[1] R. Morrill. "The Negro Ghetto." The Geographical Review, Vol. 55, (1965), pp. 337-362, R. Morrill. "Expansion of the Urban Fringe." Papers of the Regional Science Association, Vol. 15, (1965), pp. 185-202, L.A. Brown. Diffusion Process and Location. (Philadelphia, Pa.: The Regional Science Research Institute, Bibliography Series, No. 4, 1968), pp. 9-36.

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expected to maintain themselves in a kind of "trickle down" theory of urban occupancy.[1]

Traditionally these three basic models of urban spatial structure have been viewed as conflicting descriptions of intra-urban location patterns.[2] However, the empirical work of Anderson and Egeland suggest that these descriptions may be additive with each pattern being associated with different aspects of urban structure.[3] The basis for this linkage was pointed out by Hurd in his 1903 study but the methodological background for more recent empirical research has come from social area analysis.

---

1 W.F. Smith. "The Housing Stock as a Resource." Papers and Proceedings of the Far-East Conference of the Regional Science Association, Vol. 1, (Sept., 1963), pp. 77-82, I.S. Lowry. "Filtering and Housing Standards: A Conceptual Approach". Land Economics Vol. 36, No. 4, (Nov.,1960), pp. 362-370.

2 B.J.L. Berry (1964), Op. Cit., pp. 125-129, B.J.L. Berry. "Internal Structure of the City" Law and Contemporary Problems. Vol. 30, (Winter, 1965), pp. 111-119, J.W. Simmons. "Descriptive Models of Urban Land Use." The Canadian Geographer Vol. 9, (1965), pp. 170-174.

3 T.R. Anderson and J. Egeland. "Spatial Aspects of Social Area Analysis". American Sociological Review. Vol. 26, (June, 1961), pp. 392-399.

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Social area analysis has contributed an important aspect of methodology to the present study. Shevky and Bell, in their ennuciation of social area analysis, rely heavily on the literature concerning economic development in modern society to identify postulates and isolate key aspects of urban social change.[1] Particular emphasis is placed on the works of Ogburn, on development and the changing function of the family; of Florence, on the relationship between industrial development and reorganization of economic and government structures; of Wirth, on increasing scale and urban living; and of Clark, on social conditions required for economic progress.[2] From these works three dominant characteristics are postulated as the basis for studying a particular

---

1 E. Shevky and W. Bell. Social Area Analysis. (Stanford: Stanford University Press, 1955).

2 W.F. Ogburn. "The Family and Its Foundations". Recent Social Trends in the United States (New York: McGraw-Hill, 1933), Vol. I, pp. 661-708, S. Florence. The Logic of British and American Industry. (London: Routledge and Kegan Paul, 1953), L. Wirth. "Urbanism as a Way of Life." American Journal of Sociology. Vol. 44, (July, 1938), pp. 1-24, C. Clark. The Conditions of Economic Progress. rev. ed., (London: MacMillan & Co., 1951).

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social system at any one point in time. These are social rank operationalized as economic status, urbanization operationalized as family status, and segregation operationalized as ethnic status. Although criticized on many grounds, researchers from other fields have viewed the development and application of social area analysis favourably. The economist Tiebout and the geographers Berry, Timms and Herbert have commented favourably on the utility of social area analysis.[1] To quote Berry,

> ...although social area analysis began in a "look-see" manner, with later work facilitated by advancing computer technology, their work has now laid the basis for a spatial model of the internal socio-economic pattern of cities in which the relevance and role of the traditional concepts is clear.[2]

---

[1] C.M. Tiebout. "Hawley and Duncan on Social Area Analysis: A Comment." Land Economics. Vol. 34, (May, 1958), pp. 182-184, B.J.L. Berry (1964), Op. Cit., p. 129, D. Timms. "Quantitative Techniques in Urban Social Geography." Frontiers in Geographical Teaching. ed. by R.J. Chorley and P. Haggett, (London: Methwen, 1965), pp. 250-256, D.T. Herbert. "Social Area Analysis: A British Study." Urban Studies, Vol. 4, (1967), D.T. Herbert. "The Use of Diagnostic Variables in the Analysis of Urban Structure". Tijdschrift voor Economische en Sociale Geographie. Vol. 57, (1967), pp. 5-10.

[2] B.J.L. Berry. (1964), Op. Cit., p. 129.

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After reviewing empirical research in this area, Murdie sums up,

> These analyses suggest that all three indexes are necessary to describe socio-economic differentiation within such a system, but do not mean that these indexes are sufficient to describe all socio-economic differentiation within such a system. However, the results give some reason to believe that the concepts are adequate to describe a good deal of differentiation in the published census characteristics.[1]

Murdie's summary table of previous empirical work in this area has been included and updated (See Table 1.1). From the limited number of studies available, there is marginal evidence to support a concentric circle or zonal distribution of family status and a wedge or sector distribution of economic status.[2]

Spatial Characteristics

Geography has long been concerned with the use of summary statistics in describing areal phenomena.

---

[1] Murdie. Op. Cit., p. 25.

[2] Ibid.

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TABLE 1.1

Comparison of Empirical Studies on Urban Ecological Structure

(After Murdie, 1969)

Study Orientation - Social Area Analysis

Author, Title (Date of Publication)	City	Variables (Data Source)	Analytical Techniques	Structural Character	Spatial Pattern
E. Shevky & M. Williams *The Social Areas of Los Angeles* (1949)	Los Angeles	Occupation Education Fertility Women in the Labor Force Single Family Dwelling Units Race & Ethnicity (U.S. Census of Population 1940 & 1950)	Social Area Analysis	Economic Family Ethnic	Generally corresponds with known structure of town
E. Shevky & W. Bell *Social Area Analysis* (1955)	San Francisco Bay Region				
D.T. Herbert *Social Area Analysis* (1967)	Newcastle under-Lyme	Occupation Education Fertility Women in the Labor Force (British Census of Population 1961)			

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TABLE 1.1 - Continued

Study Orientation - Empirical Verification

Author, Title (Date of Publication)	City	Variables (Data Source)	Analytical Techniques	Structural Character	Spatial Pattern
R.C. Tryon Identification of Social Areas by Cluster Analysis (1955)	San Francisco Bay Region	Thirty-three census variables (U.S. Census of Population 1940)	Cluster Analysis	Economic	
W. Bell Economic, Family & Ethnic Status: An Empirical Test (1955)	Los Angeles San Francisco	Six social area variables (U.S. Census of Population 1940)	Factor	Family	
M. Van Arsdol, Jr. S.F. Camilleri, C.F. Schmid The Generality of Urban Social Area Indexes (1958)	Ten large cities in U.S.	Six social area variables (U.S. Census of Population 1950)		Ethnic	
T.R. Anderson & L.L. Bean The Shevky-Bell Social Areas: Confirmation of Results and a Reinterpretation (1961)	Toledo, Ohio	Thirteen census variables (U.S. Census of Population 1950)	Analysis	Economic Family Ethnic Urbanization	

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TABLE 1.1 - Continued

Study Orientation - Spatial Patterns

Author, Title (Date of Publication)	City	Variables (Data Source)	Analytical Techniques	Structural Character	Spatial Pattern
T.R. Anderson J. Egeland Spatial Aspects of Social Area Analysis (1961)	Akron Dayton Indianapolis Syracuse	Six social area variables (U.S. Census of Population 1950)	Social Area	Economic	Sectorial (Economic Status) Concentric (Family Status)
D.C. McElrath The Social Areas of Rome: A Comparative Analysis (1962)	Rome, Italy	Nonmanual workers Literacy Fertility Women in Labor Force (Census of Rome, Italy, 1951)	Analysis, Analysis of	Family	Economic & Family status are both sectorial and concentric, Economic Status is highest in the central district
D.C. McElrath J.W. Barkey Social and Physical Space: Models of Metropolitan Differentiation (1964)	Chicago	Six social area variables (U.S. Census of Population 1960)	Variance	Economic Family Ethnic	Sectorial (ethnic status) Concentric (economic status) (family status)

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TABLE 1.1 - Continued

Study Orientation - Multivariate Analysis

Author, Title (Date of Publication)	City	Variables (Data Source)	Analytical Techniques	Structural Character	Spatial Pattern
F.L. Sweetser The Social Ecology of Metropolitan Boston: 1950 (1961) F.L. Sweetser The Social Ecology of Metropolitan Boston: 1960 (1962) F.L. Sweetser Patterns of Change in the Social Ecology of Metropolitan Boston: 1950-1960 (1967)	Metro Boston	Seventeen Census Variables (U.S. Census of Population 1950 and 1960)	Linkage Analysis	Economic Family	Sectorial (Variables related to economic status) Concentric (Other variables)

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TABLE 1.1 - Continued

Study Orientation - Multivariate Analysis (Continued)

Author, Title (Date of Publication)	City	Variables (Data Source)	Analytical Techniques	Structural Character	Spatial Pattern
E. Gittus An Experiment in the Definition of Urban Sub-Areas (1964-5)	Mersey-side and Hampshire	Sixty census variables (U.K. Census 1961)	Component Analysis	Crowding Household Amenities	Analysis of county borough of Bootle within Merseyside confirms preconceived notions
C.F. Schmid & K. Tagashira Ecological and Demographic Indices: A Methodological Analysis (1964)	Seattle	Forty-two variables (U.S. Census 1960)	Factor Analysis	Economic Family Ethnic Maleness Population Stability	
F.L. Sweetser Factor Structure as Ecological Structure in Helsinki, 1960 (1965)	Helsinki and Boston	Twenty census variables (Finnish & U.S. Census 1960)	Factor Analysis	Economic Progeniture Urbanism	

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TABLE 1.1 - Continued

Study Orientation - Multivariate Analysis (continued)

Author, Title (Date of Publication)	City	Variables (Data Source)	Analytical Techniques	Structural Character	Spatial Pattern
F.L. Sweetser Factorial Ecology: Helsinki 1960 (1965)	Helsinki	Forty-two census variables (Finnish census 1960)	Factor Analysis	Economic, Feminine Career, Residential Established Familism Progeniture	
F.L. Jones A Social Profile of Canberra, 1961 (1965)	Canberra, Australia	Twenty-four census variables (Australian Census 1961)	Component Analysis	Ethnicity, Demographic structure, Age of area	
B.J.L. Berry R.J. Tennant Metropolitan Planning Guidelines: Commercial Structure (1965)	North-eastern Illinois	Fifty social & economic variables (Suburban Factbook, 1960)	Factor Analysis	Economic, Family, Ethnic, New Suburbs, Distance-Density, Housing Vacancies	Economic Status (somewhat sectorial) Family Status (somewhat concentric)

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TABLE 1.1 - Continued

Study Orientation - Multivariate Analysis (continued)

Author, Title (Date of Publication)	City	Variables (Data Source)	Analytical Techniques	Structural Character	Spatial Pattern
P.O. Pederson An Empirical Model of Urban Population Structure: A Factor Analytic Study of the Population Structure in Copenhagen (1965)	Copenhagen	Fourteen census variables (Danish census 1950 and 1960)	Factor	Family, Economic, Growth and Change	Sectorial (Economic status) Concentric (Family status)
G.W. Carey The Regional Interpretation of Manhatten Population and Housing Patterns through Factor Analysis (1966)	Manhatten New York City	Thirty-three demographic & housing variables (U.S. Census of Population 1960)	Analysis	General Manhattan, Puerto Rican, Middle Income Negro, Low Density, Transient Residence, West side Rooming House	Factor scores are mapped but the resulting patterns are not compared with the classic descriptive models

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TABLE 1.1 - Continued

Study Orientation - Multivariate Analysis (continued)

Author, Title (Date of Publication)	City	Variables (Data Source)	Analytical Techniques	Structural Character	Spatial Pattern
L.S. Burns A.L. Harman The Complex Metropolis (1968)	Los Angeles	Sixty-seven demographic, housing and land use variables (U.S. Census of Population and Housing, Los Angeles Transportation Study 1960)	Factor	Affluence, Aged, Mobile, Centrality Institutions Minorities Industrial Areas	Factor scores are mapped and patterns discussed but not objective measure of pattern is carried out
B.J.L. Berry R.J. Tennant Commercial Structure Discussion in Berry & Horton Urban Systems 1970	Chicago	Fifty-seven census variables (U.S. Census 1960)	Analysis	Socio-economic Family Race & resources Immigrant & Catholic Size Jewish Old Housing Mobility	Socio-economic status & Family status Indeterminant between zones & sectors Analysis of Variance

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TABLE 1.1 - Continued

Study Orientation - Multivariate Analysis (continued)

Author, Title (Date of Publication)	City	Variables (Data Source)	Analytical Techniques	Structural Character	Spatial Pattern
R.A. Murdie Factorial Ecology of Metropolitan Toronto 1951-1961 (1969)	Toronto	One hundred and ten census variables (Canadian Census 1951, 1961)	Factor Analysis	Economic, Family, Ethnic difference Recent growth Household-employment Change Family Ethnic Employment Residential	Economic (Sectorial) Family (Zonal) Remainder mixed Analysis of Variance Change Family (Zonal & Mixed) Mixed Mixed Zonal

In these discussions clear distinction has been drawn between distribution and arrangement. In this context distribution is recognized as a useful but unidimensional concept that when used in summary form (frequency distribution) reduces areal phenomena from two dimensions to one dimension. Dacey's example is illustrative of this problem.[1] (See Table 1.2).

In this example the distribution of A and B in summary form (frequency) are identical while the corresponding arrangement of values in cells or "census tracts" are clearly different. Arrangement, on the other hand, makes explicit the location of values. When the location of values takes on an overall spatial form such form is referred to as pattern. Since this study attempts to yield statements about the distribution and arrangement of specific aspects of urban structure, it is vital that these distinctions be kept in mind.

In this study, distribution will be examined by dispersion measures (location quotients) applied to

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[1] M.F. Dacey. "A County-Seat Model for the Areal Pattern of an Urban System." Geographical Review. Vol. 56, (1966), p. 529.

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TABLE 1.2

Distribution and Arrangement

Distribution A		Arrangement A				
Value	Frequency					
0	6	0	0	1	2	2
1	3	0	0	1	2	2
2	6	0	0	1	2	2

Distribution B		Arrangement B				
Value	Frequency					
0	6	0	2	0	2	1
1	3	0	2	1	0	2
2	6	1	0	2	0	2

(Source: M.F. Dacey. "A County-Seat Model for the Areal Pattern of an Urban System." Geographical Review. Vol. 56, (1966), p. 529.)

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urban structure variables. By comparing the results of a set of grouping algorithms with the original data, arrangement patterns will be analyzed and compared. The techniques utilized in this analysis will be limited to various correlation and regression methods.

Expectations

Although specific hypotheses will be discussed in direct connection with analyses to be performed at each step of the study, some general expectations will be noted here. These are related to four basic areas of the present study dealing with (1) the development of the primary variable, urban structure; (2) the development of the urban distribution variable; (3)the relationship of urban structure to the distributional character of its component variables; and (4) the relationship between urban structure and arrangement.

In the case of the primary variable, both social area analysis and previous research which have utilized multivariate techniques produce certain expectations. These hypotheses relate to the composition, order of explanation, and number of dimen-

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sions needed to differentiate urban structure (See Chapter IV). The second set of expectations are exploratory. The distributional character of urban residential variables is expected to be quite different from the structural character. These differences should be most clearly exhibited in the composition of distributional as opposed to structural dimensions. The hypotheses in this set of expectations are definitely the most tenuous, having little theoretic underpinnings and almost no previous work upon which to rely (See Chapter V). The final set of expectations relate directly to the arrangement or patterns associated with particular aspects of urban residential structure. Hypotheses will be identified that relate specific pattern characteristics to the social area dimensions of urban structure (See Chapter VI).

In a broader context this study, being carried out in a bi-cultural setting, is a partial test of the criticism levelled by sociologists that social area analysis' most glaring defect is its culture-boundness.[1] A final point should be kept in mind.

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[1] Sjoberg, Op. Cit., p. 180.

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If the structure of this study seems at first quite abstract it is not without reason, for as Sjoberg in a review of theory and research in urban sociology has noted, "Only at higher levels of abstraction do many of the similarities among cities emerge..."[1]

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[1] Ibid., p. 178.

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CHAPTER II

FRAMEWORK

The conceptual framework of this study will be explained by the traditional "geographic matrix" [G] which is a rectangular array of data with locations on one axis and attributes of these locations on the other. Locations may be any point or land aggregate that can be fixed uniquely by a Cartesian coordinate system. They may be cities or, in this case, a city subdivision, a census tract. Attributes are simply various measurements of a location.

Previous Framework

The procedure that is commonly carried out on this geographic matrix is the basic multi-variate technique of intercorrelation [R]. This can be done by correlating locations with locations over different attributes (Q mode), but as is more often done, in geographic studies, by correlating attributes with attributes over different locations (R mode). A

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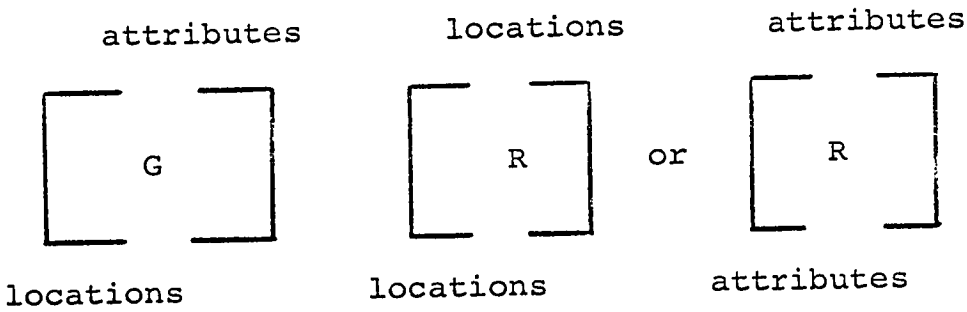
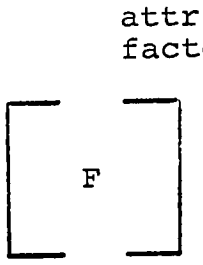
principal component or principal factor matrix[1] [F] is then developed to identify which attributes covary more with each other than with any other attribute. In this way, groups of attributes called principal components or principal factors are created.





(R mode)

After appropriate rotation, usually varimax, the components or factors are then mapped and the spatial distribution of each factor is described.

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[1] Whether the analysis is principal components or principal factor depends on the way in which the "communality problem" in the main diagonal is treated. This problem will be commented upon later. In the meantime, these terms are used interchangeably.

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At this point, process is often inferred from the distribution of each factor.

More recently, this approach has been extended in time in an attempt to better understand the processes and dynamics of a given system.[1] The above procedure may be carried out for the same attributes at the same locations for two points in time. The result will be two factor matrices. The main object is to relate these, temporally separated, factor matrices. This has been done through the use of a secondary matrix, a transaction matrix (T). The purpose of this transaction matrix is to typify the process involved in change by embodying the flows between locations during the intervening period, t_2-t_1. Typical flows used in a transaction matrix are number of phone calls, amount of mail, value and/or tonnage of trade. In the case of the transaction matrix symmetry is not present, as it is in the intercorrelated geographic matrix, since the flow that occurs between any two places will

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[1] M. Megee. "Economic Factors and Economic Regionalization in the United States." Geografiska Annaler. Vol. 478 (1965), pp. 125-137.

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not necessarily be reciprocal. This approach was used in Berry's study of trade patterns among Indian provinces.[1] Such detail in interaction data is difficult to obtain in meaningful levels of disaggregation for metropolitan areas and applications of this type of multivariate technique to urban analysis have been sparse.[2]

Another approach has been to identify a set of change attributes and to regress them on a consolidated factor change matrix.

$[F_1]$	$[F_2]$	$[F_{2-1}]$
Structure Matrix t_1	Structure Matrix t_2	Change Matrix t_2-t_1

This has been the approach of Hodge.[3] The attributes regressed on the change matrix " F_{2-1}" were derived from attributes included in the structure

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[1] B.J.L. Berry. Essays on Commodity Flows and the Spatial Structure of the Indian Economy. (Chicago: Dept. of Geography, Research Paper No. 111, Univ. of Chicago, 1966).

[2] J. Simmons. "Review of Urban Geography Research on Toronto". (Seminar Lecture, McGill University, September, 1969).

[3] Gerald Hodge. "Urban Structure and Regional Development." Papers of the Regional Science Association, Vol. 21 (1968), pp. 101-123.

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matrices and hence correlation was not unexpected. All this type of analysis yields is that change in factor Fm containing attribute "j" was correlated with change in attribute "j" to the level that "j" was correlated with factor Fm. In short, very little can be said from an explanatory viewpoint. However, it should be noted that Hodge's study was attempting to identify growth poles for regional planning and examine the stability of change correlates for various regions and not identify independent change correlates *per se*.

Murdie used a similar approach to examine change in Toronto.[1] Although his change measures are dependent on his structure measures, he only attempts to utilize these in interpreting alterations in the spatial form of his structure factors.

Neither of the above studies came directly to grips with correlates of urban spatial change. What form should the explanatory matrix take? Do we want a transaction matrix? What measures should be used as correlates to change in the urban

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[1] Murdie (1969), *Op. Cit.*

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structure matrices? How do we "shed some light" on the pattern of urban spatial structure and change?

Present Framework

An alternative approach to the spatial aspect of that problem is suggested here. Utilizing existing methodology concerning the identification of urban structure, Montreal's characteristic urban dimensions will be outlined. In order to make statements about that structure's spatial character two aspects of spatial form were identified: distribution and arrangement. The distinction between distribution and arrangement has already been noted. However, it is necessary to clarify the difference between distribution measures and traditional measures utilized in factorial ecology.

Traditional measures used in urban ecological analyses include mainly percentage data, some ratio measures and a few absolute measures. For example, an age structure measure, old age, would most commonly be in the form of the percentage of a census tract's population over 64 years, or a

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ratio of the number of people over 64 to the number of people in the productive age groups (15-64) and in a few cases one might find the absolute number of people over 64. The distribution measure utilized in this study takes the form of a location quotient which measures the relative concentration or dispersion of a given phenomenon such as old age. This measure is not in terms of the absolute number of people in the tract but in the relative terms of the number of old people available in the urban area to be concentrated or dispersed. Using the example above as a distribution measure, one would calculate the number of old people in a particular tract as a proportion of all old people in the urban area.

At this point a hypothetical example may be useful in order to demonstrate differences in the traditional percentage measures and the suggested distribution measures. In the traditional approach it might be found that the British population never composed more than eight percent of the total population in any census tract and many tracts have only three percent British population. The British population is, therefore, concluded to be of little

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importance in all tracts. However, when examined in terms of the total British population in the urban area, the tract with eight percent of its population British, may have 75% of the total British urban population. When the concern of the study is to examine the spatial character, one aspect of which is the grouping behavior of minorities, it is clear that this approach has the potential of adding important information.

Arrangement uses the relative position of urban structure characteristics to test various pattern relationships. A set of grouping algorithms, each representative of different patterns, are the basis for the urban structure arrangement tests. It is hoped that the use of these measures in the analysis of urban structure will make the spatial characteristics of that structure more apparent.

Although change has not yet been discussed, it should be clear that its spatial character in the urban context is important. By the use of the

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shifts in factor scores (a measure of the degree to which a given locational element loads on a given factor) urban change can be examined spatially. Particular problems associated with the use of factor score change analysis will be discussed later. This method, however, can be used in measuring the spatial change in urban structure if a structure's attribute composition is similar at both points in time. Change in urban spatial structure can be treated as a dependent variable as we did for urban structure itself. Similarly the spatial characteristics, distribution and arrangement, of change in urban spatial structure are of more than passing importance.

To accomplish this the following generalized steps were carried out:

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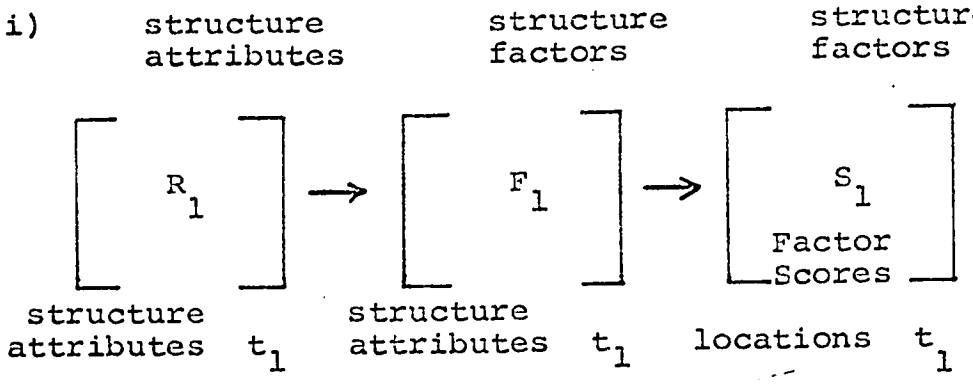
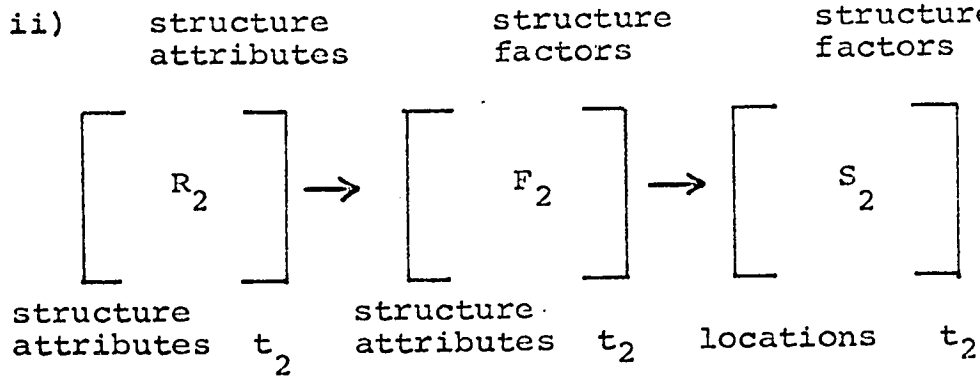
I - URBAN STRUCTURE

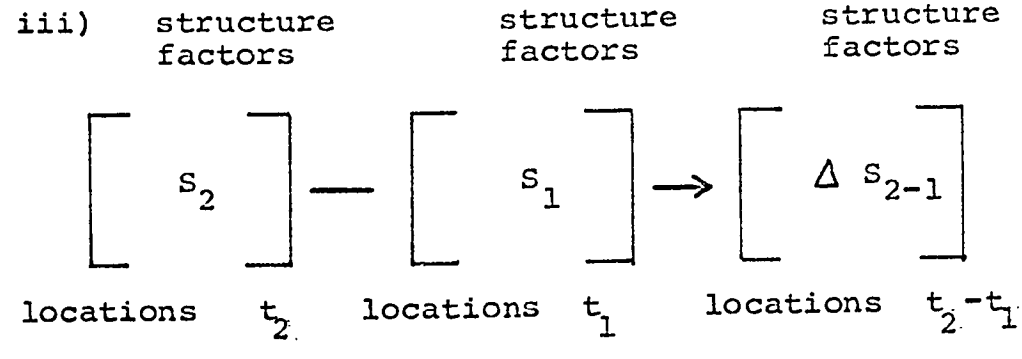
i)



ii)



iii)



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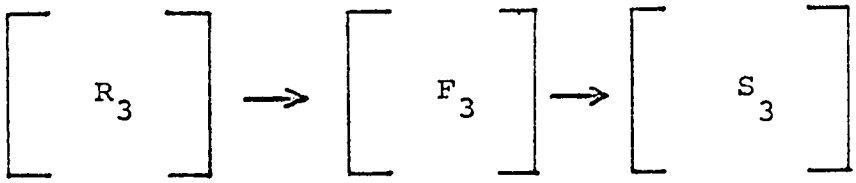
II - URBAN SPATIAL CHARACTER

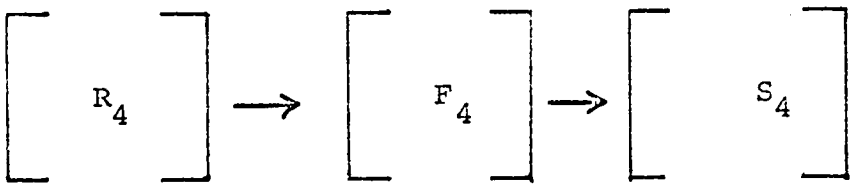
A) Distribution Measures

A(i) distribution measures → distribution factors → distribution factors



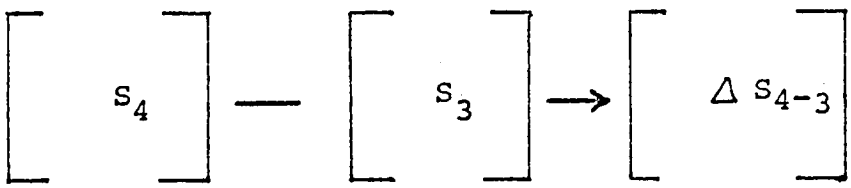
distribution measures t_1 → distribution measures t_1 → locations t_1

A(ii) distribution measures → distribution factors → distribution factors



distribution measures t_2 → distribution measures t_2 → locations t_2

A(iii) distribution factors — distribution factors → distribution factors



locations t_2 — locations t_1 → locations t_2-t_1

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B) Arrangement Measures

Concentric Zone Algorithm

B(i) This is a smoothing function[1] for the identification of patterns that vary with distance from the Central Business District (High Value Corner).

Sectorial Algorithm

B(ii) This is a second smoothing function for the identification of patterns that vary sectorially around the Central Business District (High Value Corner).

Nuclei Algorithm

B(iii) This third smoothing function is for the identification of nuclei or cluster patterns in the arrangement of structure factors.

Analytical Steps

The following analytical steps will be carried out as tests for specific sets of hypotheses.

---

[1] For discussion of the concepts of smoothing and filtering space fields see J. Holloway "Smoothing and Filtering of Time Series and Space Fields," Advances in Geophysics Vol 4 (1958), pp. 351-389 and W.K. Tobler "Of Maps and Matrices", Journal of Regional Science, Vol. 7, 1967 (No. 2, Supplement on Contributions to Geographic Theory), pp. 275-280.

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A) The development of the urban spatial structure variable, step one, includes the identification of this variable in 1951, 1961 and change (1951-1961).

B) The development of the urban distribution variable, step two, includes the identification of this variable in 1951, 1961 and change (1951-1961). The static urban structure dimensions are then compared to the static urban distribution dimensions in 1951 and 1961 by intercorrelation. Change in urban spatial structure factors are used with partial correlation in a multiple correlation to test their relationship to urban distribution factor change.

C) Static urban structure is used in a correlation analysis with three arrangement indexes for 1951 and 1961. Urban spatial change is used with partial correlation in a similar analysis.

It should be clear that this study parallels the factor analytic approach used by social area analysts and recently adopted by urban geographers.[1] Although social area analysis was originally developed for a small number of variables, usually six or seven,[2] the results are consistent across different numbers of variables, different varia-

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[1] Ibid.

[2] E. Shevky & W. Bell. Social Area Analysis. (Stanford: Stanford University Press, 1955).

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ble mixes and when applied to different urban locations.[1] Despite such empirical consistency the original methodology of deriving basic homogeneous areas from a few key variables is weak. With such methodological weakness, it is debatable whether factor analysis is the proper technique from which to build or extend theory.[2] However, the empirical consistency of previous studies is highly persuasive. Empirically such studies provide specific expectations with regard to the content of urban structure. Furthermore, the spatial character of urban structure *per se* is based on theoretical grounds laid by classical urbanists such as Park and Burgess, Hurd and Hoyt, and Harris and Ullman.[3] This work has recently been strengthened and extended through deductive economic analysis by Alonso, Wingo and Hoover.[4]

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[1] T.R. Anderson & L.L. Bean. "The Shevky-Bell Social Areas: Confirmation of Results and a Reinterpretation." *Social Forces*. Vol. 40 (December, 1961), pp. 119-124.

[2] J.S. Armstrong. "Derivation of Theory by Means of Factor Analysis or Tom Swift and His Electric Factor Analysis Machine." *The American Statistician*. Vol. 21 (1965), pp. 17-21.

[3] Park & Burgess, *Op. Cit.*, Hurd, *Op. Cit.*, Hoyt, *Op. Cit.*, Harris & Ullman, *Op. Cit.*

[4] Alonso, *Op. Cit.*, Wingo, *Op. Cit.*, Hoover, *Op. Cit.*

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The use of factor analysis in this study has two general purposes, practical and methodological. The practical purpose is to reduce a set of interrelated measures to a smaller number of uncorrelated dimensions that can serve as dependent and independent variables. The methodological purpose is to follow closely the traditional approach of factorial ecology and produce an urban structure variable based on that methodology. This study, therefore, becomes another test of that methodology. Furthermore, the results of tests carried out on the urban structure variable can be viewed as applicable to a wide range of other studies which have used similar methodology.

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CHAPTER III

DATA

The major sources for this study were the 1951 and 1961 Canadian Census Reports for Montreal. To this was added information from the Montreal City Planning Department such as data on census tract centroids and peak land value intersection location.

Because of changes in census tract boundaries between 1951 and 1961, it was necessary to group certain tracts in order to maintain comparable units for both time periods. After this areal standardization process, the number of units remaining was 292. A reference code of local place names and problem characteristics can be found in Appendix A.

The attributes for these 292 areal units were also collected to be comparable for the two temporal base points. They were further selected to be representative of a cross-section of information on residential population: age distribution, marital status, ethnic origin, religion, schooling, house-

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hold characteristics and occupational structure. The use of residential as opposed to other urban characteristics to typify urban ecological structure follows the traditional methodological approach in this field. In reviewing work on the spatial structure of cities, Schnore notes, in reference to the dependent variable, that,

> None of these writers sets out to explain the total pattern of land uses. Although the amount of detail varies from study to study, each author discusses changing patterns of residential distribution. For this reason we may take the phenomenon as the dependent variable that is common to all reports.[1]

Urban Structure

Availability at both time periods is an important consideration for the inclusion of particular attributes in this study. More important, however, is the attempt to follow the cross-sectional information utilized in previous studies in the United

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[1] Schnore. Op. Cit., p. 361.

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States and one in Canada. Among such studies using multivariate techniques, the number of variables incorporated range widely from 20 to 110. The range in recent years has risen rapidly with data availability and handling capacity of computers. This increase in range, however, does not seem to be related to any marked change in results. This study has followed a middle ground selecting 89 census tract attributes from the seven traditional categories noted above and listed in Murdie.[1] To this is added a linguistic category. This is an important addition since in Montreal's bicultural community differentiation is most clearly expressed in language.[2] A final category of attributes, typical of recent urban ecological studies was also added, physical characteristics of residential structure. This addition included such attributes as single detached dwellings, furnace heat and conveniences.

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[1] Murdie. Op. Cit.

[2] Royal Commission Report on Biculturalism and Bilingualism in Canada. (Ottawa: Queen's Printer, 1966).

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All data were available in the 1951 and 1961 Canadian Census of Metropolitan Areas. At this point it is important to note some of the differences between the United States and Canadian definitions of Metropolitan Areas. In the U.S., studies commonly rely on the Standard Metropolitan Statistical Area which includes not only a large central city but a substantial portion of a city's commuting shed. Much of the outer area of this shed is substantially agricultural in character. The Canadian Census is less ambitious. In U.S. terms the Canadian definition would include the central city, and suburbs, but not as large a portion of the fringe area.

With regard to the urban structure attributes utilized, it is clear that the reasonably wide coverage is not complete. Further, the general coverage of the data used reflects the number and kinds of attributes available in the census tract bulletins. Despite attempts to generalize and reduce the preponderence of occupational divisions it is clear that employment characteristics comprise the largest number of attributes with household characteristics and occupancy rates a strong second. Data limitations were related primarily to lack of detail in age and income breakdowns for both periods.

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Detailed explanations of census terms are available in the published census volumes. Attributes which may be subject to misinterpretation and those individually included for very specific reasons, together with a full listing of all attributes, can be found in Appendix B. Problems and sources of error in small area data are outlined in many census bulletins but a short review can be found in Murdie and Stone.[1] Basically these reviews cover such problems as error in sampling, coverage, response and processing. Although the reliability of small area data is usually less than aggregated data, for some of the reasons noted above, the range of error in Canadian Census data does not seem to be greater than that utilized in previous U.S. studies. Similar conclusions were reached by I. Fellegi.[2]

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[1] Murdie. Op. Cit., Appendix C., p. 187. L. Stone. Canadian Urban Development. Census Monograph. (Ottawa: Queen's Printers, 1966).

[2] I. Fellegi. "Urban and Regional Statistics." Unpublished paper. (Annual Meetings, Canadian Association of Geographers, Ottawa, May 31, 1967).

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A final point should be made regarding the form of urban structure data. Wherever possible the census tract attributes are transformed into percentage values which is typical of most studies in this field.

Urban Distribution

Since little theory and no previous empirical work exists on the relationship between distribution and urban structure, no information exists on which distribution characteristics are most important in the description of urban structure. As far as possible the same attributes utilized in the derivation of urban structure are used in the development of the urban distribution dimensions. Although the form of these attributes are quite different, no additional definition information other than that provided for the urban structure attributes, will be needed for interpretation. The two computational procedures basic to the new form of these attributes should be outlined.

I. For the "Proportion of M.A. 'i' in C.T." where "i" stands for some attribute of

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interest, the computation was as follows:

a. Calculate the total amount of "i" in the Montreal metropolitan area

b. Calculate the proportion of the metropolitan area's "i" in census tract "j"

c. Repeat for all census tracts such that "j" equals "N", the number of tracts minus one.

In a similar manner to a location quotient for industry this procedure provides a measure of relative locational concentration in urban space.

II. For the "Ratio of C.T./M.A. 'h' to C.T./M.A. 'i'" where "h" and "i" are attributes of interest, the computation was as follows:

a. Calculate the location measure as noted above for "h" and for "i"

b. Calculate the ratio of the relative distributions of "h" to "i" for census tract "j"

c. Repeat for all census tracts such that "j" equals "N", the number of tracts minus one.

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This is then a measure of the variation of two relative distributions in urban space. This approach does not take into account the absolute measure of an attribute or the ratio between two absolute measures but rather uses the definition of the urban system to be studied (the metropolitan area) and takes into account the concentration or dispersion of an attribute relative to the amount of that attribute available in the system to be so distributed. Thus, it has been labelled a measure of the attribute distribution within the urban system or an attribute's urban distribution. A full listing of the distribution measures are available in Appendix C.

The main consideration for the reduction in the number of distribution measures (75) from the number of measures (89) used in the structure analysis is that a few of the structure attributes were in absolute or ratio's of absolute numbers. By not including such attributes the amount of autocorrelation built into the relationship between structure and distribution is reduced. Furthermore, two

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types of distribution attributes, location quotients and ratios of location quotients are used in a similar manner as absolute values, and ratios or percentages values in the urban structure analysis. The purpose of this mixture is to avoid "building in" correlations with a closed number system.[1] This basic problem will be discussed later with particular reference to the urban structure factor analysis. Since all data are normalized and standardized there should be no problem of incompatability of number systems.

Spatial Change

Data on structure and distribution change is derived directly from the structure and distribution dimensions. By subtracting the factor score in 1951 for a given areal unit on a given factor from the factor score in 1961 for the same areal unit and the same factor a measure of change is produced. Since the areal units are the same for both periods variations are introduced at one of two levels. One

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[1] W.C. Krumbein. "Open and Closed Number Systems in Stratographic Mapping." Bulletin of American Association of Petroleum Geologists. Vol. 46 (1964), pp. 2229-2246.

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in the absolute value of these loadings would be indicated by a product moment correlation. In short, the estimation of compositional change is linked to a series of serious problems. As a consequence the isolation of spatial change is an extremely delicate issue. Within the context of the present study an important assumption is made. Once the stability of factors have been established through invariance analysis, compositional change is assumed to occur at random throughout the factor. In this way any variation in weight of an areal unit (change in factor score) on a factor is considered a function of spatial change of that factor. It is then reasonable to subtract the factor scores in 1951 and 1961 to determine the change in spatial distribution of a given factor. It is the pattern of spatial change that is a major concern in this study. The tests noted above, however, do provide important evidence of the relative need of the aforementioned assumption.

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Areal Units

The application of factor analysis assumes certain characteristics of the data. One assumption is that each data unit is of equal weight or importance hence census tract "i's" attributes are of equal importance as census tract "j's" attributes. Since we are using residential population measures, the Dominion Bureau of Statistics adjustment of census tract boundaries to produce as great residential population equity as possible goes a long way in meeting this requirement. Despite this, however, certain major discrepancies do exist. The spatial extent of the areal units utilized are highly variable and the size of the residential population in these units can also vary substantially. To some extent the size of areal units compensate for the variation in urban density with the smallest areal units in the urban core areas of greatest residential density and the largest units in low density suburbs. Furthermore, it is recognized

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that most census tract data underestimates lower status groups and their attributes especially as measured in absolute terms.[1] These problems, however, should be partially overcome in the use of relative measures as applied in the urban distribution approach.

The standardization of areal units and data to be compatible at both points in time and the normalization procedure incorporated into the factor analysis sequence are all intended to increase the data comparability and reduce "noise" in the analysis. Although some feel these adjustments are not entirely necessary,[2] others

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[1] J. Meyers. "Note on the Homogeneity of Census Tracts: A Methodological Problem in Urban Ecological Research." Social Forces. (May, 1954).

[2] F.L. Sweetzer. "Factor Structure as Ecological Structure in Helsinki and Boston." Acta Sociologica. Vol. 8 (1964), pp. 205-225. F.L. Sweetzer. "Ecological Factors in Metropolitan Zones and Sectors." Paper presented at the Symposium on Quantitative Ecological Analysis in the Social Sciences. Evian, France, (September, 12-16, 1966). Murdie (1969), Op. Cit., pp. 65-68.

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feel they are useful precautions.[1]

Technical Considerations

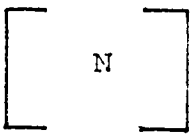
For all factor analyses, the following steps were carried out:

1) attributes

locations

Matrix G, basic data matrix, of dimensions 292 standardized study areas by area attributes.

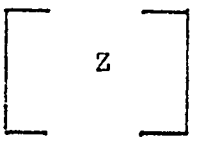
2) attributes



locations

Matrix N, normalized data matrix, same dimensions as 1, attributes transformed to be as near normal as possible. Transformations utilized are found in Appendix D.

3) attributes



locations

Matrix Z, standardized data matrix, such that mean = 0 and variance = 1, same dimensions as 1 and 2.

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[1] Pedersen. (1967). Op. Cit.

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4) attributes

$$\begin{bmatrix} R \end{bmatrix}$$

attributes

Matrix R, the zero-order intercorrelation matrix, dimension of attributes by attributes.

5) attribute factors

$$\begin{bmatrix} F \end{bmatrix}$$

attributes

Matrix F, factor loading matrix, resulting from principal component analysis, significant dimensions with $\lambda > 1$ and percent explained variance $> 5\%$, dimensions of attributes by attribute factors.

6) rotated factors

$$\begin{bmatrix} F_v \end{bmatrix}$$

attributes

Matrix F_v, rotated factor loadings using an orthogonal "varimax" solution.

7) rotated factors

$$\begin{bmatrix} S \end{bmatrix}$$

locations

Matrix S, normalized factor scores, dimensions 292 study areas by significant rotated attribute factors.

Since the factors which result from these techniques are not independent of the number and type of attributes used, some important considerations

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should be made explicit. The attributes selected, as noted previously, were intended to be representative of a cross-section of residential population data. Such a selection is under two constraints. The first is data availability and the second is comparability, both with data for earlier time periods and with other studies such that the results of this study may be thought of as affirming, rejecting or building on previous research. Furthermore, there are major problems in the use of a percentage versus an aggregate type of attribute. In the case of percentages certain aspects of size are neglected and there is the danger of "building in" correlations through the creation of a "closed number system."[1] This study has attempted to offset this in two ways. The first is by the liberal use of ratios which obviously have no real upper or lower limits and the second is by normalizing all data before factor analysis procedures. In this way, the "closed number problem" is neutralized.

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[1] Krumbein, Op. Cit.

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Many approaches to factor labelling have been developed. The approach incorporated here is purely descriptive. It is simply an attempt to efficiently represent the attributes that group together. Attempts have been made to minimize the explosion of factor labels by noting any similarity in attribute grouping with other studies and, where appropriate, utilize these previously defined labels. Obviously, this is only possible where the attribute groups are similar.

In general, the factor matrices represent a reduction from one-fifth to one-seventh of the original variable matrices. This reduction may be slightly increased or reduced depending on how the "communality problem" is handled. The higher the common variation among the attributes, the greater the reduction of the original variable matrix. If it is expected that the variation for each attribute will be explained by its covariability with the rest of the attributes used in the analysis (no uniqueness in variation for the attributes is suspected), then the use of "one" in the principal diagonal is reasonable. Cattell, however, notes that this is the absolute upper limit of data

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expectations.[1] L.J. King points out that the square of the multiple regression of one attribute with all other attributes has been favoured in geography.[2] Cattell, however, claims that this is the lower limit of expectations and that a more accurate communality estimate would be between the squared multiple regression of a given attribute with all others and unity.[3]

This deals with the "communality problem" by doing factor analysis with both the square multiple regression coefficient in the diagonal and unity in the diagonal. The results indicate that the effects of these changes were felt on the amount of explained variance for factors but were immaterial in their

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1 R.B. Cattell. "Factor Analysis: An Introduction to Essential I and II." Biometrics. Vol. 21 (1965), pp. 197-200.

2 L.J. King, Statistical Analysis in Geography. (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1969), p. 186. This is not completely true, note particularly the work of B.J.L. Berry (1966), Op. Cit.

3 Extensive discussion of the "communality problem" can be found in Cattell (1965), Op. Cit. and H.H. Harmon, Modern Factor Analysis (Chicago: University of Chicago Press, 1960), Chap. 5.

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effect on the attribute groupings for the factors *per se*. This is particularly true prior to varimax rotation for simple structure. The difference produced by the two methods of solving the communality problem (prior to rotation) was insignificant (i.e., extremely small). It is suspected that the best "rough cut" method of solving the problem is implied by Cattell's definition of the upper and lower limits. This is to "split the difference" between the squared multiple regression coefficient and unity for each attribute along the main diagonal. A more appropriate method is Guttman's image analysis.[1] All of these methods have particular problems associated with them.[2] It was decided, therefore, that the more traditional though extreme expectation of no unique variation should be used (i.e., unity in the principal diagonal). Although there are many other good reasons for the use of ones in the diagonal, the consequence of the selection of this solution to the communality

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[1] L. Guttman. "Image Theory of the Structure of Quantitative Variates." *Psychometrika*. Vol. 18 (1953), pp. 277-296.

[2] J.C. Nunnally. *Psychometric Theory*. (New York, N.Y.: McGraw Hill, 1967), pp. 348-355.

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problem rather than the squared multiple regression coefficient, as noted above, appears in this case to be insignificant. (See Appendix E).

Once an orthogonal factor analysis was completed for the urban structure of Montreal in 1951 and 1961, an important problem had to be faced. If the factors were to represent "natural" ecological dimensions, why should the constraint of orthogonality be placed on their identification? Might not these "natural" ecological dimensions be correlated with each other? This problem is not unique to this study. In fact, it has plagued most work in factor analysis and has become increasingly important as this technique has been utilized for theoretical exploration in the social sciences.[1] Why should we expect factors, supposedly representative of a simple underlying structure, to be orthogonal? The results of most research in the behavioral and social sciences would tell us to expect the opposite.

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[1] R.J. Rummel. Dimensionality of National Project. Research Report No. 7, Understanding Factor Analysis; National Science Foundation Grant No. GS-1230. Mimeograph pp. 33-34.

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For this reason, an oblique (non-orthogonal) rotation was used to test the degree of independence of these ecological structure factors. This was a test of the real world representativeness of these ecological dimensions.

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CHAPTER IV

Hypotheses

As noted previously the first step of this analysis is the identification of the dependent variable, urban ecological structure. Before this step a series of hypotheses stemming from theory and from previous studies can be outlined.

Social area analysis has indicated that the three most important indexes to expect in the description of any modern social system are social rank, urbanization and segregation.[1] These indexes have been operationalized from other studies as economic status, family status and ethnic difference.[2] The attributes that typify these indexes can also be defined. Economic status is usually

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[1] E. Shevky and M. Williams. The Social Areas of Los Angeles. (Berkeley: The University of California Press, 1949).

[2] Shevky and Bell. Op. Cit., p. 5.

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composed of income, occupation and educational characteristics. Family status is usually related to female labour force participation, suburban-type housing (single detached), high non-labour force to labour force dependency ratio and children. Ethnic difference has been related traditionally to minority groups (ethnic and/or religious) of various kinds. Although social area analysis says little about other social system characteristics, previous studies have usually identified other factors in addition to those indicated. These other factors are usually less general. Two other factors will be postulated based on specific knowledge of Montreal.

From knowledge of the importance of bilingualism in Montreal the author would expect a fourth factor which would take this aspect of urban differentiation into account. The fifth factor would be expected to differentiate the rapid growth characteristics within the city. The expectation that this factor may appear is strenghtened by the findings of similar research into the urban structure of another rapidly growing Canadian city, Toronto.

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It is, therefore, hypothesized that three major factors of a highly generalized character will be identified. In their order of importance they will be economic status, family status, and ethnic difference. The next two factors will be of a more specialized nature and in order of importance they will be a bilingual or bicultural factor and a recent growth factor. The composition of these factors is expected to follow the traditional lines as noted above.

Method

As indicated previously, a principal axis-factor analysis was carried out for the Montreal study area for 1951 and 1961. A summary of these results is outlined below (See Table 4.1). Although the order in which the principal components and rotated factors occurred has been adjusted for compatability, their original ordering can be deduced by comparing the rank-order of eigenvalues. The larger the eigenvalue and incidently the explained variance, the higher the original rank-order of the factor.

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Table 4.1

Summary of Principal Axis 1961[1]

	FACTORS[2]				
	I	II	III	IV	V
Eigenvalue	22.83	11.52	8.60	6.42	5.14
% Common variance	25.65	12.94	9.66	7.21	5.78
Cumulative explained	25.65	38.59	48.25	55.46	61.24

Trace of 89.0% was extracted by 18 roots > 1

Summary of Principal Axis 1951[1]

	FACTORS[3]				
	I	II	III	IV	V
Eigenvalue	21.82	8.09	4.63	5.96	9.43
% Common variance	24.52	9.09	5.19	6.70	10.60
Cumulative explained	24.52	33.61	38.80	45.50	56.10

Trace of 89.0% was extracted by 18 roots > 1

---

[1] Cut off value for factor listings was > 5% common variance or root > 1 whichever came first.

[2] Factor identification and labelling will be discussed later.

[3] Listed to be compatible with the 1961 ordering of factors.

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The principal axis components were then adjusted by Kaiser's varimax rotation procedure.[1] The purpose of this rotation is to obtain an approximation of Thurstone's "simple structure" in order to aid the interpretation of the factorial dimensions.[2] It may be noted that this rotation has resulted in a decline of the "cumulative explained" variance. This is not unexpected since the purpose of such a rotation is not to identify but to simplify the structure once the basic dimensions have been found. This is accomplished by minimizing the variance on all factors simultaneously rather than sequentially as in the principal-axis solution.[3] As Harley and Cattell have pointed out, however, it is also necessary to manually compare the principal-axis and varimax solutions

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1 H.F. Kaiser. "Computer Program for Varimax Rotation in Factor Analysis." Educational and Psychological Measurement. Vol. 19 (1959), pp. 413-420.

2 L.L. Thurstone. Multiple-Factor Analysis. (Chicago: University of Chicago Press, 1947), Chap. 14.

1 D.J. Veldman. Fortran Programming for the Behavioral Sciences. (New York, N.Y.: Holt, Rinehart & Winston, 1967), pp. 213-214.

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to be sure that varimax has resulted in a structure simplification.[1] This is necessary since varimax rotation may produce a solution which does not simplify the principal-axis structure. The summary results of the varimax rotation are outlined below (See Table 4.2). The rotated factors have been reordered for compatability in a similar manner to the principal-axis components.

The stability of the factor structure was tested by using an invariance technique.[2] This technique maps the two n-dimensional attribute matrices into each other and compares them by calculating the cosines between the factor vectors. The resultant matrix of cosines for orthogonal data may be interpreted as the correlation between the factors derived from the two

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[1] J.R. Harley & R.B. Cattell. "The Procrustes Program: Producing Direct Rotation to Test a Hypothesized Factor Structure." Behavioral Science. Vol. 7 (1962), p. 260.

[2] H.F. Kaiser. "Relating Factors between Studies Based Upon Different Individuals." unpublished manuscript, University of Illinois, 1960.

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Table 4.2

Summary of Rotated Factors 1961[1]

	FACTORS				
	I	II	III	IV	V
% Common variance	23.22	11.40	8.01	7.13	6.58
Cumulative explained	23.22	34.62	42.63	49.76	56.34

Summary of Rotated Factors 1951[1]

	FACTORS[2]				
	I	II	III	IV	V
% Common variance	21.37	8.17	8.07	5.11	8.09
Cumulative explained	21.37	29.54	37.61	42.72	50.81

---

[1] Varimax rotation is carried out to make factor interpretation easier by decreasing the multi-dimensionality of factors. Veldman (1961), Op. Cit., pp. 236-240.

[2] Listed to be compatible with the 1961 ordering of factors.

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original factor analyses.[1] The results of this procedure indicates by cosine comparison the stability of the factors from 1951 to 1961 (See Table 4.3). From the above procedures, it is clear that the factor structures are extremely stable in the two periods ranging from a minimum of .742 to a maximum similarity of .976.[2] Since the factor structure is an aggregate measure of the attribute loadings a listing of the cosines between the individual attribute vectors gives a more detailed analysis of structure similarity between the two periods (See Table 4.4).

The next major problem to be considered in identification of the fundamental urban ecological structure is orthogonality. The reasonably invariant structure which has been developed is

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[1] Veldman (1967), Op. Cit., pp. 236-242, and S.R. Pinneau and A. Newhouse. "Measures of Invariance and Compatability in Factor Analysis for Fixed Variables." Psychometrika. Vol. 29 (Sept., 1964), pp. 271-281.

[2] 1.0 being a measure of perfect similarity.

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Table 4.3

Factor Cosine Similarity Matrix 1951 x 1961[1]

1951 FACTORS		1961 FACTORS I	II	III	IV	V
FACTORS	I	.976	.137	-.043	.020	.134
	II	-.195	.802	-.023	.093	.377
	III	.064	.175	.742	-.003	.081
	IV	-.005	-.014	.019	.897	.093
	V	.044	.428	.149	.006	-.824

[1] This matrix of cosines for orthogonal data may be interpreted as the correlation between attribute factors derived from the two analyses. D.J. Veldman. Fortran Programming for the Behavioral Sciences. (New York, N.Y.: Holt, Rinehart & Winston, 1961), p. 237, and Rummel (1965), Op. Cit., pp. 30-32.

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Table 4.4

1951/1961 Cosine Similarity Listing of Urban Structure Attributes

1	2	3	4	5	6	7	8	9	10
.8031	.0063	.9692	.0534	.4875	.7212	.7815	.8362	.5481	.4027
11	12	13	14	15	16	17	18	19	20
.4638	.7522	.9058	.6299	.3024	.2488	.0518	.8454	.7540	.9014
21	22	23	24	25	26	27	28	29	30
.2432	.6486	.2399	.6819	.3325	.7371	.4835	.7878	.8423	.5607
31	32	33	34	35	36	37	38	39	40
.7189	.9227	.8616	.7772	.8902	.7641	.8447	.8893	.7432	.6711
41	42	43	44	45	46	47	48	49	50
.7869	.7295	.7979	.7826	.7762	.6392	.8383	.0041	.8020	.5262
51	52	53	54	55	56	57	58	59	60
.8257	.7228	.8111	.5465	.5427	.4199	.2341	.7842	.7792	.7540
61	62	63	64	65	66	67	68	69	70
.4631	.5854	.8008	.8122	.6572	.5327	.7599	.7062	.5904	.7497
71	72	73	74	75	76	77	78	79	80
.7974	.8945	.9507	.7365	.3644	.7424	.7919	.8247	.8363	.9204
81	82	83	84	85	86	87	88	89	
.7384	.7582	.7627	.8814	.6626	.3550	.3599	.7751	.5831	

orthogonal in character, i.e., each factor is mathematically independent of each other factor. This requirement is a mathematical artifact imposed on the data for the purpose of solution ease. The problem is to what degree is the orthogonality requirement an artificial imposition? To answer this question, an oblique rotation to a simple structure solution (Oblimin) was utilized for both time periods.[1] Since an oblique solution does not require orthogonality among its factors, each factor may be correlated with each other factor. The level of intercorrelation among factors indicates the degree to which orthogonality was superimposed by the first solution method. It should be noted that it is the simple structure oblique solution (Oblimin) that is utilized here

---

[1] J. Carroll. "Biquartimin Criterion for Rotation to Oblique Simple Structure in Factor Analysis." Science. Vol. 126, (November, 1957), pp. 1114-1115, and _____. "Computer Applications in the Investigation of Models in Educational Research." Proceedings of the Harvard Symposium on Digital Computers. No. 31, (1961), pp. 48-58.

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and not the direct oblique solution of the principal dimensions.[1]

A correlation analysis of the varimax and oblimin attribute loadings indicates a great similarity between the factors resulting from both procedures. (See Table 4.5). An intercorrelation matrix of the oblimin factors was then developed for each time period (See Table 4.6). From the results of these intercorrelation matrices, it is clear that orthogonality is not a major problem and that the factors are themselves basically orthogonal to each other even though they are not required to be by the solution technique (oblique rotation). It seems reasonable, therefore, to argue that, in this case, the results of the previous solution may be taken as representative of the basic urban ecological structure since neither orthogonality nor factorial composition differentiates the solutions.

---

[1] R.I. Jennrich & P.F. Sampson. "Rotation for Simple Loadings," Psychometrika. Vol. 31 (1966), pp. 313-323, and R.K. Semple, "An Oblique 'Simple Structure' Factor Analysis of Viability Measures for Southern Ontario Towns," University of Toronto, Dept. of Geography, Discussion Paper Series, No. 2 (Oct, 1969).

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Table 4.5

Intercorrelation of Attribute Loadings

Varimax by Oblimin 1961, 1951

1961

OBLIMIN

VARIMAX		I	II	III	IV	V
	I	.951	.109	.143	.033	.096
	II	.093	.948	.065	.176	.076
	III	.127	.059	.904	.149	.182
	IV	.030	.024	.197	.948	.031
	V	.336	.046	.125	.152	.810

1951

OBLIMIN

VARIMAX		I	II	III	IV	V
	I	.842	.112	.145	.196	.134
	II	.128	.965	.041	.009	.283
	III	.125	.070	.702	.062	.042
	IV	.058	.030	.212	.991	.078
	V	.073	.280	.182	.088	.988

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Table 4.6

Intercorrelation of Oblimin (oblique)

Rotation Analysis 1961, 1951

	1961 OBLIQUE FACTORS[1]				
1961 Oblique Factors	I	II	III	IV	V
I	1.000				
II	.230	1.000			
III	.129	-.003	1.000		
IV	.149	-.046	.128	1.000	
V	-.012	.085	-.109	-.049	1.000

---

[1] The intercorrelation for oblique factors was taken to ten and the highest intercorrelation value (diagonal excluded) was -.320 between factors I and VII; the next highest value was .240 (II and X) while a majority of intercorrelation values in the 10x10 matrix were below .100. This matrix of cosines may be interpreted as a measure of pattern similarity among the factors, in the same way as correlation coefficients. Rummel. (1965), Op. Cit., pp., 30-32.

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Table 4.6 (continued)

1951 OBLIQUE FACTORS[1]

1951 Oblique Factors	I	II	III	IV	V
I	1.000				
II	-.058	1.000			
III	-.090	-.024	1.000		
IV	-.016	-.006	.054	1.000	
V	.212	.211	.020	.004	1.000

---

[1] This intercorrelation was carried out for oblique factors. The highest intercorrelation value (diagonals excluded) was -.349 between factors I and IX; the next highest value was between -.264 (I and VIII) while a majority of the intercorrelation values in the 10x10 matrix were below .100. This matrix of cosines may be interpreted as a measure of pattern similarity in the same way as correlation coefficients. Rummel. (1965), Op. Cit., pp. 30-32.

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The varimax structure, therefore, will be used in this paper as the operational definition of urban ecological structure.

This operational definition seems reasonably stable for both technical and temporal considerations. Technically, the structure meets the basic orthogonality requirement whether by varimax or oblimin solution. Furthermore, it is not sensitive to alternative methods of solving the communality problem (See Appendix E). Temporally the results seem reasonably invariant for the time periods of interest, but it is likely, though unproven, that this invariance will degenerate over the long run as individual attributes change their functional relationship to each other.

The results of this operational definition are easily interpreted. Two aspects of these results are of major consideration here. The first is the distribution of factor loadings among the attributes. The second is the distribution of factor scores among the locational elements. It is this second aspect of urban ecological structure, the spatial aspect, that will be the primary topic of the following chapters.

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Factor Composition

The attribute composition of the various factors may be used to characterize the basic urban ecological dimensions. The attribute composition of the factors is indicated by the attribute loadings on each factor. Using the highest loadings, it is possible to describe and label each factor.

Factor I accounted for 21.37% of the total common variance in 1951 and 23.22% in 1961. The composition of this factor is similar at both periods (.976). Positive loadings are indicated in both periods for management occupations, professional and technical occupations, upper level occupations (class 1), eleventh grade plus education, British, German and Dutch origin population, English speaking population, Anglican religion, and earnings of over $4000 per year. Negative loadings are indicated for labourers in the labour force, earnings of under $4000 per year, lower level occupations (class 2), below high school education, Roman Catholic religion, French origin and French speaking population.

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Table 4.7

FACTOR 1[1] - Socio-economic Status[2]

	Attribute List[3]	Loadings 1951	Loadings 1961
* 9	% of population of British origin	851	860
* 11	Ratio of British origin to French origin	865	851
* 14	% of population speaking English only	819	815
* 20	% of population Roman Catholic	-800	-839
* 38	Ratio of French workers Class 1 to Class 2	816	840
* 39	% of wage-earners earning over $4000	859	571
* 80	% of population Anglican	876	893
34	% of Labour Force Class 1	533	813
35	% of Labour Force Class 2	-715	-801
37	Ratio of male workers Class 1 to Class 2	722	815
* 72	% of population not attending school with 3 years high school and up	784	866
73	Proportion not attending school with less than 9 years of education	-741	-802
10	% of population of French origin	-760	-728

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Table 4.7 (Continued)

	Attribute List	Loadings 1951	Loadings 1961
* 15	% of population speaking French only	-784	-752
* 17	Ratio of English to French speaking only	796	791
32	% of Labour Force Managers	727	784
36	% of Labour Force Labourers	-705	-629
40	% of Labour Force earning under $4000	-702	-611
* 41	Ratio of Males earning under $4000 to over $4000	760	751
42	Ratio of Females earning under $4000 to over $4000	737	806
* 76	% of population from the Netherlands	771	768
84	Ratio of Anglican to Roman Catholic	793	726
74	% of population German	660	794
64	% of the Dwellings with Furnace Heat	602	703
33	% of Labour Force Professional and Technical	661	764
22	Ratio of attending school to no education (population)	540	574

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Table 4.7 (Continued)

Attribute List		Loadings 1951	Loadings 1961
57	Ratio of cars to dwellings occupied over 6 years (affluence-stability measure)	510	-011
63	Ratio of cars to families	597	614
83	% of population Lutheran	574	727
21	% of population over 5 years with no education	-195	-534

* Over .750 in both periods (1951 and 1961)

---

[1] Factor order based on 1961 order of explained variance: 1951 factors are made compatible.

[2] All attributes with a .500 or greater correlation with factor I are listed.

[3] Occupation, education, income and major linguistic and ethnic groups.

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Table 4.8

Internal Structure of the Montreal

Socio-Economic Status Factor

(+)		(-)
English Speaking		French Speaking
British, Dutch, German origin		French Origin
Anglican		Roman Catholic
High	Income	Low
High Skill	Occupation	Low Skill
Upper Level	Education	Lower Level

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Such opposing loadings on education, income and occupation are typical of the social status factor. The loadings on major ethnic and religious differences, however, are not typical of the North American socio-economic status factors. One precedent for these results can be found in Sweetzer's work on Helsinki in which he noted that the two major ethnic groups (Finns and Swedes) loaded on the basic social status dimension.[1]

Factor II accounted for 8.17% of the total common variance in 1951 and 11.40% in 1961. The composition of this factor is also similar for both periods (.802). Positive loadings occur on predominantly male labour force, young population, high dependency ratio, single detached dwellings, and owner occupied dwellings with a mortgage. Negative loadings were on females in the labour force, percent of the labour force female and single child families. The actual label for this factor is not clear because of the indeterminant labelling situation in the literature. This group

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[1] F.L. Sweetzer. "Factorial Ecology: Helsinki, 1960." Demography II (1965), pp. 372-382.

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Table 4.9

FACTOR II - Family Status[1]

	Attribute List[2]	Loadings 1951	Loadings 1961
* 70	% of Females in Labour Force	-860	-764
* 23	Labour Force male-female ratio	822	671
* 5	% of population young (under 15)	742	849
89	Proportion of owner-occupied dwellings with a mortgage	276	750
68	% of dwellings owner-occupied with mortgage	358	743
52	% of dwellings single detached	488	732
* 3	Ratio of dependents to others	723	731
24	% of Labour Force female	-612	-650
44	Ratio of families per dwellings	676	623
34	% of Labour Force Class 1	-551	-130
47	Ratio of one child families to all families	-586	-374

* Over .650 for both periods (1951 and 1961)

---

[1] Low % of Females in the labour force, young population, high dependent ratio, single detached dwellings and mortgaged owner-occupied.

[2] All attributes with a correlation of .500 or greater with Factor II are listed.

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of loadings has been referred to as urbanization, family status, suburbanization, or life-cycle status depending on the particular researcher. All these labels refer to the same basic groupings of attributes that is represented here. The group is arbitrarily labelled family status as this is the most general label and one which implies the family aspect of life-cycle stages. Family formation is often associated with suburbanization of "middle class" North American urban dwellers.[1]

Factor III accounted for 8.07% of the total common variance in 1951 and 8.01% in 1961. The composition of this factor is the least invariant (.742). Positively loaded attributes include small families, high occupance rates, high physical quality of dwellings as measured in conveniences (bath, shower, flush toilet), and short occupancy periods. This factor is typical of recent growth a fact indicated particularly by the number of dwelling units occupied for less than two years

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[1] B.J.L. Berry & F.E. Horton. Geographic Perspectives on Urban Systems: Text and Readings. (Englewood Cliffs, N.J.: Prentice-Hall, Inc., Forthcoming), Chapter 10.

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Table 4.10

FACTOR III - Recent Growth Status[1]

	Attribute List[2]	Loadings 1951	Loadings 1961
* 43	Ratio of occupied to unoccupied dwellings	842	810
* 45	Ratio of family H.H. to non-family H.H.	834	860
* 49	Ratio of zero child families to all families	763	882
55	% of dwellings occupied less than 2 years	794	571
47	Ratio of one child families to all families	475	759
60	% of dwellings with a car	522	358
89	Proportion of owner-occupied dwellings with a mortgage	680	218
87	Ratio of dwellings occupied less than 2 years to over 6 years	734	162
* 56	Ratio of all occupied dwellings to occupied 3 to 5 years	631	620
57	Ratio of cars to dwellings occupied over 6 years (affluence-stability measure)	629	126
69	% of total males in the Labour Force	055	554

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Table 4.10 (Continued)

Attribute List		Loadings 1951	Loadings 1961
58	% of dwellings with flush toilet	195	519
59	% of dwellings with shower or bath	303	503
62	Ratio of flush toilets to families	275	549

* Over .600 for both periods (1951 and 1961)

---

[1] Short dwelling occupancy, small families, occupance rate high, morgages, high physical quality of dwellings (high conveniences).

[2] All attributes with a correlation of .500 or greater with Factor III are listed.

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and the importance of zero child and one child families. This type of attribute distribution has been labelled as mobility status by Berry[1] and recent growth status by Murdie.[2] The label utilized by this study will be recent growth, since this indirectly implies certain specific types of mobility.

Factor IV is the simplest to identify. This is the minor ethnic status factor. Positive loadings on this factor include populations of Polish, Ukranian and minor European origins. Minority religions such as Greek Orthodox and Ukranian Catholic also load positively on this factor. On the other hand, the only negative attribute loading is the ethnic status of Montreal's French majority population (70%). This is the second most stable factor across both periods in terms of attribute composition (.897). This minor ethnic status factor accounts for 5.11% of the total common variance in 1951 and 7.13% in 1961.

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[1] Berry & Horton. Op. Cit., Chapter 10.

[2] Murdie. Op. Cit., pp. 102-107.

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Table 4.11

FACTOR IV - Minor Ethnic Status[1]

Attribute List[2]	Loadings 1951	Loadings 1961
* 77 % of population Polish	806	808
* 79 % of population Ukranian	891	677
78 % of population Minor European	261	693
* 81 % of population Greek Orthodox	730	813
* 82 % of population Ukranian (Greek) Catholic	826	679
13 % of population other European origin (other than French or English)	500	795
48 Ratio of 2+ family households to 1 family households	035	559
10 % of population of French origin	-368	½552
19 % of population Jewish religion	111	502

* Over .600 for both periods (1951 and 1961)

---

[1] Recent immigrant groups (Poles, Ukranians, Greeks, Minor Europeans) and minor immigrant religions (Ukranian Catholics, Greek Orthodox.)

[2] All attributes with a correlation of .500 or greater with Factor IV are listed.

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Table 4.12

FACTOR V[1] - Secondary Employment

and Household Factor[2]

Attribute List[3]		Loadings 1951	1961
* 29	Ratio of wage-earners to self-employed	857	763
* 67	Ratio of persons per room	815	849
* 71	Ratio of persons per dwelling	898	880
* 85	Ratio of females in Labour Force to dwellings occupied 6 years plus (Female employment to family spatial stability)	798	643
* 2	Ratio of old dependents to young dependents	692	747
31	Ratio of males wage-earners to self-employed	749	473

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Table 4.12 (Continued)

Attribute List	Loadings 1951	1961
30 Ratio of female wage-earners to self-employed	563	575
18 % of population speaking one language to both	718	578

* Over .600 in both periods (1951 and 1961)

---

[1] This factor reversed its loading orientation from negatives to positives between the two periods. It has been standardized as positive in both periods. Although there may be some interpretation to this "flip flop", it is likely only a data processing anomaly and should be disregarded since attribute weights on a continuum have been created and a reverse of these is immaterial as far as interpretation is concerned. Dr. George Carey, Prof. of Regional Planning, Dept. of Geography and Planning, Rutgers University, New Brunswick, N.J. "personal communication," March 14, 1969 (Quantitative Methods Symposium, American Statistical Association & American Geographical Society, New York, N.Y.)

[2] Employment characteristics of wage-earners and household characteristics of density, length of occupancy and dependency.

[3] All attributes with a correlation of .500 or greater with Factor V are listed.

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Factor V accounted for 8.09% of the total common variance in 1951 and 6.58% in 1961. The stability of Factor V as exhibited by the similarity of the two periods is reasonably strong (.824). This factor is characterized by positive loadings on wage-earners, high density of persons per dwelling, old age oriented dependency and unilingualism. This factor is similar to that found by Murdie. Following Murdie's label, this is a secondary employment and household factor.[1]

Summary

Using the traditional approach of urban factorial ecology, five basic urban dimensions have been identified: Socio-economic status, Family status, Recent growth, Minor ethnic status, and a Secondary employment and household factor. This is a reasonably stable, orthogonal representation of between 50-60% of the variation in structure of Montreal's basic urban space.

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[1] Murdie, Op. Cit., pp. 107-115.

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The basic hypotheses of social area analysis have been reasonably substantiated for Montreal. However, it is clear that the author's hypothesis concerning the development of a bicultural-bilingual factor in Montreal was an oversimplification of urban structure. Not only was such a factor not isolated, but the primary attributes needed to compose such a factor are highly intercorrelated with Montreal's socio-economic structure. From the vantage point of hind-sight this is not a completely new development. Sweetzer had similar results in his analysis of Helsinki where the Finns and Swedes, the two overwhelmingly dominant ethnic groups loaded on the social status dimension.[1] The development of the recent growth dimension occurred much as expected.

Hypotheses with regard to the order of factors were not, in the main, substantiated. As hypothesized, the most important factor was economic status. However, among the remaining factors a great deal of realignment, in terms of explained variance,

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[1] Sweetzer. Op. Cit.

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Table 4.13

Urban Structure Dimensions

Summary

Structure Factors

I. Socio-Economic Status

II. Family Status

III. Recent Growth Status

IV. Minor Ethnic Factor

V. Secondary Employment and Household Factor

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Table 4.14

Urban Structure

Intercorrelation of Attribute Loadings

1961

		I	II	III	IV	V
1	I	.844	.122	.044	.010	.114
9	II	.218	.956	.113	.199	.400
5	III	.125	.210	.703	.002	.082
1	IV	.083	.109	.100	.969	.209
	V	.057	.341	.160	.149	.896

Urban Structure

Intercorrelation of Factor Scores

1961

		I	II	III	IV	V
1	I	.951	.039	.069	.080	.021
9	II	.042	.798	.071	.086	.065
5	III	.033	.053	.724	.031	.036
1	IV	.051	.044	.019	.654	.016
	V	.038	.084	.177	.068	.897

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occurred between 1951 and 1961. The order in 1961 is much closer to the order postulated (Economic status, Family status, Ethnic difference) than that which occurred in 1951. Furthermore, by examining the change in attribute loadings between 1951 and 1961 it is clear that compositional adjustments of attributes occurred on some factors. This means that the analysis of spatial change on those factors will be less accurate since some of the change may be compositional as well as spatial. These results also imply that the assumption of randomness in compositional change is important if spatial change is to be examined in the manner suggested here.

Finally, a test of the internal consistency of the factors indicate that the structural dimensions are not as uni-dimensional as might be supposed. Further, the reliability of factor homogeneity in urban structure is not great (See Table 4.15).

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Table 4.15

Homogeneity of Urban Structure Attributes[1]

Structure Factors	Homogeneity[2] (rh) 1951	1961	Reliability of Homogeneity Difference Significant at
I	.67	.61	(NSD)*
II	.84	.78	(NSD)*
III	.75	.57	$p > .05$
IV	.83	.76	(NSD)*
V	.92	.84	$p > .08$

* no significant difference

---

[1] Only those attributes which loaded above .400 on a given factor were utilized.

[2] See Nunnally, Op. Cit., and R.H. Gaylord, "Estimating Test Reliability from the Item Test Correlations." Educational and Psychological Measurement. Vol. 29 (1969), pp. 303-304. The formulation for this statistic is given as:

$$rh = \frac{\bar{r}_{ij}}{\bar{r}_{it}^2}$$

where "i" and "j" are items and "t" is the test. See also Athanasiou, Op. Cit.

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CHAPTER V

URBAN DISTRIBUTION

In the previous chapter, a definition of urban ecological structure was established. It was demonstrated that this structure was "naturally" orthogonal and had reasonable temporal stability. These components or factors of urban structure do not seem to be unique. All of the components have been noted by urban ecologists and social area analysts elsewhere. Furthermore, many of the approaches to the identification of urban structure although different in detail from the approach used here, are, when taken in the large, quite similar. It is the distributional characteristics of this structure that are of major concern in this chapter.

Two spatial characteristics are of interest. The first is the relative distribution of urban attributes among the locational elements that comprise the fabric of Montreal's urban space. The relationship of these attribute distributions or groups of similar attribute distributions to the previously established urban structure

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dimensions will be the prime focus of this portion of the study. The second characteristic to be examined in the next chapter will deal with the patterns that result from the spatial arrangements of urban structure factors.

Distribution

The relative geographical concentration of an attribute in the Montreal Metropolitan Area (M.A.) is examined here in terms of a "location quotient" measure.[1] Berry used this method on a smaller scale in which location quotients of specific attributes were mixed with other measures of attribute levels similar to those used to define urban structure. Since little theory and no previous studies have indicated which distributional characteristics are of primary importance in the analysis of urban structure most attributes found in the urban structure analysis are utilized in the present examination.[2] However, this produces a rather

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[1] Berry and Horton. Op. Cit., Chapter 10.

[2] The purpose of the reduction from 89 to 75 attributes will be discussed later.

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large number of independent distributional variables. This large number of variables is reduced to basic distributional dimensions through the use of principal component and factor analysis.

The purpose of the approach here is to identify a set of distribution factors made up of attributes that have distributional characteristics that covary. The attributes utilized in this identification of the basic distribution characteristics are the same as those utilized in identification of the urban structure factors. The difference between these attributes is their form. The distribution attributes are basically in the form of location quotients. In carrying out this factor analysis on attribute distributional characteristics, an attempt was made to avoid building in autocorrelation between the original urban structure attributes and the urban distributional attributes by eliminating specific attributes which were in absolute terms in the structure analysis. This results in a reduction of fourteen attributes.

The use of factor analysis to reduce and orthogonalize large numbers of variables to primary dimensions is a common practice in the social

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sciences.[1] It allows for an efficient reduction in data sets with a minimum loss of information; furthermore, the orthogonalized summary dimensions may be treated as variables in more traditional analytic techniques.

Hypotheses

Urban distribution hypotheses cover two fundamental areas. The first is the factorial structure itself and the second is the relationship between the urban distribution factors and the previously defined structure factors. With regard to both these areas, however, the character of hypotheses are tenuous and exploratory.

What basic dimensions are likely to be identified in the principal factor analysis of attribute distributions? To answer this question it is necessary to first realize what is being analyzed. Since a factor represents a set of variables that covary, what is the variable? In this case the

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[1] Rummel. Op. Cit.

[2] Carey. Op. Cit.

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variable is not the attribute itself but its distribution. A set of distributions, therefore, are being grouped based on their level of covariance. Since the first factor represents the one with the greatest explained variance it seems reasonable to expect it to be typical of the most general distributional characteristics of the city. Similarly each succeeding factor represents more localized distributional characteristics. For example, in Montreal distribution factor one should be representative of the dominant culture and language characteristics which are widespread in the city. Furthermore, it should be typical of other widespread social characteristics. On the other hand, the successive factors will represent more rigidly segregated distributions such as the spatially concentrated minority ethnic and religious groups. More concrete expectations such as which factors are typical of basic distribution levels between these extremes or even the number of fundamental dimensions to be expected will have to await further investigation. However, a note on one of the basic reasons for carrying out this portion of the analysis may be useful. Attributes which

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are of primary importance in urban structure may not have a widespread spatial or distributional character and vice-versa. In this context a given minority group may be extremely important in urban structure but may have an extremely minor though unique role in terms of its own distribution in the urban environment. On the other hand, a widespread but randomly distributed minority group, would be a major distributional characteristic of a city, but may have a minor role in urban structure.

A second set of hypotheses suggests some relationships between urban structure and urban distribution. Without precisely defining urban distribution dimensions, it is difficult to define this relationship. The question this analysis attempts to answer is, which distribution dimension is most important (delivers the most explanation) to which urban structure dimension. Since there is clearly a relationship between structure and distribution it is hypothesized that factors with similar attribute composition will be most related to each other. However, a more important hypothesis is that one important distribution dimension will

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be closely related to decentralization or suburbanization characteristics. As noted previously, urban decentralization and dispersion seem to have been of major importance in Montreal in the 1951-1961 period. The notion of decreasing density in a period of rapid growth implies an important role for "suburbs" in the process of urban change. This is likely, therefore, to be reflected in the importance of a distribution dimension characterizing the suburbs. This final comment is even more vital in terms of change in urban structure.

Method

Seventy-five attributes in the form of "location quotient" measures were compared across 292 study areas. A principal component analysis of these attributes identified five distribution dimensions in 1951 and 1961 explaining 67.9% and 75.8% of the total common variance, respectively. These dimensions have been recorded to match similar factors in the summary outlined below (See Table 5.1). These dimensions were then rotated to simple structure via Kaiser's varimax method. The results were checked

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Table 5.1

Summary of Principal Axis 1961

	FACTORS				
	I	II	III	IV	V
Eigenvalue	26.52	13.79	7.02	5.44	4.10
% Common variance	35.36	18.38	9.37	7.25	5.47
Cumulative explained	35.36	53.74	63.11	70.36	75.83

Trace of 87.8% was extracted by 10 roots > 1

Summary of Principal Axis 1951

	FACTORS				
	I	II	III	IV	V
Eigenvalue	13.26	21.96	6.08	5.20	4.46
% Common variance	17.68	29.25	8.11	6.94	5.95
Cumulative explained	17.68	46.93	55.04	61.98	67.93

Trace of 81.0% was extracted by 10 roots > 1.4

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manually to ensure a simple structure solution had been developed. After a compatibility adjustment was carried out the rotated factors were outlined (See Table 5.2).

The rotated orthogonal factors are then compared to each other through time, 1951 and 1961. The cosine matrix of factor similarity for the two time periods indicates substantial invariance (See Table 5.3). This factorial invariance is even more remarkable when the similarity of individual attribute dimensions are compared for both periods (See Table 5.4). Furthermore, when the orthogonality problem was examined, the results were similar to those of the urban structure analysis. Even when an oblique simple structure was allowed the solution remained primarily orthogonal (See Table 5.5). However, like the urban structure analysis the cluster of attribute loadings for both the varimax and oblimin solutions are very similar (See Table 5.6). It would seem, therefore, that the varimax and oblimin solutions have produced basically the same results. For compatibility and convenience, the orthogonal varimax solution will be utilized, but it is clear from these observations that its

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Table 5.2

Summary of Rotated Factors 1961

	FACTORS				
	I	II	III	IV	V
% Common variance	25.73	18.81	7.75	6.73	13.26
Cumulative explained	25.73	44.54	52.29	59.02	72.28

Summary of Rotated Factors 1951

	FACTORS				
	I	II	III	IV	V
% Common variance	19.74	17.02	7.41	5.00	12.89
Cumulative explained	19.74	36.76	44.17	49.17	63.06

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Table 5.3

Factor Cosine Similarity Matrix 1951 x 1961

1951 \ 1961 FACTORS	I	II	III	IV	V
I	.987	.144	-.003	-.028	-.030
II	.137	-.949	-.098	-.024	-.079
III	.024	-.055	.961	.019	-.017
IV	-.038	.023	.029	-.978	.044
V	-.034	.192	-.114	-.025	-.812

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Table 5.4

1951/1961 Cosine Similarity Listing of Urban System Attributes

1	2	3	4	5	6	7	8	9	10
.9498	.7651	.8924	.8996	.9511	.8231	.9270	.9761	.9441	.9350
11	12	13	14	15	16	17	18	19	20
.9494	.6402	.9395	.9693	.9693	.9465	.9706	.7106	.8951	.9307
21	22	23	24	25	26	27	28	29	30
.9113	.6590	.9130	.9167	.7255	.8591	.7946	.9115	.8688	.7911
31	32	33	34	35	36	37	38	39	40
.8228	.9273	.8949	.9075	.9033	.9015	.8997	.9063	.8136	.9647
41	42	43	44	45	46	47	48	49	50
.8345	.6581	.6671	.6371	.0261	.0265	.8693	.8805	.9462	.8700
51	52	53	54	55	56	57	58	59	60
.8851	.9500	.9324	.9111	.7408	.8260	.8752	.9024	.4592	.6046
61	62	63	64	65	66	67	68	69	70
.8348	.9234	.9449	.8783	.8451	.7488	.8032	.8505	.8456	.9374
71	72	73	74	75					
.8250	.7704	.8832	.9439	.1948					

Table 5.5

Intercorrelation of Oblimin (oblique)
Rotation Analysis 1961, 1951[1]

1961 Oblique Factors	1961 OBLIQUE FACTORS I	II	III	IV	V
I	1.000				
II	.127	1.000			
III	-.099	.176	1.000		
IV	-.075	-.094	-.071	1.000	
V	.202	-.306	-.050	.225	1.000

1951 Oblique Factors	1951 OBLIQUE FACTORS I	II	III	IV	V
I	1.000				
II	.195	1.000			
III	.142	.051	1.000		
IV	.269	.130	-.025	1.000	
V	-.248	-.303	-.048	-.042	1.000

[1] This intercorrelation was carried out for oblique factors. The highest intercorrelation value (diagonals excluded) was -.431 between Factors I and IX in 1961 and between Factors II and V (-.303) in 1951 while in both periods a majority of the intercorrelation in the 10x10 matrices were below .100.

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Table 5.6

Intercorrelation of Attribute Loadings

Varimax by Oblimin 1961, 1951

1961

OBLIMIN

VARIMAX	I	II	III	IV	V
I	.947	.062	.166	.287	.186
II	.199	.633	.187	.381	.450
III	.071	.161	.912	.439	.211
IV	.276	.134	.365	.586	.175
V	.229	.164	.187	.117	.881

1951

OBLIMIN

VARIMAX	I	II	III	IV	V
I	.971	.195	.096	.117	.031
II	.184	.969	.239	.084	.310
III	.153	.190	.956	.234	.123
IV	.006	.069	.253	.944	.024
V	.142	.233	.001	.069	.832

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selection will not bias the remaining analysis.

Factor Composition

The first factor to be identified contained 19.7% and 25.7% of the common variance in 1951 and 1961 respectively. The cosine of factor similarity indicates the remarkable invariance between these two periods (.987). Positive loadings occur in both periods for the distribution of marital status (singles and marrieds), bilingualism, low wage-earners, age (young and old), Roman Catholic and French population. Further positive loadings occur in both periods for low education, apartment dwellings, dwelling occupancy of 2 years, and dwelling conveniences (flush toilets, bath and showers). These are only the more important attributes whose distributional characteristics are similar.

The wide range of attributes that have loaded on this factor require some explanation. Such a wide range is typical of what was once called general rather than group factors. Although this differentiation is no longer used, it was typical

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of Spearman's General-Factor solutions[1] and its extension by Holzinger into the Bifactor Method.[2] Simply, this differentiation is intended to identify factors which have strong to medium level loadings with all attributes and hence indicate wide commonality among all attributes. The group factor, on the other hand, is usually dominantly related only to a few attributes and indicates the unique aspects of a particular analysis. Identification of these differences has been sharply reduced in recent years by the increased use of simple structure solutions such as varimax. This makes the generality of the urban distribution Factor I even more remarkable.[3]

The mix of attributes that have loaded on this factor is another area of major concern. What is the interpretation of such a mix? To answer this question, it is important to return to the fundamental principles involved in the construct of this part of the study. The linkage between these

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1 J.C. Nunnally. Psychometric Theory. (New York, N.Y.: McGraw Hill, 1967), pp. 340-365.

2 Ibid.

3 Homogeneity in this regard will be referred to later.

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Table 5.7

FACTOR I - Montreal Factor

	Attribute List[1]		Loadings 1951	Loadings 1961
*	7	Proportion of m.a.[2] singles in c.t.[3]	834	907
*	8	Proportion of m.a. married in c.t.	932	937
*	16	Proportion of m.a. two language population in c.t.	946	959
*	20	Proportion of m.a. Roman Catholic in c.t.	896	941
*	40	Proportion of m.a. wage-earners earning under $4000 in c.t.	941	943
*	52	Proportion of m.a. dwellings with flush toilet in c.t.	876	915
	4	Proportion of m.a. old in c.t.	702	806
*	5	Proportion of m.a. young in c.t.	888	869
*	10	Proportion of m.a. French in c.t.	835	886
	21	Proportion of m.a. with no education in c.t.	794	807
	28	Proportion of m.a. looking for work in c.t.	710	821
	39	Proportion of m.a. wage-earners earning over $4000 in c.t.	340	897
	49	Proportion of m.a. apartments and flats in c.t.	848	877

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Table 5.7 (Continued)

Attribute List		Loadings 1951	Loadings 1961
51	Proportion of m.a. dwellings occupied 2 years in c.t.	734	888
53	Proportion of m.a. dwellings with bath and/or shower in c.t.	786	879
54	Proportion of m.a. dwellings with car in c.t.	645	833
58	Proportion of m.a. population attending school in c.t.	822	869
64	Proportion of m.a. with less than 9 years of education in c.t.	800	882
63	Proportion of m.a. with 3 years high school and up in c.t.	510	720
57	Proportion of m.a. dwellings with furnace in c.t.	423	684
59	Ratio of c.t. to m.a. rooms per dwelling	-099	607
66	Proportion of m.a. Italians in c.t.	579	633
13	Proportion of m.a.'s other European in c.t.	388	550
65	Proportion of m.a.'s German in c.t.	333	502

* Over .800 in both periods (1951 and 1961)

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[1] All attributes with a .500 or greater correlation with Factor I are listed.

[2] m.a. is Metropolitan Area.

[3] c.t. is census tract.

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attributes is not necessarily an interaction of causative relationships. Rather, the linkage here is distributional. These attributes have similar levels of locational concentration in Montreal's urban space. For example, in urban structure (Factor I) it is clear from theory and other empirical studies that education, income and occupation have important causal relationships and feedbacks. However, the primary factor in this analysis links married and singles, young and old, apartments and bilingualism. The distribution of each of these attributes is extremely wide in Montreal's urban space. Apartment dwellings are mixed widely throughout the city in a similar manner to the distribution of bilingualism, young and old people, married and single people and other attributes that load on this factor.

This factor is, therefore, a measure of the most general spatial character of Montreal as a whole. A character or "urban flavour" which is not typical of Verdun, Westmount, Montreal Nord, or St. Michele, but rather is widely spread throughout the urban region. By examining this factor, it is clear that this is a French, Roman Catholic city,

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of low but rising educational levels. The low but rising income populations are spatially dispersed as are populations that are bilingual, of dependency age (young and old), of varying marital status, dwelling in apartments and flats with an occupancy rate of about 2 years. This basic urban character factor is similar to the descriptive conclusions on Montreal outlined by G. Cliffe-Phillips, Mercer and Young.[1] This factor is, therefore, labelled the Montreal Factor.

Factor II is also general in character. It accounted for 17.0% of the total common variance in 1951 and 18.8% in 1961. The composition of this factor is almost as temporally invariant as Factor I (.949). Negative loadings occur on the relative concentration of female labourers in the population, females in lower level occupations, and unemployment in the male labour force. Strong positive loadings are indicated in both periods for the concentration of females in upper level occupations; for the distribution of female managers, professionals and technicians; and for the distribution of class one

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[1] G. Cliffe-Phillips, J. Mercer and Y.M. Young, Op. Cit.

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Table 5.8

FACTOR II - Female Status[1]

		Attribute List[2]	Loadings 1951	Loadings 1961
*	34	Ratio of c.t./m.a.[3] female Class 1 workers to c.t./m.a. population	807	913
*	32	Ratio of c.t./m.a. female managers to c.t./m.a. population	806	866
*	33	Ratio c.t./m.a. female professional and technical to c.t./m.a. population	808	885
*	35	Ratio of c.t./m.a. female Class 2 workers to c.t./m.a. population	-758	-844
*	37	Ratio of c.t./m.a. male Class 1 workers to c.t./m.a. male Class 2	819	890
	38	Ratio of c.t./m.a. female Class 1 workers to c.t./m.a. female Class 2	664	829
*	41	Ratio of C.T./m.a. males earning over $4000 to c.t./m.a. males earning under $4000	790	831
	42	Ratio of c.t./m.a. females earning over $4000 to c.t./m.a. females earning under $4000	602	624
	22	Ratio of c.t./m.a. attending school to c.t./m.a. with no education	680	746
*	36	Ratio of c.t./m.a. female labourers to c.t./m.a. population	-739	-790
	56	Ratio of c.t./m.a. cars to c.t./m.a. families	698	763

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Table 5.8 (Continued)

Attribute List		Loadings 1951	1961
26	Ratio of c.t./m.a. males looking for work to c.t./m.a. males with job	-503	-605
39	Proportion of m.a. wage-earners earning over $4000 in c.t.	794	381
63	Proportion of m.a. population with 3 years high school and up in c.t.	730	567
57	Proportion of m.a. dwellings with furnace in c.t.	681	426
54	Proportion of m.a. dwellings with car in c.t.	589	322
11	Ratio of c.t./m.a. British to c.t./m.a. French origin	378	566
17	Ratio of c.t./m.a. English to c.t./m.a. French speaking	378=	500
74	Ratio of c.t./m.a. Anglican to c.t./m.a. Roman Catholic	349	570

* Over .750 in both periods (1951 and 1961)

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[1] Factor reversed its loading orientation from negatives to positives between two periods. For discussion of this problem, see footnote related to Factor V of Urban Structure.

[2] All attributes with a .500 or greater correlation with Factor II are listed

[3] c.t. is census tract. m.a. is metropolitan area.

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relative to class two workers (male and female). Positive loadings also occur for the distribution of high income population (+$4000) to total population, and high incomes to low incomes (males and females). This is a female dominant occupation-income factor and has been labelled Female Status.

With regard to both primary distribution factors (Factor I and Factor II) a certain amount of segregation can be identified which parallels the dichotomy of particular measurement sets being utilized. Factor I is almost entirely made up of simple location quotient measures and Factor II is composed to some degree of ratio of location quotient measures. This observation itself is not easily explained. Since, as noted previously, both number sets have been normalized and standardized and since some mixture of the two data measurements do occur albeit at low loadings and in less important factors, the problem of incompatability of measures is not likely. Furthermore, without a mixture of data measurements the problem of "built in" correlation might have been significant.[1] Finally, it is clear that even if these two factors result partly from the difference in measurement

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[1] Krumbein, Op. Cit.

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systems, it does not affect the basic interpretation of these factors as presented here. Both factors are highly general in character representative of widely distributed characteristics of Montreal's urban space. Furthermore, from the principal axis summary table (Table 5.1) it is clear that one was the primary factor in 1951 while the other was the primary factor in 1961. When the general increasing segregation of entire factors becomes a major interpretive question as among Factors III, IV and V, the problem of measurement dichotomization is less important since these factors are quite similar to each other in terms of explained variance and are clearly less general and more constrained distributions than either of the primary factors (Montreal Factor or Female Status.)

Factor III is a density related employment and marital status factor. For simplicity, it has been labelled the Density Factor. Positive loadings are related to the relative distribution of wage-earners to self-employed, singles to marrieds, rooms and dwellings to population, and duplexes to single-detached and apartments. An age attribute is indicated by counter loadings on old to young ratios. This factor accounted for 7.51% and 7.75% of the total common variance in 1951 and 1961

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Table 5.9

FACTOR III - Density Factor

	Attribute List[1]	Loadings 1951	Loadings 1961
* 29	Ratio of c.t./m.a.[2] wage-earners to c.t./m.a. self-employed	788	820
* 60	Ratio of c.t./m.a. population to c.t./m.a. rooms	605	825
* 62	Ratio of c.t./m.a. population to c.t./m.a. dwellings	881	823
* 6	Ratio of c.t./m.a. singles to c.t./m.a. marrieds	815	751
* 31	Ratio of c.t./m.a. males wage-earners to c.t./m.a. males self-employed	605	708
* 2	Ratio of c.t./m.a. old to c.t./m.a. young	791	616
1	Ratio of c.t./m.a. males to c.t./m.a. females	687	591
3	Ratio of c.t. old to m.a. young	-657	-497
75	Ratio of c.t./m.a. other dwellings to c.t./m.a. single-detached and apartments	-066	510

* Over .600 in both periods (1951 and 1961)

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[1] All attributes with a correlation of .500 or greater with this factor are listed.

[2] c.t. is census tract. m.a. is metropolitan area.

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respectively. The invariance of this factor between 1951 and 1961 indicates this factor is quite stable (.961).

Factor IV is the second most stable factor in this part of the analysis (.978). It accounted for 5.0% and 6.7% of the total common variance in 1951 and 1961 respectively. It is clear from the results above that this is the weakest of the factors considered (in terms of explained variance). The male-female aspect of this labour force participation factor is indicated by the counter (positive-negative) loadings on these attributes. This is a sex-oriented labour force participation factor and has been labelled the Male Labour Force Factor. The compositional similarity between the dominant aspects of this factor and the urban structure factor of family status is quite noticeable.

Factor V is the third most important factor in terms of explained variance, 12.9% in 1951 and 13.3% in 1961. This factor is temporally quite invariant (.812). Strong positive loadings were indicated for both periods for unilingual English, British ethnic, Anglican religion, and English to French speaking distributions. Positive loadings

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Table 5.10

FACTOR IV[1] - Male Labour Force Factor

Attribute List[2]		Loadings[3] 1951	1961
* 23	Ratio of c.t./m.a. male labour force to c.t./m.a. female labour force	896	902
* 24	Proportion of m.a. female labour force in c.t.	-904	-882
44	Ratio c.t./m.a. attending with 9th grade education to c.t./m.a. not attending with 9th	233	715
1	Ratio c.t./m.a. males to c.t./m.a. females	510	655
2	Ratio of c.t./m.a. old to c.t./m.a. young	106	557

* Over .600 in both periods (1951 and 1961)

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[1] Factor reversed its loading orientation from negatives to positives between two periods. For discussion of this problem, see footnote related t o Factor V of urban structure.

[2] All attributes with a correlation of .500 or greater with this factor are listed.

[3] c.t. is census tract. m.a. is metropolitan area.

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Table 5.11

FACTOR V[1] - Segregation Factor

	Attribute List[2]	Loadings 1951	Loadings 1961
	[3]		
* 14	Proportion of m.a. English speaking only in c.t.[4]	829	813
* 17	Ratio of c.t./m.a. English to c.t./m.a. French speaking	860	816
68	Proportion of m.a. Polish in c.t.	546	750
69	Proportion of m.a. Ukranian in c.t.	387	722
* 73	Proportion of m.a. Lutheran in c.t.	683	709
* 74	Ratio of c.t./m.a. Anglican to c.t./m.a. Roman Catholic	848	678
72	Proportion of m.a. Ukranian (Greek) Catholic in c.t.	334	685
71	Proportion of m.a. Greek Orthodox in c.t.	193	648
* 70	Proportion of m.a. Anglican in c.t.	820	685
65	Proportion of m.a. German in c.t.	590	654
13	Proportion of m.a. other European in c.t.	461	698
11	Ratio of c.t./m.a. British to c.t./ m.a. French origin	856	662

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Table 5.11 (Continued)

	Attribute List	Loadings 1951	1961
* 9	Proportion m.a. British in c.t.	795	615
67	Proportion of m.a. Netherlands in c.t.	665	542
19	Proportion of m.a. Jewish in c.t.	394	562
12	Proportion of m.a. Asiatic in c.t.	073	525

* Over .600 in both periods (1951 and 1961)

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[1] Factor reversed its loading orientation from negatives to positives between two periods. For discussion of this problem, see footnote related to Factor V of urban structure.

[2] All attributes with a correlation of .500 or greater with this factor are listed.

[3] m.a. is metropolitan area.

[4] c.t. is census tract.

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also occurred for Polish and Ukranian ethnic, Ukranian Catholic and Greek Orthodox religions, German and Dutch ethnic and Lutheran religion. Attributes with positive loadings which increased sharply on this factor between 1951 and 1961 included Ukranian ethnic, Ukranian Catholic, Greek Orthodox, other European origin and Jewish and Asiatic populations. This change in loadings reflects the Canadian immigration policies during this period which were most effective in attracting eastern and southern European populations. This factor is composed of Montreal's minority populations and has been labelled the Segregation Factor.

A point should be made of the difference between this distributional factor and the urban structure factor with a similar composition. One of the most noticeable differences between these two factors is that in this distribution factor, the English population is identified. It is seen as a minority group having similar spatial distribution (spatial segregation) to other minority groups.

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Distribution Summary

The loose hypotheses concerning the factorial structure of distributional characteristics seem to be substantiated. The first distributional factors are extremely general in nature while the succeeding distributional factors are more specific and typical of more constrained urban distributions such as segregation and density. A shift in the alignment of important English culture and linguistic characteristics indicates new spatial information is produced by this approach. Attributes comprising one of the most important urban structural dimensions, socio-economic status, are in their spatial character typical of one of the more constrained distributional dimensions, segregation. This is, at least, a partial indication of the need for carrying out a distribution analysis.

Although it is clear that some adjustment in attribute loadings for specific factors did occur between 1951 and 1961 intercorrelation demonstrates that this adjustment was not substantial. Further the test of factor homogeneity indicated reasonable internal consistency in the distributional factors

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Table 5.12

Urban Distribution Dimensions

Summary

Distribution Factors

I. Montreal Factor

II. Female Status Factor

III. Density Factor

IV. Male Labour Force Factor

V. Segregation Factor

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Table 5.13

Urban Distribution

Intercorrelation of Attribute Loadings

		1961				
		I	II	III	IV	V
1	I	.953	.141	.030	.211	.010
9	II	.317	.795	.280	.124	.203
5	III	.042	.035	.943	.131	.037
1	IV	.083	.055	.117	.653	.189
	V	.219	.149	.071	.200	.841

Urban Distribution

Intercorrelation of Factor Scores

		1961				
		I	II	III	IV	V
1	I	.821	.111	.347	.226	.038
9	II	.287	.849	.018	.159	.137
5	III	.112	.299	.871	.483	.103
1	IV	.104	.148	.476	.736	.098
	V	.185	.092	.136	.073	.797

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Table 5.14

Homogeneity of Urban Distribution Attributes[1]

Distribution Factors	Homogeneity[2] (rh) 1951	1961	Reliability of Homogeneity Difference Significant at
I	.86	.90	(NSD)*
II	.88	.75	$p > .05$
III	.88	.88	(NSD)*
IV	.90	.93	(NSD)*
V	.92	.93	(NSD)*

* no significant difference

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[1] Only those attributes which loaded above .400 on a given factor were utilized.

[2] See Nunnally, Op. Cit., and R.H. Gaylord, "Estimating Test Reliability from the Item Test Correlations." Educational and Psychological Measurement. Vol. 29 (1969), pp. 303-304. The formulation for this statistic is given as:

$$rh = \frac{\bar{r}_{ij}}{\bar{r}_{it^2}}$$

where "i" and "j" are items and "t" is the test. See also Athanasiou, Op. Cit.

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and that this internal consistency is reliable between 1951 and 1961.

Structure-Distribution Relationships

A few specific comparisons between urban structure factors and the urban distributional factors have been noted in the preceeding discussion. The total relationship, however, between these two analyses is not yet clear. To identify this relationship, two tests were used to link the urban structure and urban distribution factors for the periods 1951 and 1961. Since the urban structure factors and the urban distribution factors are internally orthogonal, a simple inter-correlation analysis was utilized as the most direct approach (See Table 5.15).

From the 1951 intercorrelation matrix, it is clear that the urban structure Factor I, Socio-economic Status, is positively though weakly related (.574) to the urban distribution Factor II, Female Status. It is also negatively related to distribution Factor V, Segregation (-.643). By 1961, Socio-economic Status (structure Factor I)

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Table 5.15

Relationship between Urban Structure Factors and Distribution Factors

Urban Distribution Factors

1951

Urban Structure Factors	I	II	III	IV	V
I	-.<u>356</u>	.<u>574</u>	-.026	-.090	-.<u>643</u>
II	-.118	-.202	.031	.<u>765</u>	-.061
III	.<u>772</u>	.278	-.079	.084	-.145
IV	.099	.272	-.058	-.054	.253
V	.014	-.214	.<u>577</u>	-.258	-.195

Urban Distribution Factors

1961

Urban Structure Factors	I	II	III	IV	V
I	-.165	.<u>906</u>	-.014	.097	-.<u>458</u>
II	-.198	-.048	.110	.<u>558</u>	-.116
III	.<u>823</u>	-.154	.054	-.082	.107
IV	-.058	.264	.064	-.013	.<u>738</u>
V	.067	-.040	.<u>787</u>	.295	.024

<u>____</u> = greater than 10% shared variance

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of a live-in servant characteristic.[1]

The last urban structure dimension, Secondary Employment and Household Factor, has a strong positive association with the spatial distribution of similar attributes composing distribution Factor III, Density (.577 in 1951 and .787 in 1961). In 1951, this factor had a mild negative association with the distribution Factor IV, Male Labour Force (-.258), but by 1961 a mild positive correlation had developed (.295).

Spatial Change: Structure and Distribution

An attempt was made to examine the relationship between spatial change in urban structure and distribution. To accomplish this, change in census tract scores on Factor I of urban structure is correlated with the change in census tract scores on Factors I through V of urban distribution using stepwise multiple correlation and partial correlation analysis. This process is repeated sequentially for all urban structure Factors, I through V. The independent variables are defined as distribution factors while the dependent variables are the structure factors,[2] e.g.

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[1] Carey. Op. Cit.

[2] Although the analysis is set up in regression format only the correlation coefficients are interpreted and no cause and effect relationships are implied.

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Δ F structure = f (Δ F distribution 1-5 • Initial levels held constant, Fs_{t1} and Fd_{t1})

The purpose of this analysis was to correlate change in urban structure factors with change in urban distribution factors.

When dealing with change, it is almost always true that a high level of prediction can be gained simply by using one time period to predict the next time period. A full discussion of the temporal prediction problem can be found elsewhere,[1] but a demonstration of it can be found when the factor scores of urban structure in t_1 (1951) are used to predict the factor scores in t_2 (1961) (See Table 4.14). In a similar manner urban distribution scores in 1951 can be used to predict 1961 urban distribution scores (See Table 5.13).

Since a large amount of spatial intercorrelation occurs, it would seem that spatial stability is an important aspect of urban ecology, whether summarized structurally or distributionally. The problem of change, however, is still not answered. To identify change, it is necessary to partial out

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[1] C.D. Harris. Problems in Measuring Change. (Madison, Wisconsin: University of Wisconsin Press, 1961), pp. 5-35.

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the effect of t_1 on t_2. The residuals from this step will be that aspect of change which is not predicted by the first time period.

The two basic techniques used to produce the multiple-partial coefficient utilized here were partial correlation and multiple regression.[1] Partial correlation was utilized to calculate the correlation between a set of variables while the effects of other variables are being controlled. Step-wise multiple regression, on the other hand, was utilized to indicate how much of the total variation in the dependent variable or variable set can be explained by the independent variables acting in sets of increasing levels of explanation. These results were then evaluated using the analysis of variance F test.[2]

The dependent variable was the spatial change in factor scores as indicated by the difference in factor scores for each study area from 1951 to 1961 in Montreal. Since five significant factors were identified for each period, the dependent variable

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[1] H. Blalock. Social Statistics. (New York, N.Y.: McGraw-Hill Co., 1960), pp. 350-351.

[2] Ibid., pp. 354-357.

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set is composed of five basic change variables. The dependent variables are the variables of spatial change on the urban structure factors.

$$Y_{1-5} = \Delta F_1, \Delta F_2, \Delta F_3, \Delta F_4, \Delta F_5$$

(Change in Urban Structure Factor Scores)

The independent variable is made up of the distributional factors. These factors are used to explain Y_{1-5}. The independent variables are composed of the factor score changes of the five significant distribution factors.

$$X_{1-5} = \Delta F_1, \Delta F_2, \Delta F_3, \Delta F_4, \Delta F_5$$

(Change in Urban Distribution Factor Scores)

Each of the dependent variables Y_{1-5} is individually explained via a step-wise multiple regression of the independent variables, X_{1-5}, while partialling for the preceeding time period (t_1) for each variable set Y'_{1-5} and X'_{1-5}.[1] In

---

[1] At this point, normalization became a problem. The distribution of factor scores was already normalized for each time period, but the differences (t_1-t_2) were not necessarily normal. Histograms of the change score were printed out and based on that, a decision was made to accept the change data as reasonably close to normal. The histograms of the distribution of change scores are found in Appendix F.

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this manner multiple and partial correlation problems are handled simultaneously through the use of the multiple-partial coefficient.[1]

$$R_1Y_1 \quad (X_{1-5})\cdot Y'_1 \; X'_{1-5}$$

$$R_2Y_2 \quad (X_{1-5})\cdot Y'_2 \; X'_{1-5}$$

$$R_3Y_3 \quad (X_{1-5})\cdot Y'_3 \; X'_{1-5}$$

$$R_4Y_4 \quad (X_{1-5})\cdot Y'_4 \; X'_{1-5}$$

$$R_5Y_5 \quad (X_{1-5})\cdot Y'_5 \; X'_{1-5}$$

Although calculated in this manner the results have been reordered and placed in matrix form for presentation purposes. The multiple regression order of independent variables is indicated by the level of explanation contribution.

By examining the change matrix a number of relationships seem clear. Urban Structure Factor I, Socio-economic Status, changed with change in the spatial distribution of the general Montreal Factor (distribution Factor I). It should be noted

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[1] F. Croxton and D. Crowden. Applied General Statistics. (New York, N.Y.: Prentice-Hall, Inc., 1955), Chap. 21 and 26.

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that the correlation of change in urban structure and urban distribution produces a different relationship from the static picture which related urban structure Factor I to the urban distribution Factors II and V.

Urban Structure Factor II, Family Status, changes with change in the distribution of the Male Labour Force Factor (distribution Factor IV). This result is in direct correspondence with the intercorrelation resulting from the static analysis. The change analysis for the third urban structure factor, Recent Growth, indicates a substantial difference from the static intercorrelation matrix. It is primarily linked to change in the distribution of the Male Labour Force Factor IV. Change in the fourth urban structure factor, Minor Ethnic Status, is mildly correlated with change in the Segregation Factor. In Factor V of the urban structure dimensions, the Secondary Employment and Household Factor, change is associated with the distributional change of the distribution Factor IV, the Male Labour Force Factor.

By analyzing change, it is clear that the most important distribution change factor in explaining change in urban structure is the Male Labour Force

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dimension. Although even the multiple "R" level of explanation of change in urban structure by change in urban distribution is not high, certain specific factors can be explained more effectively than others. The three urban structure change factors with multiple R's greater than .30 are also those most closely related to the factor of change in Male Labour Force distribution.

The static analysis of urban structure and urban distribution dimensions indicates specific spatial relationships that are not necessarily apparent in the analysis of urban structure by itself. Furthermore, the analysis of change indicates that the spatial distribution factor identified as the Male Labour Force dimension is closely related to change in urban structure. It is interesting that this factor with loadings on the relatively small numbers of females in the labour force in specific tracts is typical of the suburbs and the stage in the life cycle they represent. From this, it would seem that change in urban structure in Montreal during this period is related primarily to the distribution factor typical of suburbanization.

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Table 5.16

The Distributional Character of Change in Urban Spatial Structure[1]

1951-1961		R^1	Change in Urban Distribution Factors[2] I	II	III	IV	V
	I	.264	.185	.004	.008	.003	.061
Change in Urban Structure Factors[2]	II	.368*	.018	.017	.035	.299	.010
	III	.355*	.027	.035	.004	.293	.005
	IV	.184	.003	.026	.010	.006	.158
	V	.338*	.056	.004	.001	.282	.002

* 10% or more of the explained variance

$R = .018$ is significant at $p > .05$

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[1] Multiple-partial coefficient may be interpreted the same as the correlation coefficient of multiple regression.

[2] t_1 partialled out.

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Summary

As noted in the preliminary distribution summary the exploratory hypotheses have been substantiated. Furthermore, the usefulness of a distributional analysis in generating new information has been clearly demonstrated. Since this new information is primarily spatial in character, it may be argued that distributional analysis is an important addition to the traditional factor analytic approach used by such spatial analysts as urban ecologists and geographers.

In a similar manner to urban structure, Montreal's distributional character has proved to be naturally orthogonal with reasonable temporal stability. Furthermore, the homogeneity of Montreal's distributional factors and the reliability of their homogeneity is superior to the factors resulting from the structural analysis. Whether this is a general characteristic of distribution versus structural analysis or a characteristic peculiar to this Montreal analysis, it is difficult to say. Further comparative work in the use of distribution analysis may be productive in this regard.

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Hypotheses regarding the relationship between distributional characteristics and urban structure are, in the main, well supported. The close aggregate relationship between structure and distribution is reflected in the high intercorrelation between factors with similar attribute composition characteristics. However, the secondary correlations in the static analysis did not reflect the close association which was hypothesized for all urban structure dimensions, i.e. the suburban related (Factor IV) distribution dimension. In all cases the secondary correlations were extremely weak.

It was in the change analysis that the hypothesized importance of the suburban oriented distribution dimension was substantiated. In this case the distribution Factor IV, Male Labour Force, became the most significant contributor to the explanation of urban structure change dominating three out of five factors. This demonstrates the need to use some kind of temporal analysis in the examination of a process phenomenon such as suburbanization. Further, it is also clear from distributional analysis that the spatial character of such a process is not structurally unique.

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CHAPTER VI

URBAN ARRANGEMENT

In this chapter, attention will be focused on the geometric patterns that result from the spatial expression of Montreal's urban structure. Continued use will be made of the operational definition of this structure as developed in Chapter IV. The approach here is not to repeat the analysis of the relative concentration or dispersion of an attribute or groups of attributes in urban space. Instead, an attempt is made to extend the analysis to the recognition of spatial patterns that are a consequence of such concentration or dispersion. Since previous studies have noted that certain dimensions of urban structure are associated with particular geometric patterns, this chapter is designed to test these associations for Montreal. In addition, the geometric patterns of structural change will be examined.

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Hypotheses

Theory and previous studies regarding the arrangement of urban structure characteristics indicate that hypotheses fall into two basic groups; those dealing with the static patterns and those concerned with patterns of spatial change in urban structure.

Traditional static theories of urban structure postulate one of three spatial patterns: (1) the sectorial or wedge shaped pattern, (2) the zonal, concentric circle or ring pattern and (3) the nucleated, clustered or multiple nuclei pattern. These arrangement patterns are not mutually exclusive nor exhaustive of pattern possibilities. However, they do comprise the classical patterns suggested by urban theorists. Previous studies have emphasized the distinction between sectorial and zonal patterns of urban structure. From the summary of the results of these studies in Chapter I it is clear that economic characteristics have been observed as being primarily sectorial in their arrangement. Little attention has been paid to the measurement of minority arrangements in

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urban structure,[1] and general observations, from factor mapping, have interpreted these patterns as sectorial, nucleated and indeterminant.[2]

The importance of objective rather than subjective pattern interpretation has been noted by Burns and Harman[3] and should be reemphasized here. It is only through objective pattern recognition that the generality of spatial geometry can be translated and tested as relevant spatial theory. For this reason traditional mapping and observation have not been utilized in the interpretation of factor patterns since Burns and Harman note that the same complex factor patterns may be perceived differently by different observers. Such perceptive variation is highly dependent upon which theory of spatial arrangement is brought into play. Although it is possible to eliminate subjectivity in selecting which theories are most important, it is possible

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[1] One notable exception is the work by Murdie who found minority patterns to be sectorial in one case but indeterminant between zonal and sectorial arrangements in other cases. Murdie. Op. Cit., pp. 164-165.

[2] Berry and Horton. Op. Cit., Chapter 10.

[3] Burns and Harman. Op. Cit., p. 77.

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to choose among a set of predefined theoretical expectations objectively. This is one of the major purposes of the analysis in this chapter.

Among the early theorists on urban spatial structure, Hurd was one of the first to note that socio-economic characteristics are distributed sectorially reflecting their relationship to the rent structure of urban areas.[1] Burgess, on the other hand, postulated the theory that the dominant characteristics of urban structure are distributed in concentric zones or rings around the city center.[2] More recently the theoretical work of Wolpert and Alonso has pointed out the linkage between the behavioral life-cycle demand for land and children and the normative relationship between commuting costs and the land value gradient from the CBD.[3] This recent work indicates family status should be among the more dominant urban structure characteristics which are distributed in concentric zones

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[1] Hurd. Op. Cit.

[2] Burgess, in Park, Burgess and McKenzie. Op. Cit., pp. 47-62.

[3] Wolpert. Op. Cit. Alonso. Op. Cit.

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or regular gradients from the central city. Empirically it has long been noted that ethnic characteristics are distributed in isolated or relatively isolated groups or nuclei in the urban fabric. Theoretically this distribution of multiple nuclei is related to the hierarchy of urban subcentres as discussed by Harris and Ullman[1] and Berry.[2] Gans has noted that multiple nuclei theory may reflect the variable importance of urban subcentres to various urban minority groups.[3]

The following hypotheses of the static patterns of urban structure stem basically from the above review:

1) Socio-economic status will be sectorially distributed.
2) Family status will have a zonal distribution.
3) Recent growth, which would seem to be primarily an economic phenomenon, will be sectorially distributed.

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1 Harris and Ullman. Op. Cit.

2 Berry (1964) Op. Cit.

3 Gans. Op. Cit.

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4) Ethnic status will have a clustered or nucleated distribution.

5) Secondary employment and household status, which would seem to be both an economic and density phenomenon is hypothesized to be primarily sectorial but may also have important zonal characteristics.

The shape or pattern of change is less obvious. Density related phenomena such as the secondary employment and household characteristic dimension, and the family status dimension theoretically should have a zonal change pattern as they shift outward from the urban center in Blumenfeld and Newling's wave-like pattern.[1] Hoyt has argued that socio-economic structure maintains its sectorial characteristic but shifts outward from the urban centre through time as a consequence of increasing scale in the urban core.[2] This implies that although it

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[1] Blumenfeld, Op. Cit., Newling, Op. Cit.

[2] H. Hoyt. "Where the Rich and the Poor People Live". Urban Land Institute. Technical Bulletin No. 55, (April, 1966).

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maintains its sectorial pattern at any one point in time change must be zonal and wave-like similar to that of density related phenomena. This would support the work of Hoyt who noted that economic characteristics would remain "wedge shaped" but would shift further from the urban center through time.[1]

Change in the recent growth dimension is difficult to characterize. Rent structure arguments of Hurd, Hoyt, and Ratcliff and other urban location theorists would argue for a decentralization of growth related primarily to urban transport structure.[2] The most likely geometric form of this would be sectorial. In the long run, this seems reasonable but in the short run, the form is much less clear. If accessibility is recognized as a key variable in recent growth phenomenon and if the recent growth phenomenon is closely related to apartment dwelling, which it is, then nucleated development seems quite

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[1] Ibid.

[2] Hurd. Op. Cit., pp. 58-64. Hoyt (1939), Op. Cit., R.U. Ratcliff. Urban Land Economics. (New York, N.Y.: McGraw-Hill, 1949).

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likely.[1] In that case, nucleated development should be associated primarily with urban transportation nodes. These two pattern possibilities are not easily resolved.

Nucleation seems the most likely expression of minor ethnic group change since the critical factor of replacement, as was discussed previously, was a continual process during this period. This has been a dominant aspect of minor ethnic group change in Montreal and since the city will continue to be one of the prime entry points and preliminary destination centres for new Canadians, this change process is likely to continue to be important. This does not imply that upward social and spatial mobility do not occur. Rather, it is a recognition that as one group may move upward in the social structure and become dispersed spatially, it is replaced by new minorities occupying the old residential areas that others have abandoned. Thus, although change occurs, its pattern remains one of nucleation and the pattern of areal change as measured in this study is expected to be clustered.

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[1] Max Neutze. The Suburban Apartment Boom. (Washington, D.C.: Resources for the Future, 1968).

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Method

In examining a map created by the distribution of factor scores, it is difficult to isolate the underlying pattern. Furthermore, to compare the map patterns which result from the distributions of two or more factor score sets is close to impossible. For that reason, the simple smoothing or filtering techniques discussed previously were developed.[1] A brief review of these techniques may prove helpful.

1) The sectorial grouping algorithm: For each census tract an angle from the CBD is calculated. All factor scores within (+ or -) 15^0 of a given census tract will be summed and divided by the number of tracts in that sector. This sector averaged score is then allocated to the tract over which the 30° sector was centered. This is repeated for all census tracts on each factor. The result for 1951 and 1961 will be compared and the change between these two periods will also be examined. This function is used to identify patterns in a given structural factor which are primarily sectorial.

2) The concentric zone grouping algorithm: For each census tract beyond one half mile from the CBD the census tract factor scores within (+ or -) one half mile are summed and divided by the number of

[1] Holloway, Op. Cit., and Tobler, Op. Cit.

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tracts within that one mile band. This zonal averaged score is then allocated to the tract over which this one mile band was centered. This procedure will be repeated for all census tracts on each factor. The results for 1951 and 1961 will be compared and the change between these two periods will be examined. This function will be used to identify patterns in a given structural factor which are primarily zonal.

3) The nucleated grouping algorithm: For each census tract, an index is developed based on its spatial distance from each other tract weighted by the degree of structure factor score similarity between the tracts. This is carried out for each tract to all other tracts on each structure factor. This cluster index is then allocated to each tract. The results are compared for 1951 and 1961 and the change between these two periods is also examined. This function will be used to identify change in a given structural factor which are primarily nucleated.

$$NFS_i = \sum_{j=n}^{i=1} [d_{ij} (FS_i - FS_j)]/N\text{-}1$$

Where NFS_i = the new factor score for tract i

d_{ij} = the distance between i and j, where i is the tract of interest and j goes from 1 to N

FS_i = the factor score of tract i on a given factor

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FS_j = the factor score of tract j, on the same factor as i but where j goes from 1 to N

The same basic three smoothing or filtering techniques were applied to all five urban structural dimensions. In this way, each pattern may be compared across all factors and each factor may be compared across all patterns.

At this point, it is important to indicate that the selection of the actual level of smoothing or filtering is arbitrary because the final solution to this question, while possible, is beyond the scope of this study. Why a thirty degree sector instead of a ten degree one? Why one mile concentric zone grouping, instead of a two mile grouping? Why a unitary weight for the distance parameter in the clustering function, instead of a parameter that squares distance? Although these choices are arbitrary, it should be remembered that the consequences of boundary choices are known. If the smoothing or filtering function is too fine, there will be no difference between the original data distribution and the processed data and as a consequence the pattern will be no clearer.

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Similarly, if the smoothing or filtering function is too coarse, all the important variations will be "washed out" and no pattern will emerge. To be specific, if the sectors are so small that each tract will be in a sector by itself, no averaging or smoothing will occur. At the other extreme, if there are only two 180° sectors pattern differentiation is likely to be obliterated.

On the other hand, some information was used in the selection of these smoothing or filtering criteria. In the case of the sector size, the present choice was tested against a sector of one-third the size (10°) and the results were similar. Furthermore, the thirty-degree sector allows the results to be compared directly with that of Murdie who used the same sector size in a vectorial analysis of Toronto.[1] In the zonal analysis, the choice of one mile was predicated on other work carried out on the disaggregation of urban density functions in Montreal. In this analysis, the variance in the density functions (aggregate density and net residential density) increased markedly

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[1] Murdie. Op. Cit.

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when zonal aggregation went below one mile.[1] Finally, the choice of a unitary distance parameter was chosen in the light of almost complete ignorance of Montreal's interaction field. However, it is felt that this is the lower bound of values that might be chosen.[2]

Simple intercorrelation between the original factor scores and different filter patterns indicates the level of similarity between them. Although this is a reasonable approach for the static analysis, change is more complex. In a manner similar to the analysis in Chapter V, the effect of the distribution of factor scores in the first time period (1951) must be controlled for. For this purpose, partial correlation is utilized.

Factor Patterns

The data is outlined in the following tables in terms of which pattern is most typical of a

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[1] K.E. Haynes and H. Markovits, "The Disaggregation of Urban Density Functions." (unpublished paper, research project, Summer Urban Institute, McGill University, September, 1969).

[2] Path analysis techniques may be useful in solving these problems.

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given factor score distribution.

Urban structure Factor I, Socio-economic Status, was basically sectorial in its spatial pattern in 1951 (.744) and remained sectorial in 1961 (.782). Non-time dependent change between 1951 and 1961 for this factor, however, is nucleated (.699).

The results, however, are not as conclusive as they might first appear. A Z transformation of the sectorial (.744) and nucleated (.700) correlations (.9594 and .8673 respectively) indicate that they are not significantly different at even the ten percent level in 1951. However, Socio-economic Status is significantly (one percent level) more sectorial than nucleated in its distribution in 1961. With regard to change, Socio-economic Status is distributed in a nucleated pattern being significantly more nucleated than zonal at the five percent but not the one percent level.

The static picture basically supports the findings of other studies that socio-economic status is more sectorial than zonal in its distribution.[1] As noted above, however, socio-

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[1] Murdie. Op. Cit., pp. 152-166.

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Table 6.1

Urban Structure Factor I

Socio-Economic Status

Pattern Correlations

	Sectorial	Zonal	Nucleated
1951^{S}	.744	.342	.700
1961^{S}	.782	.413	.674
$Change^{P}$	.438	.549	.699

s: simple correlation

P: partial correlation - initial scores (1951) held constant

: all correlations are significantly different from zero at the .01 level, F test, unless otherwise indicated.

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economic status is not significantly more sectorial than nucleated in 1951 but it had become significantly more sectorial by 1961. As a consequence the basic hypothesis of sectorial patterning of this dimension can not be wholly accepted. The pattern of change in socio-economic status is less ambiguous. The results are quite different from expected and the hypothesis of zonal or even sectorial arrangement of change must be rejected.

Although the static results basically support the findings of others who used analysis of variance techniques, it does bring into question the practice of only comparing sectorial and zonal distributional patterns. From this study it would appear that nucleation is extremely important in the basic pattern of the socio-economic structure of Montreal. This does not seem to be typical of other North American findings as reported in theoretical discussions or in generalized empirical observations.[1] However, it is difficult to know if the lack of observations concerning nucleation and Socio-economic Status is

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[1] Ibid., pp. 32-38. Berry and Horton. Op. Cit., Chapter 10.

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the result of the lack of the nucleation pattern elsewhere or an inadequacy in previous methods to recognize this pattern.

The patterns of Factor II of urban structure, Family Status, agree closely with the expectations from previous studies and theory. Furthermore, the agreement with the other objective analysis of this pattern is also close. The basic zonal character of Family Status is borne out in 1951 (.586) and 1961 (.709) in this study of Montreal. Tests of significance (Z transformation) indicate that the hypothesis of zonal rather than sectorial or nucleated patterning of the static aspects of family status can be accepted at the .01 level. The pattern of change in family status is not at all clear. Although it would seem to be basically a zonal pattern, this would be an incorrect interpretation. The correlation coefficient is so poor that an F test reveals no significant difference between .075 and zero at the .05 level. Since none of the other change coefficients are significant, little can be said about the relationship between pattern and family status change. These results do not agree with the hypothesis as previously outlined nor with

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Table 6.2

Urban Structure Factor II

Family Status

Pattern Correlations

	Sectorial	Zonal	Nucleated
1951^{s}	.311	.586	.226
1961^{s}	.423	.709	.338
$Change^{P}$	$.005^{n}$	$.075^{n}$	$.069^{n}$

n: not significantly different from zero, .05 level F test

s: simple correlations

P: partial correlations ; initial scores (1951) held constant

: all correlations are significantly different from zero at the .01 level, F test, unless otherwise indicated.

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the findings of Murdie which indicated zonal patterns for such similar process dimensions as suburbanization.[1]

Murdie's study, the only other study to objectively analyze ecological change, is ambiguous in this area since the process dimension of urbanization, often linked to the Family Status factor, is classified as indeterminant between sectorial and zonal patterns.[2]

Recent Growth Status, urban structure Factor III, proved not to be sectorial in either its static or dynamic aspects. The pattern of this factor appears primarily zonal in 1951 (.459) and nucleated in 1961 (.480). However, tests of significance indicate that the Recent Growth pattern is indeterminant between zonal and sectorial in 1951, although it is significantly more nucleated than zonal (.01 level) in its distribution in 1961. The hypothesis concerning the static pattern of Recent Growth must be rejected. Furthermore, tests of significance on the difference between zonal and nucleated change indicate that although the results

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[1] Murdie. Op. Cit., p. 164.

[2] Ibid.

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Table 6.3

Urban Structure Factor III

Recent Growth Status

Pattern Correlations

	Sectorial	Zonal	Nucleated
1951^{s}	.345	.459	.162
1961^{s}	.259	.365	.480
$Change^{P}$	$.053^{n}$	.121*	.210

n: not significantly different from zero .05 level, F test.

*: significant at the .05 level, F test.

s: simple correlations

P: partial correlations - initial scores (1951) held constant

: all correlations are significantly different from zero at the .01 level, F test, unless otherwise indicated.

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seem to support the short term hypothesis of nucleated growth (.210) there is no significant difference between the nucleated and zonal pattern of change in Recent Growth. This supports closely the descriptive findings of Langlois on urban growth in Montreal during the late 1950's, but not the findings of others on the growth of specific sub-areas in the metropolitan region.[1] Some of these differences, however, may simply reflect the critical role of scale in urban analysis. Although the sectorial hypothesis must be placed in suspicion, the results lend some support to the preliminary findings of Murdie who identified Recent Growth as having primarily a zonal pattern in 1951.[2] Since the Murdie study was not constructed to deal with the clustered or nucleation pattern, Recent

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[1] C. Langlois. "Problems of Urban Growth in Greater Montreal" The Canadian Geographer, Vol. 5 (1961) versus B. Greer-Wootten and K. Bridges, "Landscape Components and Residential Urban Growth in Western Montreal Island," Revue de Geographie de Montreal. Vol. 19 (1965).

[2] Murdie, Op. Cit. Murdie is the only previous researcher who has carried an objective pattern analysis of urban ecological structure beyond the first two factors, Economic and Family Status.

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Growth was identified as becoming increasingly indeterminant between zonal and sectorial in 1961. This indeterminacy was reflected in this study as the increasing importance of nucleation.[1]

Although Minor Ethnic Status Factor IV is expected by theory to be clustered in urban space, Murdie found it to be basically sectorial, ranging in variation from primarily sectorial to indeterminant between sectorial and zonal in patterning.[2] Murdie found this to be true for both the static and dynamic qualities of this factor. It is noted here, again, that this is not a uniform test of this factor since the methods used in the Toronto analysis excluded any test for a clustered or nucleated type pattern.

In the present study, the nucleated pattern was by far the most significant for Minor Ethnic Status in 1951 (.721) and 1961 (.730). With regard to change, nucleation continued to be the primary pattern during this period (.846). When the second level patterns are examined, Murdie's results are

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[1] This point will be pursued later.

[2] Murdie, Op. Cit.

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Table 6.4

Urban Structure Factor IV -

Minor Ethnic Status

Pattern Correlations

	Sectorial	Zonal	Nucleated
1951[S]	.289	.421	.721
1961[S]	.365	.274	.730
Change[P]	.384	.294	.846

S: simple correlations

P: partial correlations - initial scores (1951) held constant

: all correlations significantly different from zero at the .01 level, F test, unless otherwise indicated.

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supported. When only comparing sectorial and zonal patterns, this factor would seem to be becoming more sectorial than zonal which supports Murdie's findings. To repeat, the key aspect of this analysis is that Minor Ethnic Status clusters in urban space according to theoretical expectations. The hypotheses for this factor are clearly supported.

The fifth urban structure factor is related to household density, crowding and lower employment status. The recent label used by Murdie to relate this dimension is Secondary Employment and Household Status. From urban density studies, this density related factor is expected to be zonal in its pattern distribution and its dynamics are expected to take the form of wave-like zonal migration from the urban centre. The findings of Murdie support these expectations although the findings presented here indicate that the pattern of this factor is statistically indeterminant between a sectorial or zonal pattern.

The major findings, however, again indicate the problem associated with the analysis of variance approach used by others since the significant pattern for this factor is nucleation. Factor V is nucleated

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Table 6.5

Urban Structure Factor V

Secondary Employment and Household Status

Pattern Correlations

	Sectorial	Zonal	Nucleated
1951^{s}	.269	.258	.880
1961^{s}	.218	.258	.763
Change^{P}	.024^{n}	.149*	.247

n: not significantly different from zero .05 level, F test.

*: significant at the .05 level, F test.

s: simple correlations

P: partial correlations - initial scores (1951) held constant

: all correlations significantly different from zero at the .01 level, F test, unless otherwise indicated.

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in 1951 (.880) and in 1961 (.763). Its non-time dependent change pattern, however, is not significantly more nucleated than zonal. The hypotheses concerning the pattern of this factor are decisively rejected.

Pattern Structure

A comparison of all factors across each pattern also has been carried out. The results are presented in the following tables. From this comparison, it is clear that Socio-economic Status, Factor I, has the most sectorially oriented pattern of any factor. However, the Minor Ethnic Factor (IV) is the second most important sectorially oriented change factor. This result agrees closely with the findings from Murdie's analysis. The zonal pattern is dominated by Factor II, Family Status, as expected. It is important to note, however, that this is only in the static analysis. In the change character of this zonal pattern, Socio-economic Status (Factor I) is by far the most important dimension. In fact, Factor I, Socio-economic Status, shows a moderate correlation with all three change measures. The nucleated pattern is important to three factors.

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Table 6.6

Factor Correlations with the
Sectorial Pattern (30° sectors)

Urban Structure Factors

	I	II	III	IV	IV	ΣI-V/N
1951^{s}	(1).744	(3).311	(2).345	(4).289	(5).269	.411
1961^{s}	(1).782	(2).423	(4).259	(3).365	(5).218	.401
Change^{P}	(1).438	(-).005^{n}	(-).053^{n}	(2).384	(-).024*	.189

( ): rank among factors

* : significantly different from zero at the .05 level, F test.

n: not significantly different from zero at the .05 level, F test.

s: simple correlations

P: partial correlations - initial scores (1951) held constant

_: 50% or more of variance explained

: all correlations significantly different from zero at the .01 level, F test, unless otherwise indicated.

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Table 6.7

Factor Correlations with the

Zonal Pattern (1 mile zones)

Urban Structure Factors

	I	II	III	IV	V	ΣI-V/N
1951^{s}	(4).342	(1).586	(2).459	(3).421	(5).258	.413
1961^{s}	(2).413	(1).709	(3).365	(4).274	(5).258	.403
Change^{P}	(1).549	(5).075^{n}	(4).121*	(2).121	(3).129*	.237

( ): rank among factors

*: significantly different from zero at the .05 level, F test.

n: not significantly different from zero at the .05 level, F test.

s: simple correlations

P: partial correlations - initial scores (1951) held constant

_: 50% or more of variance explained

: all correlations significantly different from zero at the .01 level, F test, unless otherwise indicated.

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Table 6.8

Factor Correlations with the

Nucleated Pattern (Unitary distance parameter)

Urban Structure Factors

	I	II	III	IV	V	∑I-V/N
1951^{s}	(3).700	(4).226	(5).162	(2).721	(1).880	.564
1961^{s}	(3).674	(5).338	(4).480	(2).730	(1).763	.597
Change^{P}	(2).699	(5).069^{n}	(4).210	(1).846	(3).247	.414

( ): rank among factors

*: significantly different from zero at the .05 level, F test.

n: not significantly different from zero at the .05 level, F test.

s: simple correlations

P: partial correlations - initial scores (1951) held constant

_: 50% or more of variance explained

: all correlations significantly different from zero at the .01 level, F test, unless otherwise indicated.

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In their order of importance from the static analysis: Factor V, Secondary Employment and Household Status; Factor IV, Minor Ethnic Status; and Factor I, Socio-economic Status. However, in a dynamic sense, the nucleation pattern dominates Minor Ethnic Status and Socio-economic Status in that order.

In summarizing this comparative aspect of the analysis, it is clear that the pattern of Socio-economic change is important in all of the three patterns considered. On the other hand, the change pattern of Factor II, Family Status, remains quite obscure having little to do with the tested patterns.

To obtain an estimate of the overall dominant urban spatial pattern, it would be necessary to multiply each factor's explained variance by the pattern correlation and sum across all factors. Doing this for each time period provides a relative index of each pattern's overall importance. However, since the distribution of explained variance is the same across all factors in the same time period, it is the equivalent of multiplying each set of correlations by a constant. Therefore, a measure of the dominant overall pattern associated

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with Montreal's urban ecological structure can be obtained by simply summing across all factors for each time period. By dividing each summation by the number of factors an overall average pattern correlation is obtained. From this procedure, it is clear that nucleation is by far the most important pattern in Montreal's urban structure, while zonal and sectorial patterning are less important respectively. This result indicates that the lack of inclusion of the nucleation pattern may have been a critical omission in previous studies. Furthermore, by comparing the results of previous studies with the results of the present study some interesting pattern consistencies appear. Substantial agreement is found among the first two factors dealing with Socio-economic and Family status. However, where indeterminacy exists in other studies between sectorial and zonal distributions this study indicates primarily nucleated distributions (See Table 6.9). This may indicate similarity rather than dissimilarity in the findings if failure to include the nucleated pattern resulted in that pattern being called indeterminant. This would seem a reasonable but by no means proved explanation for some of the difference in findings.

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Table 6.9

Comparative Summary of

Urban Structure Factor Patterns[1]

FACTORS	SECTORIAL	ZONAL	NUCLEATED	INDETERMINANT BETWEEN SECTORIAL AND ZONAL PATTERNS
Static Patterns				
Socio-Economic Status (51)	(T) (C) (A) (M)			
Socio-Economic Status (61)	(T) (C) (A) (M)			
Family Status (51)		(T) (C) (A) (M)		
Family Status (61)		(T) (C) (A) (M)		
Ethnic Status (51)			(M)	(T)
Ethnic Status Italian (61)			(M) (C)	(T)
Ethnic Status Jewish (61)	(T)			

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Table 6.9 (Continued)

FACTORS	SECTORIAL	ZONAL	NUCLEATED	INDETERMINANT BETWEEN SECTORIAL AND ZONAL PATTERNS
Recent Growth (51)	(T)	(M)		
Recent Growth (61)			(M)	(T) (C)
Secondary Employment (51)			(M)	(T)
Household Characteristics (51)	(T)			
Secondary Household and Employment (61)	(T)		(M)	
Change Patterns				
Suburbanization Urbanization Family Status Change	(T)			(T) (M)*
Ethnic Change	(T)		(M)	
Eastern Europe Ethnic Change				(T)

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Table 6.9 (Continued)

FACTORS	SECTORIAL	ZONAL	NUCLEATED	INDETERMINANT BETWEEN SECTORIAL AND ZONAL PATTERNS
Secondary Household and employment Change			(M)	(T)
Residential Change		(T)		
Recent Growth Change			(M)	

C: Chicago Study by Berry and Tennant (1965) using Analysis of Variance, as reported in Berry and Horton, Op. Cit. (no time dimension)
A: Akron, Dayton, Indianapolis and Syracuse Studies by Anderson and Egeland (1961) using Analysis of Variance (no time dimension). T.R. Anderson and J.A. Egeland, "The Spatial Aspects of Social Area Analysis," American Sociological Review, Vol. 26 (June, 1961), pp. 392-398.
T: Toronto Study by Murdie (1969) using Analysis of Variance (time dimension)
M: Montreal Study using Spatial Filtering and Correlation Techniques (time dimension)
*: Indeterminant among all three patterns

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1 Summary of findings as noted in Berry and Horton, Op. Cit., Murdie, Op. Cit. and present study.

CHAPTER VII

SUMMARY

Review of Conclusions

The purpose of this study was to examine Montreal's urban structure in terms of two spatial characteristics, distribution and arrangement. In order to do this the Montreal urban structure was summarized by factor analysis for 1951 and 1961. The results confirm much of the previous research in factorial ecology and social analysis in a cross-cultural setting. Furthermore, tests on the characteristics of urban ecological structure indicate it is a "naturally" orthogonal structure[1] with strong temporal invariance. Although the internal consistency of factors is not as great as might be desired, the consistency is reasonably reliable. The spatial distribution of factors created by this analysis is extremely stable through time.

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[1] Structure is defined here as a group of variables or attribute sets otherwise called factors. It is these factors and hence the variables that make them up that are "naturally" orthogonal.

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Three aspects of the spatial character or urban ecological structure were examined. The first dealt with the relative concentration or dispersion of attributes of urban structure, rather than an absolute measurement of the level of an attribute in a locational element. The different results which developed from the urban distribution analysis indicate that new information is generated by utilizing relative rather than absolute measurements. Although comparative analysis indicated the robustness of each technique, another spatial parameter distribution, was added to our understanding of urban structure. This new parameter indicated that the mutually orthogonal urban structure factors had similar uni-dimensional distributional characteristics in urban space. This analysis also indicated that specific attributes or groups of attributes that were a dominant aspect of one of Montreal's urban structure factors, such as the English on the Socio-economic Factor (Structure Factor I), was in its uni-dimensional distributional character as segregated as other minority groups. This does not mean that the uni-lingual English characteristics and minority group characteristics occupied the same

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locational position in urban space, but rather that their relative distribution or degree of dispersion is quite similar. Furthermore, a specific minority group such as the Italian population in Montreal has a distributional characteristic similar to that of the most wide-spread urban characteristics. The importance of this result is that it emphasizes the spatial cross-patterning of urban structure, a patterning that is not at all clear from traditional factorial ecology which simply identifies the co-variance among absolute measures.

The second level of analysis deals with the arrangement in space of urban structure. The arrangement patterns tested were generated from theoretical expectations of the three classical urban models. The results were compared with other empirical findings. Two conclusions are noteworthy. First, the techniques utilized by previous studies excluded clustered or nucleated patterns. The consequence of this seems to have been an artificial constraining of results which characterized nucleated patterns as indeterminant between sectorial and zonal patterns. Second, the limited empirical quantitative findings of previous studies have been, in the main,

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substantiated for Montreal despite the city's special cultural characteristics.

The final and perhaps most important aspect of this study has been the emphasis placed on spatial change in urban structure. Spatial change was examined in the context of distribution and arrangement. In the context of the former, it was demonstrated that spatial change in urban structure was most correlated with that aspect of distributional change typified by the general Montreal Factor (distribution Factor I) and by the distributional dimension typical of suburbanization, distribution Factor IV (Male Labour Force). In the context of arrangement, however, the dominant pattern of spatial change was nucleation. These results may or may not be unique to Montreal since comparative studies had not dealt with the distributional character of urban structure nor allowed for the range of patterns tested here. As was noted earlier, substantial agreement does exist between the results of static analysis in this study and those of others, particularly in the areas of zonal and sectorial patterning. Further, it was shown that where other studies' results were indeterminant between zonal

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and sectorial patterns on specific factors this analysis tested them as being basically clustered or nucleated. This indicated that the lack of inclusion of a nucleated pattern to be tested may account not only for the indeterminancy of their results, but also for some of the disagreement in findings between this study and others. If this is the case, the results indicate that Montreal does not appear to be unique in regard to its urban spatial structure.[1]

Directions of Future Research

Future research in this field will be of two general types. The first is to continue this macro-level approach and the second is to shift the emphasis from areal to individual characteristics and examine more specifically the process of change itself. With regard to the former an important line of research has been outlined but not fully exploited. It deals with the relationship of

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[1] L.J. King. "Cross-sectional Analysis of Canadian Urban Dimensions." The Canadian Geographer, Vol. 10 (1966), pp. 205-244.

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ecological structure to change in urban scale. Hawley and Duncan have criticized social area analysis as not taking into account this relationship.[2] Furthermore, only Udry has dealt with the relationship between scale and spatial differentiation against the theoretical backdrop of social area analysis.[2] Recent findings, however, do indicate that the spatial pattern of urban structure may be sensitive to changes in urban scale.[3] An important research thrust into this area may be able to "shed light" on the relationship between growth and spatial differentiation in urban areas.

A second possible line of future research would concentrate on the individual rather than areal characteristics of change. An understanding of the process by which an area's social characteristics change involves focussing closely on the mechanisms

---

1 A.H. Hawley and Otis Dudley Duncan. "Social Area Analysis: A critical Appraisal." Land Economics. Vol. 33 (November, 1957), pp. 337-345.

2 R. Udry. "Increasing Scale and Spatial Differentiation: New Tests of Two Theories from Shevky and Bell." Social Forces. Vol. 42 (May, 1964), pp. 403-417.

3 Berry and Horton. Op. Cit.

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that relate to change, the most overt of which would seem to be migration. The need to shift the focus of studies from this macro-level analysis of areal change to the decision process of individuals or groups that produce such change is compelling.[1] The recent revival of interest in social indicators may be useful in building a conceptual bridge between the social characteristics of areas and the decision characteristics of individual actors that make them up. If this link could be forged, the results would prove extremely fruitful to the fields of urban geography and regional planning.

---

[1] A beginning has been suggested by W.S. Robinson. "Ecological Correlations and the Behavior of Individuals." American Sociological Review, Vol. 15 (1950), pp. 351-357, and presently is being researched in the migration context by Lawrence A. Brown and Eric Moore, "The Intra-Urban Migration Process: An Actor Oriented Model," (unpublished paper, Dept. of Geography, University of Iowa, April, 1968).

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APPENDIX A

Summary of Local Place Names and Problem Characteristics of Study Areas

For reference purposes, local place names associated with particular study areas have been arranged in an arbitrary hierarchy. Numbers refer to study areas. Study areas with particular problem characteristics have been identified.

I - Montreal Island - Central

A)	St. Laurent	i)	Jules Poitras	- 208
		ii)	Saraguay	- 280
		iii)	Ste. Croix	- 209
		iv)	Bois-Franc	- 211
		v)	Du College	- 210
B)	Back River	i)	Cartierville	- 207
		ii)	Bordeaux	- 206
		iii)	Ahuntsic	- 205, 204 201, 292
C)	Montreal West	i)	Lachine	249, 250, 251 252, 253, 254

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ii) St. Pierre - 255, 256

iii) Cote St. Luc 257,291*, 290*

iv) Hampstead 96, 97, 260, 261

v) Notre-Dame-de-Grace 83, 84 85, 86, 87, 90, 91, 92, 93

D) Montreal South

i) Lasalle 246, 247, 248

ii) Cote Saint-Paul 257, 278, 290, 291

iii) Verdun 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244*, 245, 246

iv) Pointe St. Charles 61*, 62, 63, 64, 65, 60*

E) Lower Montreal

i) St. Henri 70, 71, 72, 73, 74, 75

ii) Petit Burgundy 58, 66, 67, 68, 69

iii) St. Jacques 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 49, 50, 48, 51, 52

iv) Commercial District (CBD) 53, 54, 57

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F) Upper Montreal

i) Westmount 223, 224, 225, 226, 227, 228, 229

ii) Cote-des-Neiges 94, 95, 98, 99, 102, 103*, 104*

iii) Town of Mount-Royal 101, 213, 214, 100*, 278*

iv) Outremont 215, 216, 218, 219, 220, 221, 222

v) McGregor-Pine 105*

G) St. Denis

i) Milton Parc 106, 107, 108, 109, 110, 112, 121, 122, 123, 124, 125, 126, 127

ii) Parc Lafontaine 126, 127, 128, 129, 130, 140, 141*, 142, 143 145, 146, 144

iii) Esplanade 112, 113, 114, 115, 116, 117, 118, 111, 119, 120

iv) Villeray 188*, 172, 173, 171, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200

v) Laurier 134, 135, 136, 137, 138, 150, 133, 132, 131, 139, 148, 147, 151

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	vi)	Mile End	182, 183, 184, 179, 180
	vii)	Parc Extension	185, 186, 187
	viii)	St. Edward	174, 176, 175, 177, 178, 181

II - West Island

A) West End	i)	Senneville	-277
	ii)	Ste. Anne de Bellevue	-276
	iii)	Baie d'Urfe	-274
	iv)	MacDonald College	-275*
B) Lakeshore	i)	Beaconsfield	-273
	ii)	Pointe Claire	-272
	iii)	Dorval	-262
C) Northshore	i)	Dollard-des-Ormeaux	-279
	ii)	Ste. Genevieve	-258
	iii)	Pierrefonds-Roxboro	-288
	iv)	Ile Bizard	-160*

III - East Island

A) East End	i)	Pointe-aux-Trembles	-271

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	ii)	Riviere-des-Prairies	-268
	iii)	Ville d' Anjou	-267
	iv)	Longue-Pointe	1, 2, 3, 4, 5*, 270*
	v)	Montreal-Est	-269
B) Maisonneuve	i)	Rosemont	151, 152, 153, 154, 155, 156, 157, 158, 159, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 145, 146, 147, 148, 144, 289*
	ii)	Hochelaga-Frontenac	6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25, 26, 27, 28, 29, 30, 23
C) East River	i)	St. Leonard	-266
	ii)	St. Michel	-263
	iii)	Sault-aux-Recollets	203, 264
	iv)	Montreal-Nord	-265

IV - Off-Island

A) Ile Jesus	i)	Chomedey	-287
	ii)	Laval	-212

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	iii)	Pont Viau	-259
B) South Shore	i)	Preville	-286
	ii)	Ste. Lambert	-202
	iii)	Greenfield Park	-285
	iv)	Lafleche	-283
	v)	Longueuil	-282
	vi)	Jacques-Cartier	-281

* Areas where parks, institutions and other non-residential land uses predominate; MacDonald College of McGill University (275); Ile Bizard, recreation area, seasonal housing, golf course, country club (160); St.-Jean-de-Dieu Hospital (270); Maisonneuve Park, golf course, botanical gardens (289); Longue-Pointe railway yards (5); Lafontaine Park (141); Douglas Hospital (244); Universite de Montreal (103); Cimetiere Notre-Dame-des-Neiges (104); Mixture of residential, park, hospital and higher education institutions (105); Blue Bonnets Race Course, light industry and cemetery (290), (291) and (100); Jarry Park, sports (188); Pointe St. Charles Railway Yards (61); Harbour Ware; houses (60); Industrial (278).

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APPENDIX B

As noted previously, most of the variables used in the definition of urban structure are found in the Census of Canada 1951 and 1961. Although most of the variable definitions are reasonably straight-forward, a discussion of the more complex variables has been carried out.

1) Males to females (ratio)

2) Age Dependency - refers to the ratio of non-labour force age population (under 15 and over 65) to labour force age population (16 - 64), regardless of sex or actual labour force participation. (ratio)

3) Total Dependency - refers to the ratio of total population to labour force population, regardless of sex or age. (ratio)

4) Population over 65 (percent)

5) Population under 15 (percent)

6) Singles to marrieds (ratio)

7) Single population (percent)

8) Married population (number)

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9) Population of British ethnic origin (percent)

10) Population of French ethnic origin (percent)

11) British to French ethnic origin (ratio)

12) Population of Asiatic ethnic origin (percent)

13) Population of other European ethnic origin (percent) (ethnic origin from a major European nationality other than those listed elsewhere). The purpose was to capture the distribution of the residual European ethnic population.

14) Population listing English as their official language (number)

15) Population listing French as their official language (percent)

16) French and English language, population which considers itself bilingual (percent)

17) Uni-lingual French to uni-lingual English (ratio)

18) Uni-lingual population to bilingual population (ratio)

19) Population of Jewish affiliation (number)

20) Population of Roman Catholic religious affiliation (percent)

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21) Population not attending school with no formal education (percent)

22) Population attending school to population with no formal education (ratio)

23) Male labour force to female labour force (ratio)

24) Female labour force (percent)

25) Males to females looking for work (ratio)

26) Males looking for work[1] to those with jobs (ratio)

27) Females looking for work[1] to those with jobs (ratio)

28) Total labour force looking for work (number)

29) Total wage-earners to total self-employed (where wage-earners is defined as persons working for others for wages, tips or salaries, and self-employed is defined as persons operating their own business or professional practice).[2] (ratio)

30) Female wage-earners to female self-employed[1] (ratio)

31) Male wage-earners to male self-employed[1] (ratio)

32) Labour force population with occupational classification as Managers (percent)

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33) Labour force population with occupational classification as Professional and Technical (percent)

34) Division of occupational classification grouping the labour force in clerical, sales, services and recreation, and transportation and communications as class I workers.[3] (percent)

35) Division of occupational structure grouping the labour force in agriculture (gardeners, etc.), miners, quarrymen and related workers, craftsmen and production process oriented worker occupations as class 2 workers.[3] (percent)

36) Labour force with an occupational classification of labourers (percent)

37) Male labour force in class 1 to class 2 occupational groupings[1,3] (ratio)

38) Female labour force in class 1 to class 2 occupational groupings[1,3] (ratio)

39) Wage-earners with a yearly income $>$ \$4,000 (percent)

40) Wage-earners with a yearly income $<$ \$4,000 (percent)

41) Male wage-earners with a yearly income $<$ \$4,000 to those $>$ \$4,000 per year (ratio)

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42) Female wage-earners with a yearly income < $4,000 to those > $4,000 per year (ratio)

43) Occupied dwelling units to vacant dwelling units (ratio)

44) Families per dwelling unit (number)

45) Family to non-family households (ratio)

46) Population attending to not attending school (ratio)

47) Families with one child (number)

48) One family households to others (ratio)

49) Families with zero child (number)

50) Families with more than five children (number)

51) Families without wage-earner heads (number)

52) Dwellings which are single and detached (percent)

53) Dwellings which are apartments (percent)

54) Single detached dwellings to apartment dwellings and flats (ratio)

55) Dwellings occupied less than two years (percent)

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56) Dwellings occupied three to five years (ratio)

57) Affluence to spatial stability (ratio). Surrogate values were used to create this measure. Number of cars was used as a surrogate for affluence and number of years of dwelling occupancy was used as a measure of spatial stability.

58) Dwelling units with private flush toilets (percent)

59) Dwelling units with private bath or shower (percent)

60) Cars per dwelling (percent)

61) Housing quality to affluence (ratio). Flush toilets were used as a lower bound surrogate measure of housing quality and number of cars was used as a measure of affluence.

62) Flush toilets to families (ratio)

63) Cars to families (ratio)

64) Dwellings with furnace heat (central heating) (number)

65) Population attending school (number)

66) Rooms per dwelling unit (ratio)

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67) Persons per room (ratio)

68) Dwellings mortgaged (percent)

69) Males in current labour force (number)

70) Females in current labour force (number)

71) Persons per dwelling (ratio)

72) Population not attending school with three years of high school education, and over (percent)

73) Population not attending school with less than 9 years of education (percent)

74) Population of German ethnic origin (percent)

75) Population of Italian ethnic origin (percent)

76) Population of Dutch ethnic origin (percent)

77) Population of Polish ethnic origin (percent)

78) Population of minor European (not classified by nationality) ethnic origin (percent)

79) Population of Ukranian ethnic origin (percent)

80) Population of Anglican (Church of England) religious affiliation (percent)

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81) Population of Greek Orthodox religious affiliation (percent)

82) Population of Ukranian (Greek) Catholic religious affiliation (percent)

83) Population of Lutheran religious affiliation (percent)

84) Population of Anglican to Roman Catholic religious affiliations (ratio)

85) Labour force female to the length of dwelling occupancy (ratio)

86) Single detached plus apartment dwellings to others. This is an attempt to identify the large number of semi-detached multiple family dwellings (duplexes) which make up an important part of the housing stock in Montreal's inner suburbs.[4] (ratio)

87) Dwelling occupancy of less than two years to greater than six years. (ratio)

88) Dwellings owner-occupied (percent)

89) Dwellings owner-occupied with a mortgage (number)

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[1] Dominion Bureau of Statistics notes that sex is a major income differentiator in Canadian employment. J.R. Podoluk, Earnings and Education (Ottawa: Dominion Bureau of Statistics, Advance Release from Census Monography 'Income of Canadians", Central Research and Development Staff, 1965), Catalogue No. 91-510, Occasional.

[2] Research by the Dominion Bureau of Statistics indicates that this is a critical variable in income differentiation among Canadians, next to sex, age and education, respectively. Podoluk, Op. Cit., p. 29.

[3] This division does have validity with regard to income differentiation after standardization for age and education. Poduluk, Op. Cit., and U.S. Bureau of the Census, Present Value of Estimated Lifetime Earnings, Technical Paper No. 16. (Washington, D.C.: U.S. Government Printing Office, 1967).

[4] P. Camu. "Types de maisons dans la region suburbaine de Montreal." The Canadian Geographer, No. 9 (1957), pp. 21-29.

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APPENDIX C

Variables used in the definition of urban distribution are derived from the structure variable list found in Appendix B. As noted in the text the primary difference between the structure and distribution variables is their form. These form differences are discussed in the text. Discussion of the inclusion of specific variables found in Appendix B applies equally to their altered form as listed below.

1) Ratio c.t./m.a.[1] males to c.t./m.a. females

2) Ratio of c.t./m.a. old to c.t./m.a. young

3) Ratio of c.t. old to m.a. young

4) Proportion of m.a. young in c.t.

5) Proportion of m.a. young in c.t.

6) Ratio of c.t./m.a. singles to c.t./m.a. marrieds

7) Proportion of m.a. singles in c.t.

8) Proportion of m.a. married in c.t.

9) Proportion m.a. British in c.t.

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10) Proportion of m.a. French in c.t.

11) Ratio of c.t./m.a. British to c.t./m.a. French origin

12) Proportion of m.a. Asiatic in c.t.

13) Proportion of m.a.'s other European in c.t.

14) Proportion of m.a. English speaking only in c.t.

15) Proportion of m.a. French speaking only in c.t.

16) Proportion of m.a. two language population in c.t.

17) Ratio of c.t./m.a. English to c.t./m.a. French speaking

18) Ratio of c.t./m.a. bilingual population to c.t./m.a. unilingual population

19) Proportion of m.a. Jewish in c.t.

20) Proportion of m.a. Roman Catholic in c.t.

21) Proportion of m.a. with no education in c.t.

22) Ratio of c.t./m.a. attending school to c.t./m.a. with no education

23) Ratio of c.t./m.a. male labour force to c.t./m.a. female labour force

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24) Proportion of m.a. female labour force in c.t.

25) Proportion of m.a. male labour force in c.t.

26) Ratio of c.t./m.a. males looking for work to c.t./m.a. males with job

27) Ratio of c.t./m.a. females looking for work to c.t./m.a. females with job

28) Proportion of m.a. looking for work in c.t.

29) Ratio of c.t./m.a. wage-earners to c.t./m.a. self-employed

30) Ratio of c.t./m.a. female wage-earners to c.t./m.a. females self-employed

31) Ratio of c.t./m.a. males wage-earners to c.t./m.a. males self-employed

32) Ratio of c.t./m.a. female managers to c.t./m.a. population

33) Ratio c.t./m.a. female professional and technical to c.t./m.a. population

34) Ratio of c.t./m.a. female Class 1 workers to c.t./m.a. population

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35) Ratio of c.t./m.a. female Class 2 workers to c.t./m.a. population

36) Ratio of c.t./m.a. female labourers to c.t./m.a. population

37) Ratio of c.t./m.a. male Class 1 workers to c.t./m.a. male Class 2

38) Ratio of c.t./m.a. female Class 1 workers to c.t./m.a. female Class 2

39) Proportion of m.a. wage-earners earning over $4,000 in c.t.

40) Proportion of m.a. wage-earners earning under $4,000 in c.t.

41) Ratio of c.t./m.a. males earning over $4,000 to c.t./m.a. males earning under $4,000

42) Ratio of c.t./m.a. females earning over $4,000 to c.t./m.a. females earning under $4,000

43) Proportion of m.a. labour force earning over $4,000 in c.t.

44) Ratio c.t./m.a. attending with 9th grade education to c.t./m.a. not attending with 9th

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45) Ratio of c.t./m.a. occupied dwellings to c.t./m.a. unoccupied dwellings

46) Ratio of c.t./m.a. family households to c.t./m.a. non-family households

47) Proportion of m.a. one child family households in c.t.

48) Proportion of m.a. single detached dwellings in c.t.

49) Proportion of m.a. apartments and flats in c.t.

50) Ratio of c.t./m.a. apartments, flats to c.t./m.a. single detached

51) Proportion of m.a. dwellings occupied 2 years in c.t.

52) Proportion of m.a. dwellings with flush toilet in c.t.

53) Proportion of m.a. dwellings with bath and/or shower in c.t.

54) Proportion of m.a. dwellings with car in c.t.

55) Ratio of c.t./m.a. conviences (bath, shower, flush toilet) to c.t./m.a. families

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56) Ratio of c.t./m.a. cars to c.t./m.a. families

57) Proportion of m.a. dwellings with furnace in c.t.

58) Proportion of m.a. population attending school in c.t.

59) Ratio of c.t. to m.a. rooms per dwelling

60) Ratio of c.t./m.a. population to c.t./m.a. rooms

61) Proportion of m.a. dwellings owner occupied with a mortgage in c.t.

62) Ratio of c.t./m.a. population to c.t./m.a. dwellings

63) Proportion of m.a. population with 3 years high school and up in c.t.

64) Proportion of m.a. with less than 9 years of education in c.t.

65) Proportion of m.a.'s German in c.t.

66) Proportion of m.a. Italians in c.t.

67) Proportion of m.a. Netherlands in c.t.

68) Proportion of m.a. Polish in c.t.

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69) Proportion of m.a. Ukranian in c.t.

70) Proportion of m.a. Anglican in c.t.

71) Proportion of m.a. Greek Orthodox in c.t.

72) Proportion of m.a. Ukranian (Greek) Catholic in c.t.

73) Proportion of m.a. Lutheran in c.t.

74) Ratio of c.t./m.a. Anglican to c.t./m.a. Roman Catholic

75) Ratio of c.t./m.a. other dwellings to c.t./m.a. single-detached and apartments

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[1] c.t. is census tract. m.a. is metropolitan area.

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APPENDIX D-I

DATA TRANSFORMATIONS

-Data transformed to be as near normal as possible using Snedecor's tests for Symmetry and Kurtosis[1]

Transformations Used (1961, 1951)

I	Log
II	Square
III	Cube
IV	Square Root
V	Cube Root

Attribute No.	Transformation Used (61, 51)		Attribute No.	Transformation Used (61, 51)	
1	I	I	24	V	I
2	I	I	25	I	I
3	III	None	26	II	II
4	I	I	27	III	II
5	II	None	28	I	I
6	I	I	29	I	I
7	I	I	30	I	I
8	V	III	31	I	I
9	I	I	32	I	I
10	III	III	33	I	I
11	I	I	34	I	I
12	I	I	35	II	II
13	I	I	36	I	None
14	I	I	37	I	I
15	II	None	38	I	I
16	II	II	39	I	I
17	I	I	40	III	III
18	I	I	41	I	I
19	I	I	42	IV	III
20	III	III	43	V	IV
21	I	I	44	I	III
22	I	I	45	I	IV
23	I	I	46	I	I

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Attribute No.	Transformation Used (61, 51)		Attribute No.	Transformation Used (61, 51)	
47	I	I	69	III	II
48	II	I	70	I	I
49	I	V	71	I	I
50	IV	III	72	I	I
51	V	I	73	III	III
52	I	I	74	I	I
53	III	III	75	I	I
54	I	I	76	I	I
55	II	IV	77	I	I
56	IV	II	78	I	I
57	IV	I	79	I	I
58	III	III	80	I	I
59	III	III	81	I	I
60	None	V	82	I	I
61	I	I	83	I	I
62	I	III	84	I	I
63	None	I	85	I	I
64	None	I	86	I	I
65	II	I	87	IV	I
66	I	III	88	IV	I
67	I	I	89	I	I
68	I	I			

---

[1] G.W. Snedecor. Statistical Methods. (Ames, Iowa: Iowa State College Press, 1946).

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APPENDIX D-II

DATA TRANSFORMATIONS

Data was transformed to be as near normal as possible using Snedecor's tests for Symmetry and Kurtosis.[1]

Transormation Used (1951, 1961)

I Log
II Square
III Cube
IV Square Root
V Cube Root

Attribute No.	Transformation Used (61, 51)		Attribute No.	Transformation Used (61, 51)	
1	V	IV	21	I	I
2	V	-	22	V	IV
3	I	V	23	IV	IV
4	V	IV	24	I	I
5	I	V	25	IV	V
6	V	V	26	IV	IV
7	V	IV	27	I	I
8	I	V	28	V	V
9	I	I	29	V	V
10	I	IV	30	V	V
11	I	I	31	V	V
12	I	I	32	V	V
13	I	I	33	V	V
14	I	I	34	II	IV
15	I	I	35	II	II
16	I	IV	36	V	None
17	I	I	37	V	V
18	I	I	38	V	V
19	I	I	39	I	I
20	I	IV	40	V	IV

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Attribute No.	Transformation Used (61, 51)		Attribute No.	Transformation Used (61, 51)	
41	V	I	59	IV	II
42	V	I	60	I	I
43	III	II	61	I	I
44	V	V	62	I	I
45	V	None	63	I	I
46	IV	None	64	I	V
47	IV	IV	65	I	I
48	I	I	66	I	I
49	V	IV	67	I	I
50	I	I	68	I	I
51	V	V	69	V	V
52	I	IV	70	I	I
53	I	IV	71	I	I
54	I	V	72	I	I
55	IV	II	73	I	I
56	None	IV	74	I	I
57	I	V	75	I	I
58	I	I			

---

[1] Snedecor. Op. Cit.

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APPENDIX E

Results of Multiple R Solution of Communality Problem

Multiple R^2 Principal Axis Factor Analysis

Dimensions		% Explained Variance	
I	Socio-Economic Status	26.7	25.9
II	Family Status	13.5	11.2
III	Recent Growth	10.0	9.6
IV	Ethnic Status	7.5	7.0
V	Secondary Household Characteristic Status	6.0	5.5

Principal Axis (R^2) Stability Matrix 1951 x 1961

		1961				
		I	II	III	IV	V
1	I	.945	.011	.065	.021	.045
9	II	-.020	.884	.425	-.078	.061
5	III	.051	.412	-.741	.338	-.354
1	IV	-.044	-.111	.420	.806	-.201
	V	-.051	.095	-.067	.075	.519

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Summary of Principal Axis (R^2) Factor Analysis (1961)[1]

	I	II	III	IV	V
λ	22.78	11.48	8.56	6.35	5.11
Explained variance	26.73	13.47	10.04	7.45	5.99
Cumulative variance	26.73	40.20	50.24	57.69	63.68

88.75% of the trace was extracted by 15 roots >1.

Summary of Principal Axis (R^2) Factor Analysis (1951)

	I	II	III	IV	V
λ	21.77	9.39	8.04	5.89	4.57
Explained variance	25.94	11.19	9.58	7.01	5.45
Cumulative variance	25.94	37.13	46.71	53.72	59.17

87.66% of the trace was extracted by 17 roots > 1.

---

[1] Since the Varimax Rotation did not produce simple structure in 1961, it was decided to compare the principal axis factors for both periods.

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DIMENSION I

SOCIO-ECONOMIC STATUS

(Occupation, Education, Income & Major Ethnic Groups)

Dimension I Attribute List*		Loadings 1951	1961
9	% of population of British origin	761	783
10	% of population of French origin	-751	-717
14	% of population speaking English only	784	771
15	% of population speaking French only	-809	-748
20	% of population Roman Catholic	-803	-822
32	% of Labour Force Managers	862	894
33	% of Lab our Force Professional & Technical	751	799
34	% of Labour Force Class 1 workers	610	848
35	% of Labour Force Class 2 workers	-838	-840
36	% of Labour Force Labourers	-814	-702
37	Ratio of Class 1 to Class 2 (male)	779	815
38	Ratio of Class 1 to Class 2 (females)	768	793
39	% of Wage Earners over $4,000	900	726
40	% of Labour Force under $4,000	-758	-750
41	Ratio under $4,000 to over $4,000 (males)	768	822
42	Ratio under $4,000 to over $4,000 (females)	760	833
63	Ratio of cars to families	770	760
64	% of Dwellings with furnace heat	781	787
72	% of population with 3 years high school education and above	856	928
73	% of population with 9 years of education or less	-862	-351
74	% of population German	617	768
80	% of population Anglican	753	794

* All attributes with a .750 correlation with Factor I for at least one point in time are listed.

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DIMENSION II

(Young population, high dependency ratio, inverse females in labour force)

Dimension II Attribute List*		Loadings 1951	Loadings 1961
3	Ratio of dependents to others	439	771
5	% of population young (under 15)	624	879
65	% of population over 5 years & attending school	346	759
70	% of females in labour force	-516	-803
4	% of population old	-563	-630
7	% of total population over 15 & single	-640	-650
23	Labour force male/female ratio	472	671
24	% of labour force female	-509	-665
44	Ratio of families per dwelling	236	668

* All attributes with a correlation of .650 with Dimension II for at least one point in time are listed.

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DIMENSION III

RECENT GROWTH

(Recent occupancy, young family, few children, low structural density, apartment oriented)

	Dimension III Attribute List*	Loadings 1951	1961
2	Ratio of old dependents to young dependents	-273	-571
3	% of dependents to others	-519	-080
6	Ratio of single to married	-076	-583
18	Ratio of speaking one language to both	-597	-516
29	Ratio of total wage-earners to self-employed	-360	-540
43	Occupied to unoccpueid dwelling units	337	572
45	Family households to others	265	646
47	Ratio of 1 child families to other families	683	635
49	Ratio of 0 child families to all families	439	695
62	Ratio of flush toilets to families	564	468
67	Persons per room	-502	-715
69	% of total males in labour force	639	552
70	% of females in labour force	570	189
71	Ratio of persons per dwelling	-469	-761
52	% of dwellings single detached	-578	-110
55	% of dwellings occupied less than 2 years	122	500
53	% of dwellings apartments to flats	708	441
56	Ratio of all occupied dwellings to occupied 3-5 years	-082	500

* All attributes listed with .500 correlation with Dimension III for at least one time period are listed.

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DIMENSION IV

ETHNIC STATUS

(Minor religions, recent immigrants & minor ethnic groups)

Dimension IV Attribute List*		Loadings 1951	1961
3	% of dependents to others	519	300
12	% of population other European origin	320	597
16	% of population speaking both languages	-507	-528
18	Ratio of population speaking one to speaking both languages	597	553
21	% of population over 5 with no education	221	585
77	% of population Polish	650	601
79	% of population Ukranian	678	631
81	% of population Greek Orthodox	515	616
82	% of population Ukranian (Greek) Catholic	603	610

* All attributes with greater than .500 correlation with Dimension IV for at least one time period are listed.

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DIMENSION V

SECONDARY HOUSEHOLD CHARACTERISTICS

(Marital status, education, participation, employment characteristics)

	Dimension V Attribute List*	Loadings 1951	1961
6	Ratio of single to married	165	583
7	% of population single and over 15	305	596
8	% of population married	-036	-746
45	Family households to others	572	238
46	Ratio of those attending school with 9 years of education to those not attending with 9 years	114	585
51	Ratio of families without wage-earner heads per household	-267	577
43	Occupied to unoccupied dwelling units	579	267
29	Ratio of total wage-earners to self-employed	536	056

* All attributes with loadings over .500 on Dimension V are listed. It is interesting that employment characteristics are not reflected in this dimension. Murdie encountered a similar problem in the stability aspect of this dimension in his Toronto study. Murdie (1969), Op. Cit., pp. 87 and 107-115.

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APPENDIX F

Factor scores were produced in standardized and normalized formats for each time period 1951 and 1961. However, a problem did develop with regard to the normalization of the change scores. Since the first time period was being 'partialled for', it was clear that any transformation for normalization of the change scores would alter the relationship between change and the preceding time period. After examination of the data (see histogram outputs), it was decided that change scores in most cases did approximate a normal distribution and hence it was not necessary to transform the data to normality. Although this is fortuitous in this study, it is clear that this problem could be an important obstacle in this form of analysis.

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HISTOGRAM PLOT OF STRUCTURE CHANGE FACTOR ONE

FREQUENCY	2	1	6	17	45	96	75	24	9	7	4	6

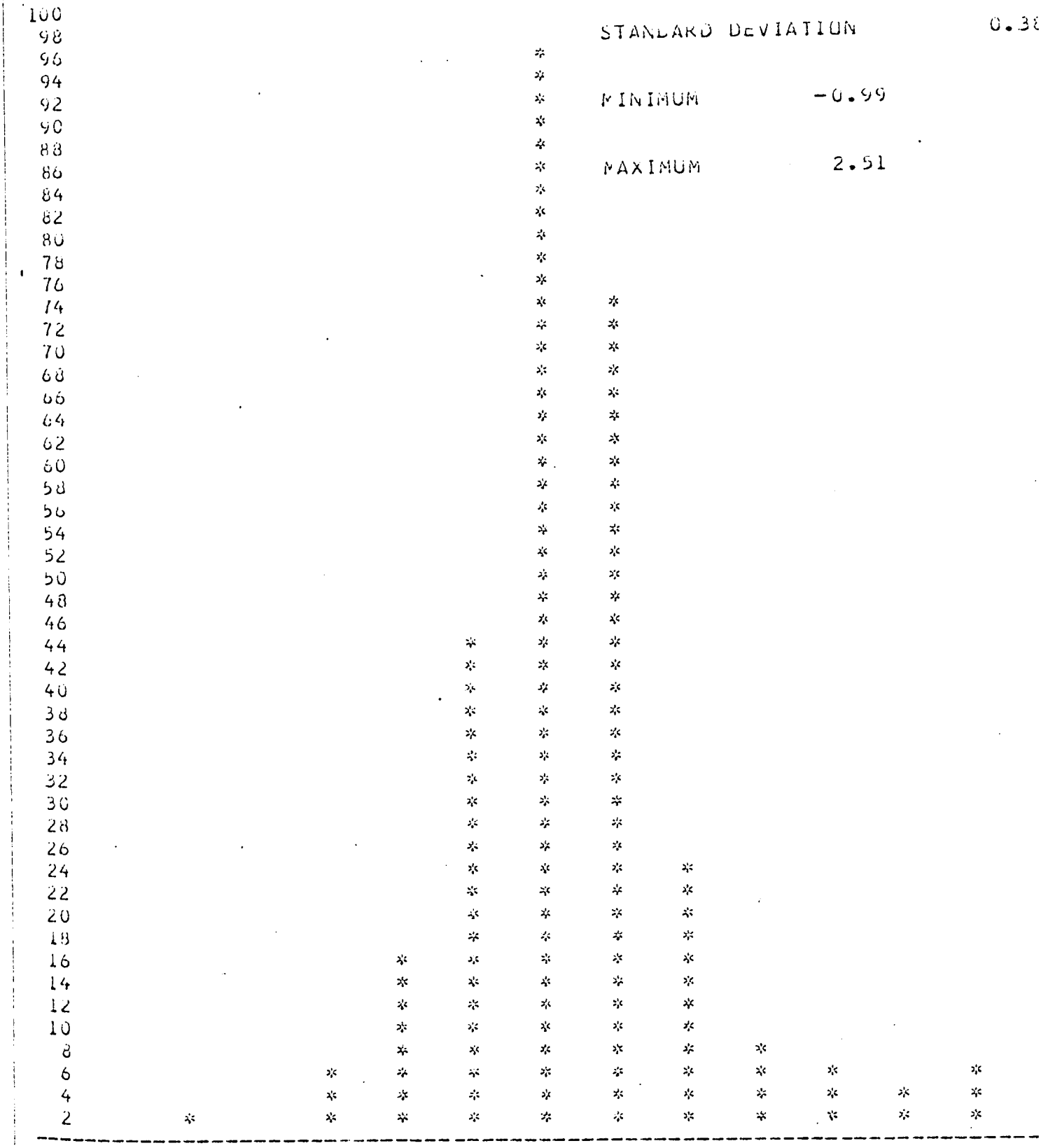
EACH * EQUALS 2 POINTS

AVERAGE -0.00

STANDARD DEVIATION 0.38

MINIMUM -0.99

MAXIMUM 2.51



INTERVAL	1	2	3	4	5	6	7	8	9	10	11	12

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HISTOGRAM PLOT OF STRUCTURE CHANGE FACTOR INC

FREQUENCY 2 4 6 1 17 158 96 12 1 1 0 3

EACH * EQUALS 4 POINTS

AVERAGE -0.00

STANDARD DEVIATION 1.9

MINIMUM -5.51

MAXIMUM 21.10

```
200
196
192
188
184
180
176
172
168
164
160
156  *
152  *
148  *
144  *
140  *
136  *
132  *
128  *
124  *
120  *
116  *
112  *
108  *
104  *
100  *
 96  *  *
 92  *  *
 88  *  *
 84  *  *
 80  *  *
 76  *  *
 72  *  *
 68  *  *
 64  *  *
 60  *  *
 56  *  *
 52  *  *
 48  *  *
 44  *  *
 40  *  *
 36  *  *
 32  *  *
 28  *  *
 24  *  *
 20  *  *
 16  *  *  *
 12  *  *  *  *
  8  *  *  *  *
  4  *  *  *  *
```

INTERVAL 1 2 3 4 5 6 7 8 9 10 11 12

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HISTOGRAM PLOT OF STRUCTURE CHANGE FACTOR THREE

FREQUENCY	2	1	6	24	53	78	61	34	16	7	3	7

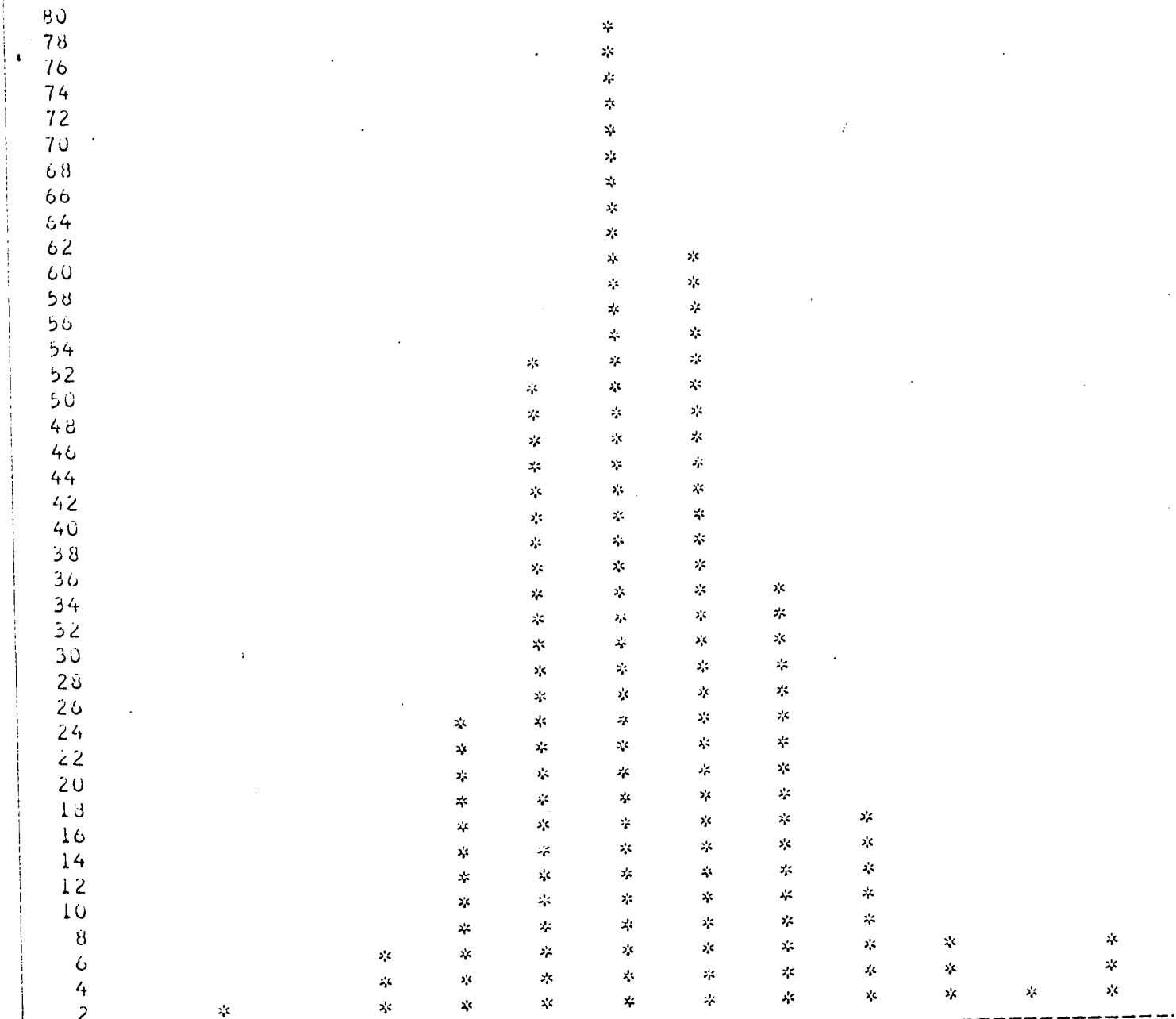
EACH * EQUALS 2 POINTS

AVERAGE 0.00

STANDARD DEVIATION 0.8

MINIMUM -2.09

MAXIMUM 3.12



INTERVAL	1	2	3	4	5	6	7	8	9	10	11	12

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HISTOGRAM PLOT OF STRUCTURE CHANGE FACTOR FOUR

FREQUENCY	4	3	6	15	28	107	83	25	1	10	2	8

EACH * EQUALS 3 POINTS

AVERAGE -0.00

STANDARD DEVIATION 0.87

MINIMUM -2.85

MAXIMUM 4.39

```
150
147
144
141
138
135
132
129
126
123
120
117
114
111
108
105                                  *
102                                  *
 99                                  *
 96                                  *
 93                                  *
 90                                  *
 87                                  *
 84                                  *
 81                                  *  *
 78                                  *  *
 75                                  *  *
 72                                  *  *
 69                                  *  *
 66                                  *  *
 63                                  *  *
 60                                  *  *
 57                                  *  *
 54                                  *  *
 51                                  *  *
 48                                  *  *
 45                                  *  *
 42                                  *  *
 39                                  *  *
 36                                  *  *
 33                                  *  *
 30                                  *  *
 27                            *     *  *
 24                            *     *  *  *
 21                            *     *  *  *
 18                            *     *  *  *
 15                      *     *     *  *  *
 12                      *     *     *  *  *
  9                      *     *     *  *  *        *
  6               *      *     *     *  *  *        *        *
  3      *        *      *     *     *  *  *        *        *
```

INTERVAL 1 2 3 4 5 6 7 8 9 10 11 12

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HISTOGRAM PLOT OF STRUCTURE CHANGE FACTOR FIVE

FREQUENCY 9 3 2 13 35 59 104 46 11 3 2 5

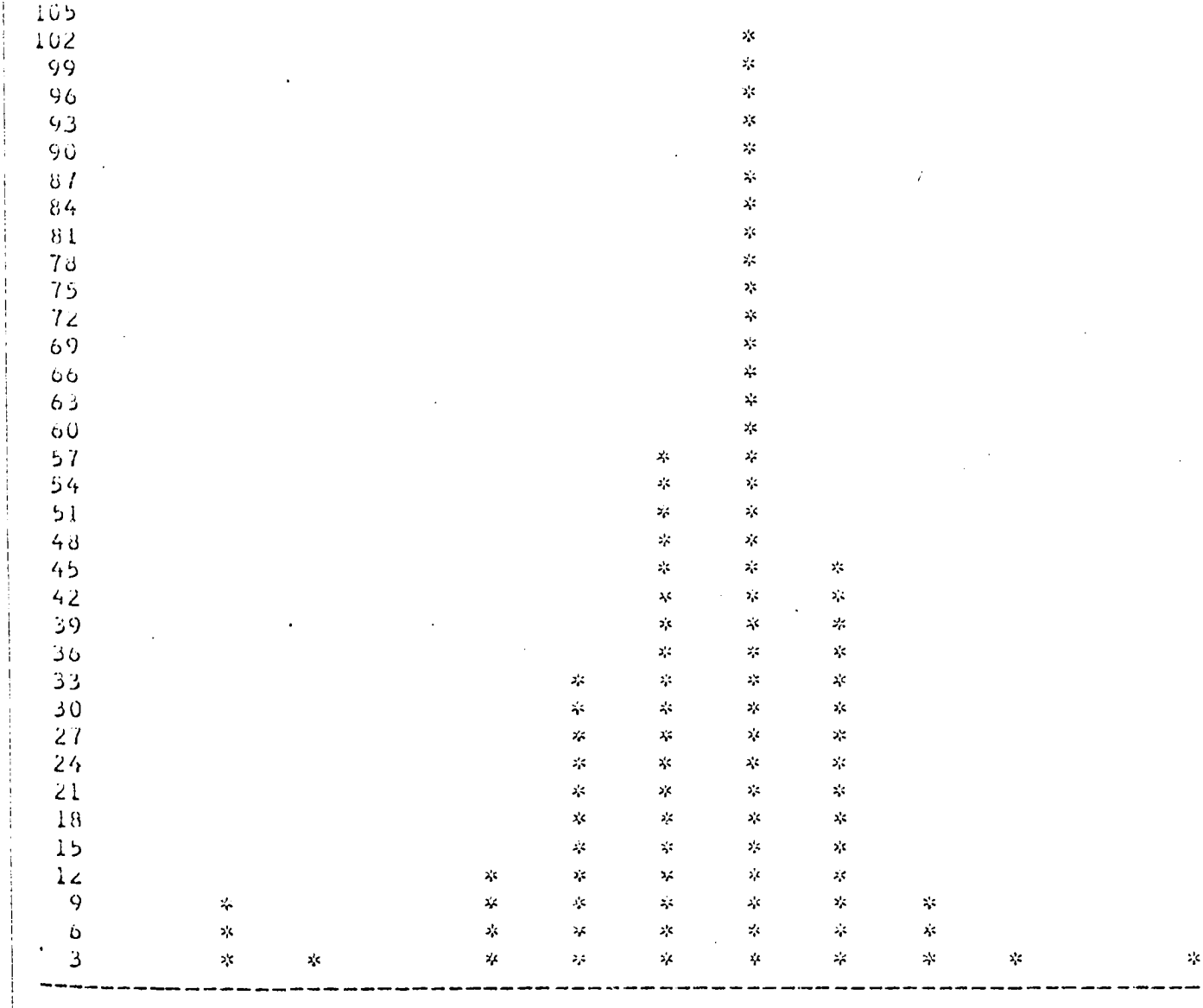
EACH * EQUALS 3 POINTS

AVERAGE 0.00

STANDARD DEVIATION 0.77

MINIMUM -3.79

MAXIMUM 2.68



INTERVAL 1 2 3 4 5 6 7 8 9 10 11 12

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HISTOGRAM PLOT OF SYSTEMS CHANGE FACTOR ONE

FREQUENCY	0	5	6	19	53	102	44	31	10	10	6	4

EACH * EQUALS 3 POINTS

AVERAGE 0.00

STANDARD DEVIATION 0.[illegible]

MINIMUM -1.37

MAXIMUM 2.47

150												
147												
144												
141												
138												
135												
132												
129												
126												
123												
120												
117												
114												
111												
108												
105												
102						*						
99						*						
96						*						
93						*						
90						*						
87						*						
84						*						
81						*						
78						*						
75						*						
72						*						
69						*						
66						*						
63						*						
60						*						
57						*						
54						*						
51					*	*						
48					*	*						
45					*	*						
42					*	*	*					
39					*	*	*					
36					*	*	*					
33					*	*	*					
30					*	*	*	*				
27					*	*	*	*				
24					*	*	*	*				
21					*	*	*	*				
18				*	*	*	*	*				
15				*	*	*	*	*				
12				*	*	*	*	*				
9				*	*	*	*	*	*	*		
6			*	*	*	*	*	*	*	*	*	*
3		*	*	*	*	*	*	*	*	*	*	*
INTERVAL	1	2	3	4	5	6	7	8	9	10	11	12

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HISTOGRAM PLOT OF SYSTEMS CHANGE FACTOR TWO

FREQUENCY	3	11	17	18	19	61	71	47	31	12	1	1

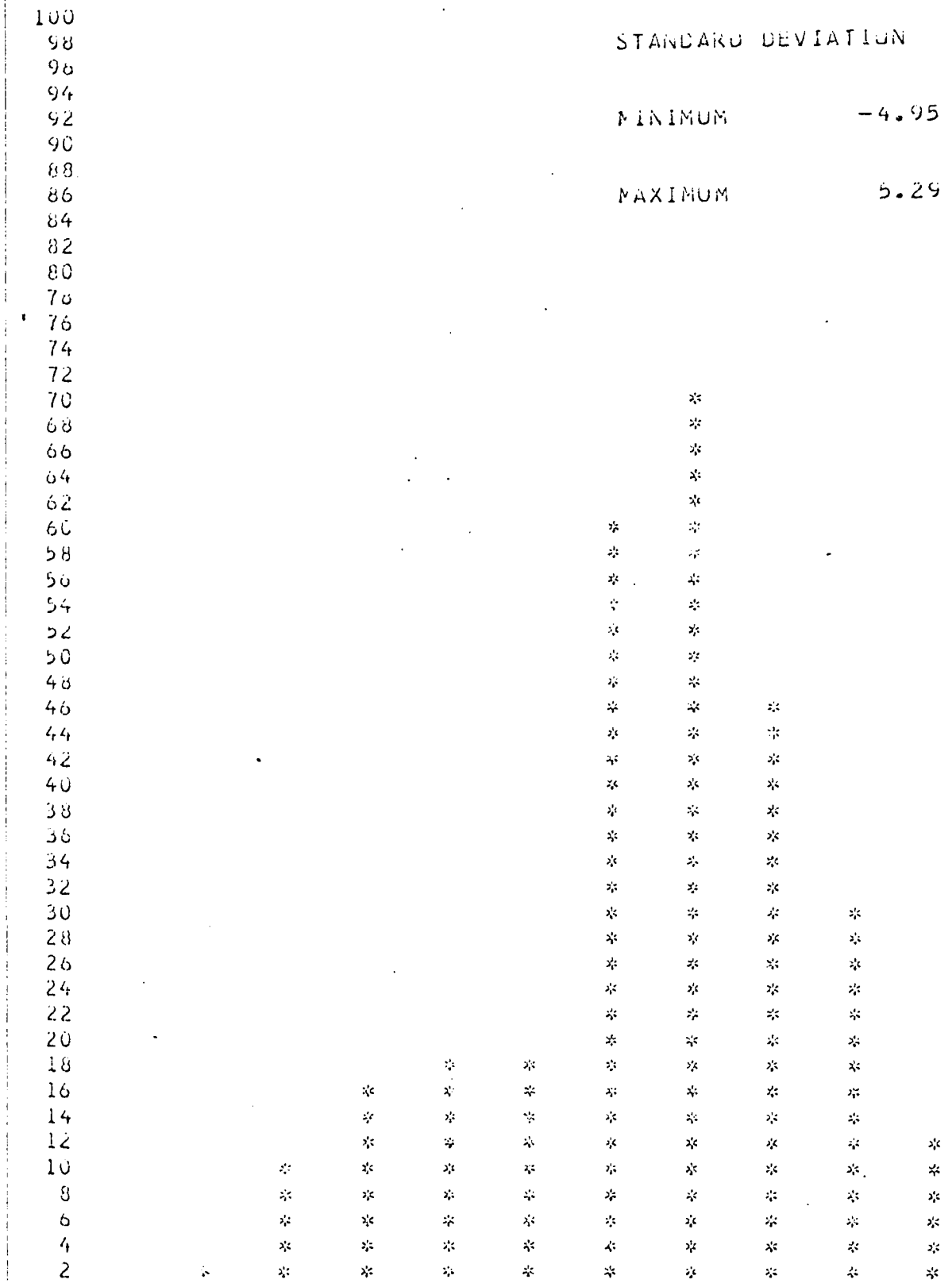
EACH * EQUALS 2 POINTS

AVERAGE 0.00

STANDARD DEVIATION 1.91

MINIMUM -4.95

MAXIMUM 5.29



INTERVAL	1	2	3	4	5	6	7	8	9	10	11	12

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HISTOGRAM PLOT OF SYSTEMS CHANGE FACTOR THREE

FREQUENCY	3	1	0	3	19	111	125	22	4	2	0	2

EACH * EQUALS 3 POINTS

AVERAGE -0.00

STANDARD DEVIATION 0.70

MINIMUM -7.47

MAXIMUM 5.97

150												
147												
144												
141												
138												
135												
132												
129												
126												
123							*					
120							*					
117							*					
114							*					
111						*	*					
108						*	*					
105						*	*					
102						*	*					
99						*	*					
96						*	*					
93						*	*					
90						*	*					
87						*	*					
84						*	*					
81						*	*					
78						*	*					
75						*	*					
72						*	*					
69						*	*					
66						*	*					
63						*	*					
60						*	*					
57						*	*					
54						*	*					
51						*	*					
48						*	*					
45						*	*					
42						*	*					
39						*	*					
36						*	*					
33						*	*					
30						*	*					
27						*	*					
24						*	*					
21						*	*	*				
18					*	*	*	*				
15					*	*	*	*				
12					*	*	*	*				
9					*	*	*	*				
6					*	*	*	*				
3	*			*	*	*	*	*	*			

INTERVAL	1	2	3	4	5	6	7	8	9	10	11	12

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HISTOGRAM PLOT OF SYSTEMS CHANGE FACTOR FOUR

FREQUENCY	2	0	5	12	54	97	66	25	18	5	2	6

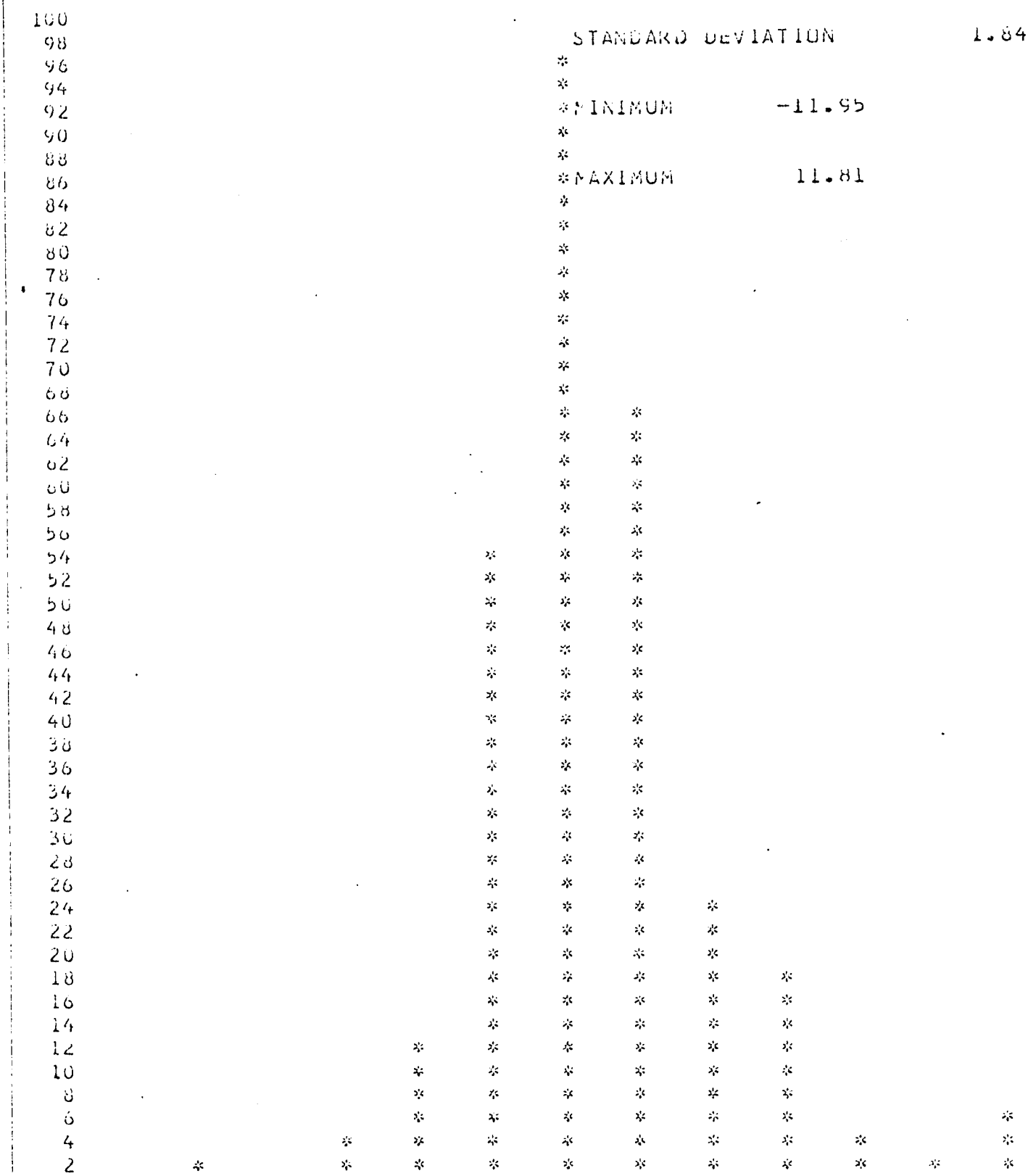
EACH * EQUALS 2 POINTS

AVERAGE 0.00

STANDARD DEVIATION 1.84

MINIMUM -11.95

MAXIMUM 11.81



INTERVAL	1	2	3	4	5	6	7	8	9	10	11	12

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HISTOGRAM PLOT OF SYSTEMS CHANGE FACTOR FIVE

FREQUENCY	1	0	11	47	46	40	49	40	38	17	2	1
50								AVERAGE			0.00	
49							*					
48							*					
47				*			*	STANDARD DEVIATION				1.69
46				*	*		*					
45				*	*		*					
44				*	*		*	MINIMUM			-5.26	
43				*	*		*					
42				*	*		*					
41				*	*		*	MAXIMUM			5.42	
40				*	*	*	*	*				
39				*	*	*	*	*				
38				*	*	*	*	*	*			
37				*	*	*	*	*	*			
36				*	*	*	*	*	*			
35				*	*	*	*	*	*			
34				*	*	*	*	*	*			
33				*	*	*	*	*	*			
32				*	*	*	*	*	*			
31				*	*	*	*	*	*			
30				*	*	*	*	*	*			
29				*	*	*	*	*	*			
28				*	*	*	*	*	*			
27				*	*	*	*	*	*			
26				*	*	*	*	*	*			
25				*	*	*	*	*	*			
24				*	*	*	*	*	*			
23				*	*	*	*	*	*			
22				*	*	*	*	*	*			
21				*	*	*	*	*	*			
20				*	*	*	*	*	*			
19				*	*	*	*	*	*			
18				*	*	*	*	*	*			
17				*	*	*	*	*	*	*		
16				*	*	*	*	*	*	*		
15				*	*	*	*	*	*	*		
14				*	*	*	*	*	*	*		
13				*	*	*	*	*	*	*		
12				*	*	*	*	*	*	*		
11			*	*	*	*	*	*	*	*		
10			*	*	*	*	*	*	*	*		
9			*	*	*	*	*	*	*	*		
8			*	*	*	*	*	*	*	*		
7			*	*	*	*	*	*	*	*		
6			*	*	*	*	*	*	*	*		
5			*	*	*	*	*	*	*	*		
4			*	*	*	*	*	*	*	*		
3			*	*	*	*	*	*	*	*		
2			*	*	*	*	*	*	*	*	*	
1	*		*	*	*	*	*	*	*	*	*	*

INTERVAL	1	2	3	4	5	6	7	8	9	10	11	12

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APPENDIX G

```
C
C               A ROUTINE THAT CALCULATES A WEDGE MEASURE OF ARRANGEMENT
C
C
C
C               A ROUTINE THAT WILL GROUP AREAS ON THE BASIS OF A SCORE
C               AND AN INDICATION OF THE RANGE OF SCORES TO BE INCLUDED
C               IN THE GROUP, IT PERFORMES ON TWO SETS OF SCORES AT ONCE
C               AND FINDS THE DIFFERENCE BETWEEN THEM AS WELL
C
      DIMENSION ANGL(300), SC(300, 16), TOT(16)
C
C               READ IN THE NUMBER OF OBSERVATIONS NUMBER OF SCORES AND
C               RANGE TO BE WITHIN THE GROUP
C
      READ 3, NOBS, NSC, SPEC
    3 FORMAT (2I5, F5.1)
      DO 10  K = 1;NOBS
C
C               READ IN THE ANGLE OF THE AREA AND THE SCORES FOR THE AREA
C
      READ 5, ANGL(K), (SC(K,J), J = 1,NSC)
    5 FORMAT (10X, F10.4, /, 8X, 7F9.4, /, 8X, 7F9.4)
   10 CONTINUE
      NSC2 = NSC / 2
      DO 1000  K = 1,NOBS
C
C               ESTABLISH THE MAXIMUM AND MINIMUM ANGLES TO DEMARKATE THE
C               AREA TO BE USED FOR THIS PARTICULAR REGION
C
      ANGLMN = ANGL(K) - SPEC
      ANGLMX = ANGL(K) + SPEC
      DO 50  M = 1,NSC
C
C               ZERO OUT THE TOTAL AND THE COUNTER
C
   50 TOT(M) = 0.0
      SCNT = 0.0
      DO 100  J = 1,NOBS
      IF (ANGL(J) .LT. ANGLMN) GO TO 100
      IF (ANGL(J) .GT. ANGLMX) GO TO 100
      SCNT = SCNT + 1.0
      DO 80  L = 1,NSC
      TOT(L) = TOT(L) + SC(J,L)
   80 CONTINUE
  100 CONTINUE
      PRINT 40, SCNT
   40 FORMAT (120X, F10.4)
      DO 200  L = 1,NSC
C
C               OBTAIN THE AVERAGE
```

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```
C
      TOT(L) = TOT(L) / SCNT
  200 CONTINUE
C
C             PRINT AND PUNCH THE RESULTS
C
      PRINT 7, K, (TOT(L), L = 1,NSC2)
      PUNCH17, K, (TOT(L), L = 1,NSC2)
      NPF = NSC2 + 1
      PRINT 6, K, (TOT(L), L = NPF, NSC)
      PUNCH16, K, (TOT(L), L = NPF, NSC)
      DO 300  L = 1,NSC2
      NSC3 = L + NSC2
C
C             SUBTRACT TO FIND DIFFERENCE BETWEEN EQUIVALENT SCORES IN
C             EACH SET
C
      TOT(L) = TOT(NSC3) - TOT(L)
  300 CONTINUE
      PRINT 8, K, (TOT(L), L = 1,NSC2)
      PUNCH18, K, (TOT(L), L = 1,NSC2)
 1000 CONTINUE
    8 FORMAT (10X, I3, 1X, 'WGCHG', 1X,  8F10.4,/)
    7 FORMAT (10X, I3, 2X, 'WGT1', 1X, 8F10.4)
    6 FORMAT (10X, I3, 2X, 'WGT2', 1X, 8F10.4)
   16 FORMAT (I3, 'WG2', 2X, 8F9.4)
   17 FORMAT (I3, 'WG1', 2X, 8F9.4)
   18 FORMAT (I3, 'WGG', 2X, 8F9.4)
      STOP
      END
```

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```
C
C                    CONCENTRIC CIRCLE FILTER OR AVERAGE ROUTINE
C
C
C
C               A ROUTINE THAT WILL GROUP AREAS ON THE BASIS OF A SCORE
C               AND AN INDICATION OF THE RANGE OF SCORES TO BE INCLUDED
C               IN THE GROUP, IT PERFORMES ON TWO SETS OF SCORES AT ONCE
C               AND FINDS THE DIFFERENCE BETWEEN THEM AS WELL
C
      DIMENSION DIST(300), SC(300, 16), TOT(16),DIT2(300)
C
C               READ IN NUMBER OF OBSERVATIONS, NUMBER OF SCORES FOR EACH
C               AND THE RANGE OF VALUES TO BE INCLUDED IN THE GROUP
C
      READ 3, NOBS, NSC, SPEC
    3 FORMAT (2I5, F5.1)
      DO 10  K = 1,NOBS
C
C               READ IN ONE DISTACCE FROM THE CENTRE FOR EACH TIME PERIOD
C               AND A SET OF SCORES FOR EACH REGION AND STORE IN CORE
C
      READ 5, DIST(K), DIT2(K), (SC(K,J), J = 1,NSC)
    5 FORMAT (10X, 2F10.3, /, 8X, 7F9.4, /, 8X, 7F9.4)
   10 CONTINUE
      NSC2 = NSC / 2
      NP1 = NSC2 + 1
      DO 1000  K = 1,NOBS
C
C               ESTABLISH ACTUAL MAXIMUM AND MINIMUM LIMITS TO BE USED
C               IN EACH CASE IN TURN
C
      DISTMN = DIST(K) - SPEC
      DISTMX = DIST(K) + SPEC
      DIT2N = DIT2(K) - SPEC
      DIT2X = DIT2(K) + SPEC
      DO 50  M = 1,NSC
   50 TOT(M) = 0.0
C
C               ZERO THE COUNTERS
C
      SCNT = 0.0
      SCNT2 = 0.0
      DO 100  J = 1,NOBS
      IF (DIST(J) .LT. DISTMN) GO TO 100
      IF (DIST(J) .GT. DISTMX) GO TO 100
      SCNT = SCNT + 1.0
      DO 80  L = 1,NSC2
      TOT(L) = TOT(L) + SC(J,L)
   80 CONTINUE
  100 CONTINUE
```

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```
      DO 101  J = 1,NOBS
      IF ( DIT2(J) .LT. DIT2N) GO TO 101
      IF ( DIT2(J) .GT. DIT2X) GO TO 101
      SCNT2 = SCNT2 + 1.0
      DO 81  L = NPF, NSC
      TOT(L) = TOT(L) + SC(J,L)
   81 CONTINUE
  101 CONTINUE
C
C             PRINT AND PUNCH THE RESULTS FOR EACH TIME PERIOD
C
      PRINT 40, SCNT
      PRINT 40, SCNT2
   40 FORMAT (120X, F10.4)
      DO 200  L = 1,NSC2
      TOT(L) = TOT(L) / SCNT
  200 CONTINUE
      DO 201  L = NPF, NSC
      TOT(L) = TOT(L) / SCNT2
  201 CONTINUE
      PRINT 7, K, (TOT(L), L = 1,NSC2)
      PUNCH17, K, (TOT(L), L = 1,NSC2)
      NPF = NSC2 + 1
      PRINT 6, K, (TOT(L), L = NPF, NSC)
      PUNCH16, K, (TOT(L), L = NPF, NSC)
      DO 300  L = 1,NSC2
      NSC3 = L + NSC2
C
C             SUBTRACT THE TWO TIME PERIODS TO OBTAIN THE DIFFERENCES
C
      TOT(L) = TOT(NSC3) - TOT(L)
  300 CONTINUE
      PRINT 8, K, (TOT(L), L = 1,NSC2)
      PUNCH18, K, (TOT(L), L = 1,NSC2)
 1000 CONTINUE
    7 FORMAT (10X, I3, 2X, 'CR51', 1X, 8F10.4)
    6 FORMAT (10X, I3, 2X, 'CR61', 1X, 8F10.4)
    8 FORMAT (10X, I3, 1X, 'CRCHG', 1X,  8F10.4,/)
   16 FORMAT ( I3, 'CPT1', 1X, 8F9.4)
   17 FORMAT ( I3, 'CPT2', 1X, 8F9.4)
   18 FORMAT (I3, 'CRG',2X,8F9.4)
      STOP
      END
```

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```
C
C               A ROUTINE THAT CALCULATES A NUCLEATION MEASURE
C
C
C               A ROUTINE THAT WILL GROUP AREAS ON THE BASIS OF A SCORE
C               AND AN INDICATION OF THE RANGE OF SCORES TO BE INCLUDED
C               IN THE GROUP, IT PERFORMES ON TWO SETS OF SCORES AT ONCE
C               AND FINDS THE DIFFERENCE BETWEEN THEM AS WELL
C
C
C               THIS ROUTINE EXPECTS A TABLE IN WHICH EVERY LOCATION
C               HAS THE DISTANCES TO ALL OTHER LOCATIONS AVAILABLE
C
C               THIS VERSION EXPECTS THE DISTANCES TO BE READ FROM UNIT
C
      DIMENSION D(300), SC(300,16), AT(16)
C
C               READ IN THE NUMBER OF OBSERVATIONS AND THE NUMBER OF
C               SCORES FOR EACH
C
      READ 5, NOBS, NSC
    5 FORMAT (2I5)
      NSC2 = NSC / 2
      DO 10  L = 1,NOBS
C
C               READ IN THE SCORES FOR EACH REGION AND STORE
C
      READ (5,3,ERR=99)( SC(L,J), J = 1,NSC)
    3 FORMAT (8X, 8F9.4, /, 8X, 8F9.4)
   10 CONTINUE
      DO 1000  L = 1,NOBS
      DO 15  J = 1,NSC
   15 AT(J) = 0.0
C
C               READ IN THE DISTANCE VALUES FROM A TAPE IN THIS CASE,
C               THAT GO WITH THAT LOCATION
C
      READ (2,25) (D(J), J = 1,NOBS)
   25 FORMAT (40(10X, 7F10.4,/), 10X, 7F10.4)
      DO 100  J = 1,NOBS
      IF (J .EQ. L) GO TO 100
      DO 30  K = 1,NSC
      SCD = ABS ( SC(L,K) - SC(J,K) )
      AT(K) = AT(K) + (SCD * D(J))
   30 CONTINUE
  100 CONTINUE
C
C               PRINT AND PUNCH THE AVERAGES IN EACH TIME PERIOD
C
      PRINT 7, L, (AT(K), K = 1,NSC2)
```

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```
            DO  110  I = 1,NSC
            AT(I) = AT(I) / ( NOBS - 1)
          PUNCH 17, L, (AT(K), K = 1,NSC2)
  110       CONTINUE
          NPF = NSC2 + 1
          PRINT 6, L, (AT(K), K = NPF, NSC)
          PUNCH 16, L, (AT(K), K = NPF, NSC)
          DO 200  J = 1,NSC2
          NSC3 = J + NSC2
C
C               OBTAIN THE MEASURES OF CHANGE
C
          AT(J) = AT(NSC3) - AT(J)
  200     CONTINUE
          PRINT 8, L, (AT(J), J = 1,NSC2)
          PUNCH 18, L, (AT(J), J = 1,NSC2)
 1000     CONTINUE
    6     FORMAT (10X, I3, 2X, 'MNT2', 1X, 8F10.4)
    7     FORMAT (10X, I3, 2X, 'MNT1', 1X, 7F10.4)
    8     FORMAT ( 10X, I3, 1X, 'MNCHG', 1X, 7F10.4, /)
   16     FORMAT (I3, 'MN2', 8F9.3)
   17     FORMAT (I3, 'MN1', 8F9.3)
   18     FORMAT ( I3, 'MNG', 2X, 8F9.3)
   99     STOP
          END
```

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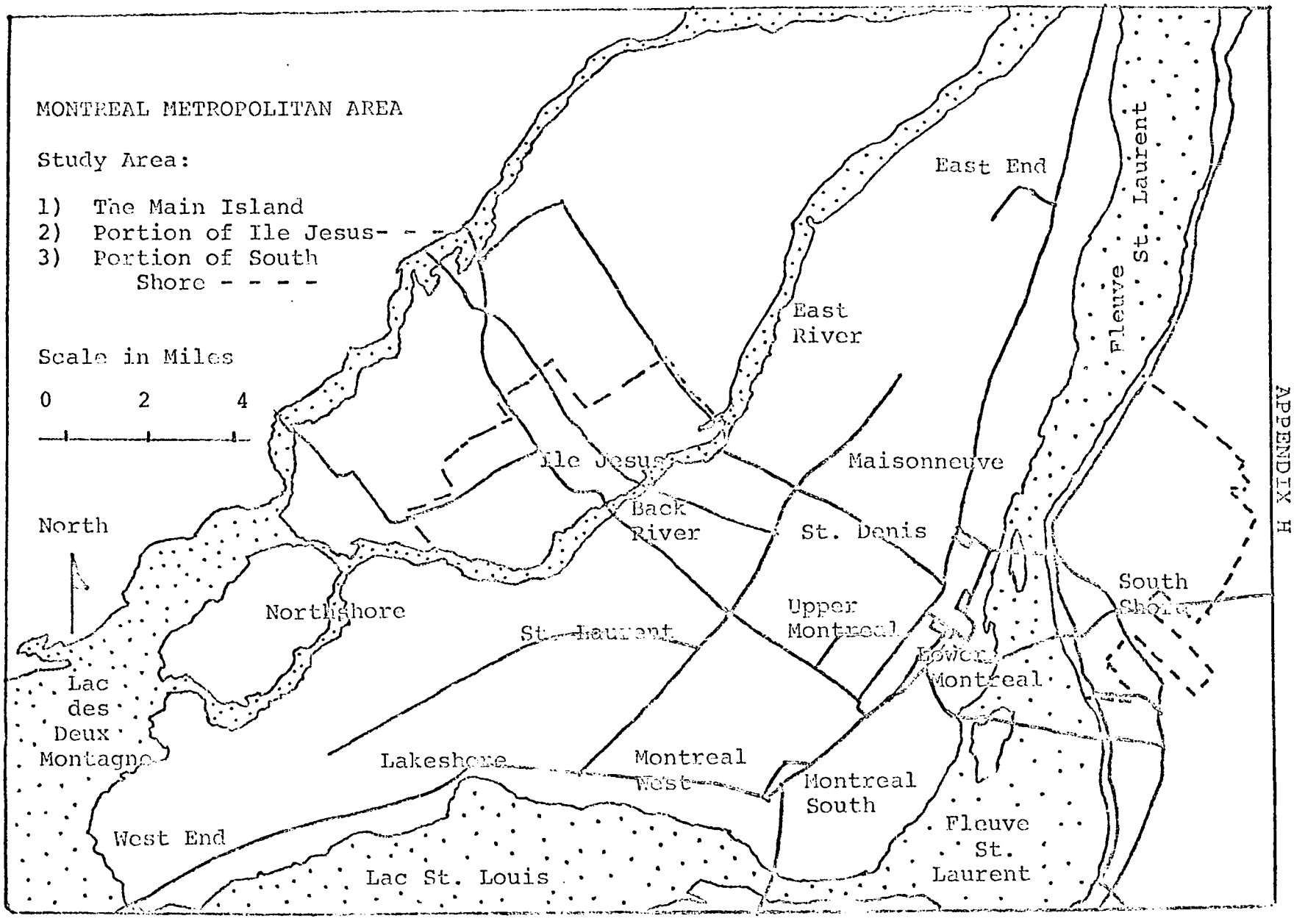

APPENDIX H

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Vita

Kingsley Edwin Haynes was born October 21, 1942 in Toronto, Ontario, Canada. He attended Drummond Hill Public Elementary School in Niagara Falls, Ontario and the Stamford Collegiate Institute, secondary school, in the same city. In 1960 the author became an undergraduate at Western Michigan University and was graduated with a B.A. in January 1964. His three undergraduate majors included honours history, political science and geography and a minor was completed in French. An M.A. in geography was granted by Rutgers University in 1965. His M.A. thesis "An Analysis of Inter-Metropolitan Migration: Tests on the Distance and Intervening-Opportunity Hypotheses" was under the direction of Dr. Arthur Getis.

From 1965 to 1968 the author was a full time graduate student in the Ph.D. program of the Isaiah Bowman Department of Geography at The Johns Hopkins University. During this period the author was a lecturer at The Memorial University of Newfoundland, at The University of Maryland Baltimore Campus, and at The Johns Hopkins University. The author also acted as a consultant to Consad Research Corporation

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on second generation models being developed for the Northeast Corridor Transportation study.

In September 1968 Mr. Haynes accepted a full time position as Lecturer in Economic Geography at McGill University in Montreal and held that position until August 1970. During this period (1968-1970) the author was a member of the Advisory Board for Long Range Planning and Urban Design for the Canadian Government's National Capital Commission. As a consultant to van Ginkel Associates and Ecos Ltd. the author worked on Environmental Impacts of the new Montreal International Airport, University Location and Educational Planning in Prince Edward Island, and on economic impacts of Airport Investments in Salvador, Bahia, Brazil. During the summer of 1970 the author was employed as Economic Planner for the Pahang Tenggara Regional Master Planning Study carried out for the Malaysian Government under the Canadian International Development Agency's funding program. The author is presently Assistant Professor of Geography at the University of Texas, Austin, Texas.

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