

DIURNAL PATTERNS OF SOCIAL GROUP DISTRIBUTIONS IN A CANADIAN CITY*

DONALD JANELLE and MICHAEL GOODCHILD

The University of Western Ontario

Space-time diaries, describing the locations of more than 1500 randomly sampled respondents throughout a twenty-four hour period, are used to compile census-like data at six different times of the day for spatial units in Halifax, Canada. Simple spatial statistics, including the location quotient, the index of dissimilarity, the density gradient, and centrophobic measures, were used to monitor changing levels of geographical concentration, segregation, and mobility for selected sub-populations and role groups. From these analyses, it is evident that urban social geography is far more complex than suggested in the urban, social-ecological literature.

The vast social science literature on the social and demographic geography of cities has been derived almost exclusively from data based on the residential (night-time) locations of respondents. This bias stems from the reliance on census enumerations which have focussed on the household as the basic observational unit, and it is becoming more severe as the proportion of households with two or more incomes continues to rise. People move around considerably over the course of the day to satisfy needs for income, education, goods, services, entertainment, and so forth. In fact, it is clear that structural changes in land use and activity patterns have been closely associated with shifts from public to private transportation. In general, increases in the flexibility and levels of mobility have intensified the degree of diurnal variations in the social and demographic char-

acteristics of urban areas that, as yet, are poorly understood. Both the theoretical and practical importance of understanding these shifting but recurring patterns have been recognized for some time [4; 9], and crude estimates of the changes have been attempted [23]. However, most of this work focussed on the numbers of people in different parts of the city and did not differentiate by social and demographic subpopulations.

The principal impediment to the incorporation of detailed temporal considerations in practical analyses and also ultimately in inductive theory-building and deductive hypothesis-testing has been the lack of appropriate data. And, until recently, very little theoretical direction has been provided. Taylor and Parkes [26] offered an important illustration of how temporal information could be used to enhance our understanding of urban ecological structure, but they were forced to use artificial data for a hypothetical British city. Although this precluded any substantive contribution, their work did call attention to the limitations of conventional ecological studies. Their conclusion, that many of the problems of cities can only be specified fully in an integrated time-space framework, provided an important motivation for the research reported on in this paper. None-

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theless, the enhancement of empirical research has also been important. In this research, the results of survey techniques for recording space-time diaries [1] and the perspectives of time geography [11; 12; 22] are combined with simple spatial statistics in an attempt to discern diurnal changes in a city's social group distributions.

This study uses a sample of nearly 1600 space-time diaries for respondents in Halifax and Dartmouth, Canada—twin cities with a combined population of 187,000 in 1971. The geographical locations and activities of respondents are recorded for a complete diary day and are supplemented with a socio-demographic profile on each respondent. In the context of these data, the objectives of this paper are: (1) to describe the locations of different subpopulations at different times of the day; (2) to illustrate the use of simple spatial statistics in monitoring diurnal changes in the relative levels of concentration, segregation, and mobility of subpopulations; and (3) to evaluate research findings at different levels of respondent aggregation. Although the principal thrust of the research is largely empirical, both the approach and the results should have significant implications for the design of future research that aims toward improving the theoretical understanding of relationships between human behavior and urban structure.

The data for this study, based on a pioneering survey by the Institute of Public Affairs at Dalhousie University [8; 14], provide the space and time coordinates of sampled individuals for a full day, in addition to details on their social and demographic characteristics. Conducted between October, 1971 and May, 1972, this survey was part of an unusually extensive and carefully structured investigation into the daily activity patterns of over 2100 respondents from the metropolitan area of Halifax. Although it followed the typology and coding of activities adopted for the ambitious International Time Budget Study [24], its

geocoding of respondents' locations by six-digit UTM (Universal Transverse Mercator) coordinates represents a significant improvement over traditional time-budget surveys. Thus, respondents' daily movements can be traced to the nearest 0.10 kilometer, and their individual social and demographic traits can be continually reassigned to the different locations that they occupy.

SAMPLING AND AGGREGATION PROBLEMS

Because of the sampling design used in the Halifax survey, a complete reaggregation of the data, using the individual respondents as the basic units, was required. The original survey was multi-stage in nature. Thus, 83 or 474 Census Enumeration Areas (EAs) were randomly selected. The number of households sampled in each of these areas was proportional to the EAs total number of households. The specific individuals surveyed within households were selected such that, in the aggregate, they would match closely the variation in the actual demographic and social profiles of the metropolitan area's population. Exceptions to this were the exclusions of potential respondents under 19 and over 64 years of age, and the exclusions of individuals who came from households that lacked at least one full-time, non-agricultural employee. Although the survey divided the sample among the seven days of the week and included respondents from beyond the municipal boundaries, this analysis will make use only of those 1561 respondents who kept weekday diaries (Monday to Friday) and who lived within the cities of Halifax and Dartmouth. This area contained 380 census EAs in 1971, of which 68 were sampled.

Even though it is theoretically possible to trace individuals continuously through time, it is of practical necessity that a standard set of times be selected. In their hypothetical example, Taylor and Parkes [26] used eight periods (durations) to

represent eight routine activity types. In this analysis, the morning and early-evening travel episodes are excluded from analyses and only six times are used. The times were selected according to the frequencies with which respondents were engaged in various activities. For example, the maximum proportion of the sample who were sleeping (81 percent) occurred at 2:00 a.m. The study times resulting from this analysis are shown in Table 1. The activities included in each of these categories are based on activity codes from the International Time-Budget Study [24].

Because of the random sampling of EAs, the original data base does not give complete representation for all parts of the Halifax-Dartmouth area. However, this shortcoming is circumvented by the use of an algorithm which aggregates the EAs into larger units that encompass the entire study region. Internally, each of these 32 larger units, or Pseudo Census Tracts (PCTs), contain EAs that are similar in their socio-demographic composition. Each PCT has from one to three sampled EAs which are designated as the core areas about which unsampled EAs are grouped. Where more than one of the sampled EAs were designated as cores, care was taken to link those that were geographically close and that had generally similar socio-demographic characteristics. Then, the unsampled EAs were joined with the most similar contiguous core areas such that, according to a least-increase-in-the-sum-of-squares criterion,

the similarity of EAs within PCTs was maximized. The data used in the algorithm were derived from the census and included the 14 variables listed in Table 2.

Having established a suitable set of spatial units, the social and demographic traits of sampled respondents are assigned to PCTs. Thus, for each of the six designated study times, the 1561 individuals are sorted according to their geocoded locations into the 32 PCTs. Their corresponding social and demographic traits are then aggregated to form 22 variables. The resulting data refer to the numbers and percentages of the respondents in the tract for a given time that belong to each of the 22 subpopulations listed in Table 3. Later in this paper, these groups will be disaggregated by representing respondents with a combination of variables. For example, sex, employment status, marital status, and childcare responsibilities may be combined to define a number of role types. However, the significance of such distinctions is more clearly seen by comparing the results against the more aggregate groupings. This approach allows initially for easier interpretations of the spatial statistics, and it permits an assessment of the sensitivity of the results to different levels of aggregation.

DESCRIBING THE SPACE-TIME PATTERNS OF URBAN SUBPOPULATIONS

Since a data set compatible with the study's objectives has been defined, it is

TABLE 1

SAMPLING TIMES

BASED ON PARTICIPATION IN DOMINANT ACTIVITIES

Dominant Activity	Time of Maximum Participation
Sleeping	2:00 a.m.
Morning Phase of Worktime	9:10 a.m.
Lunchtime	12:15 p.m.
Afternoon Phase of Worktime	3:00 p.m.
Early Evening Discretionary Time	7:00 p.m.
Late Evening Activities	10:30 p.m.

TABLE 2

CENSUS VARIABLES USED FOR GROUPING
ENUMERATION AREAS INTO PSEUDO CENSUS TRACTS

— Proportion of Population Aged less than 5 years
— Proportion of Population Aged 5-14 years
— Proportion of Population Aged 15-24 years
— Proportion of Population Aged 25-34 years
— Proportion of Population Aged 65+ years
— Average Number of Unmarried Children at Home
— Proportion of Population Married
— Proportion of Dwellings Constructed 1961-1970
— Proportion of Dwellings Owned
— Proportion of Dwellings Apartments
— Average Rent of Tenant-Occupied Dwellings
— Proportion of Population Main Language Spoken, French or Other (Non-English)
— Proportion of Family Heads, Schooling Less than Grade 9, including those with no schooling
— Proportion of Family Heads, Some University and/or with University Degrees

Source: Statistics Canada. *1971 Census of Canada*, "Population and Housing Characteristics; Halifax," (Series A, March, 1973; Series B, June, 1974).

possible to conduct a preliminary survey of the space-time patterns associated with selected subpopulations. At this stage, only easily interpreted spatial statistics are calculated. The location quotient is used as an indicator of relative concentration; density gradients provide measures of centralization and dispersal; and the dissimilarity index offers one measure of the relative segregation between paired populations. Whereas these three measures are based on data aggregated to the PCT level, a centographic analysis of the shift in mean centers is calculated from the geocoded locations of individual respondents for each of the 22 subpopulations. This allows for general comparisons of their diurnal mobility patterns.¹

LOCATION QUOTIENTS

The location quotient is used to answer two related kinds of questions. First, how does the mix of subpopulations within a

TABLE 3

SUBPOPULATIONS

Category	Sample Size
Males	694
Females	867
Unemployed	549
Employed	1012
Age group 18-29 years	536
Age group 30-49 years	716
Age group 50-64 years	257
Income less than \$12,000	1095
Income greater than or equal to \$12,000	466
Married	1141
Not Married	408
Children present at home	981
No children present at home	580
One or more cars at residence	1271
No cars or trucks at residence	290
Education—Grade 11 or less	953
Education—Grade 12 or more	595
Some years at university	528
Less than 2 years at present residence	721
Two or more years at present residence	832
Home owners	783
Home renters	750

given area change over the diurnal cycle? Second, how do individual subpopulations alter their locational patterns throughout the day? In each case the location quotient is defined as a measure of relative concentration, with a value of 1.0 indicating that a PCT has the same proportion of its population in a particular category as does the study area as a whole.

In Figure 1, location quotients for six times are plotted for selected subpopulations for a single PCT, number 14. This is a wealthy residential area along the Northwest Arm of the Halifax Peninsula. It contains three of the city's principal social and boating clubs and is near Dalhousie University. The dichotomous subpopulations, based on sex and income, illustrate reciprocal relationships. Thus, for exam-

Location Quotients for Subpopulations in Pseudo-Tract 14, Halifax-Dartmouth, Canada.

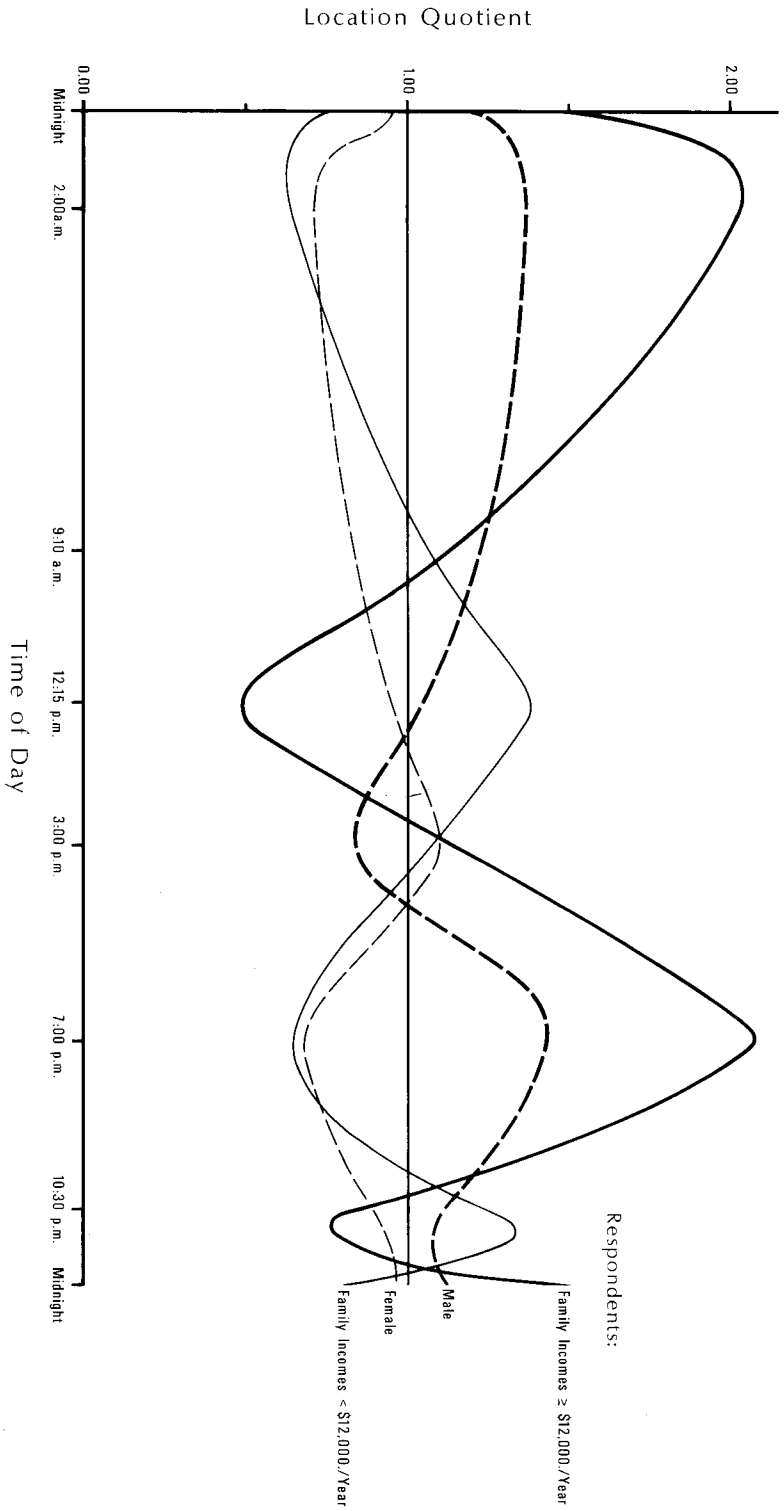


Figure 1

ple, as the relative concentration of males increases, there is a relative decline in the representation of females. The same relationship holds for the two income groups. The curves are perfectly in phase, have equal wavelengths, but are opposite in direction.

¹The actual data, aggregated by PCTs, and technical details on formulae and programs used in this analysis are available from the authors. Within certain limits, the technical supplement [17] provides a base for replicating this paper's research design and for comparing its results with analyses based on other approaches and measures.

In Figure 2, dichotomous populations are excluded so that attention is directed to the considerable hourly variations that occur in the tract's social and demographic composition. The cycles for some subpopulations, for instance respondents in the age range of 50 to 64 and those from non-auto-owning households, show great fluctuation in amplitude, whereas others, such as those in the 30 to 49 age group, have nearly equal representation throughout the day. Intensive changes in composition are most evident during the mid-day lunch period and in the early-evening hours. Many people who live and work on the peninsula find it convenient to go home for lunch and to take advantage of nearby restaurants and entertainment in the evening. Although a similar kind of change in composition takes place in the morning, with the transfer from residences to jobs, it is somewhat less abrupt. Whereas phase differences of peak and low amplitudes are apparent for any pair of subpopulations, some are in reasonably close correspondence with each other—for example, respondents who are unmarried, those with no access to automobiles, and renters.

The changes in tract 14 are more dynamic than in most other PCTs; however, the socio-demographic mix is subject to considerable temporal variation throughout the Halifax-Dartmouth area. This is illustrated in Figure 3 for a single subpopulation, unmarried respondents.

In this case, the individual curves represent the location quotients for different PCTs, general descriptions of which are given in Table 4. The tracts were selected to illustrate the different kinds of response that one might expect in a complex urban region. The principal distinction is between tracts surrounding the Halifax business area, within the older and more densely settled peninsula (numbers 8, 10, 12, 14, and 20), and those in Dartmouth (25, 28, and 30) and suburban Halifax (3, 4, and 5). Thus, the PCTs on the peninsula (excluding 20—a blue-collar area of small, single-family homes) have greater proportions of their populations in the unmarried category than for the entire study area; however, considerable fluctuations are evident. The cycle for PCT 8 differs from the others in that it is consistently high, has a low amplitude, and is opposite in direction. This tract includes the two principal universities of Halifax. But, in contrast to the peninsula, the more suburban PCTs have values that are consistently below or near the city average and show only minor variations in amplitude. The only exception is tract 28, a combination industrial, residential, and defense-oriented area in the southern periphery of Dartmouth.

Figure 4 is a mapping of the daily changes in location quotients for unmarried respondents over all 32 pseudo tracts. It carries the clock metaphor "forward" to suggest the continual repetition of these patterns from day to day for weekday periods. Although location quotients mask the actual numerical significance of subpopulations, their graphic and cartographic representations through time do provide useful indicators of the spatio-temporal changes in the concentration of subpopulations. Other measures are more useful for portraying the numerical strength of these groups.

DENSITY GRADIENTS

Population density gradients [5; 20] provide graphic and numerical indicators

Location Quotients for Selected Subpopulations in Pseudo-Tract 14, Halifax-Dartmouth, Canada.

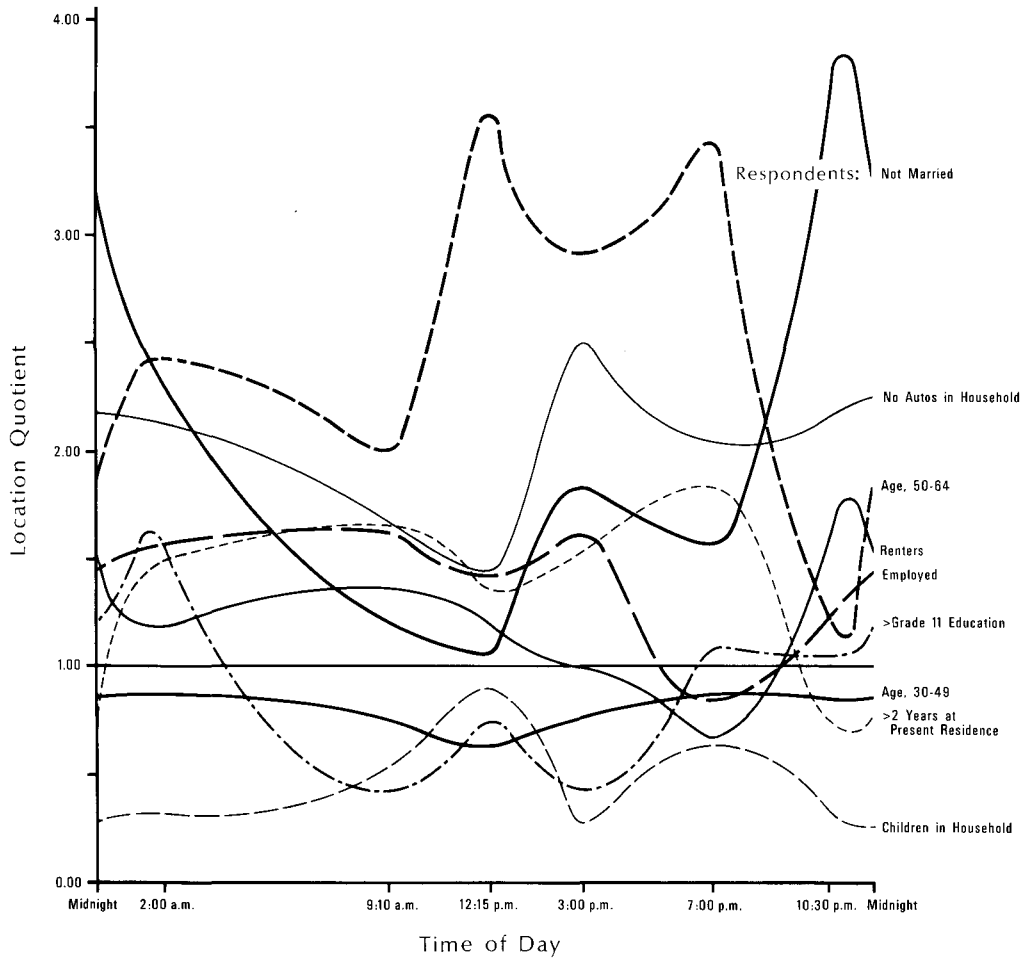


Figure 2

of the relative magnitudes of subpopulations and their comparative levels of dispersal throughout the study region. In Figure 5, lines of best fit from simple regression show the general first-order relationships between density and straight-line distance from the center of pseudo tracts to the designated center of Halifax, the city hall. For each group of respondents, these were calculated separately for each of six times of the day. All groups show higher degrees of dispersal and lower over-all densities during the

daylight hours than in the late evening and early morning periods. Sharp differences in the absolute densities and in the slopes of density gradients between dichotomous groupings (based on income, employment status, and home-ownership status) are clearly evident. However, an easier way to compare diurnal changes in the relative levels of concentration and dispersal for selected subpopulations is to graph the regression coefficients, as shown in Figure 6. In general, the curves show similar patterns, but the differences

in gradients among groups are quite great. Employed and lower-income respondents were the most concentrated spatially, whereas the unemployed and higher-income subpopulations were the most highly dispersed. Except for the

higher-income group, the time of maximum dispersal occurs for all groups in the mid-afternoon. The higher-income population is out of phase with this pattern and is maximally dispersed in the early evening hours.

Diurnal Variations in the Concentration of Unmarried Respondents in Selected Tracts.

(Based on Location Quotients)

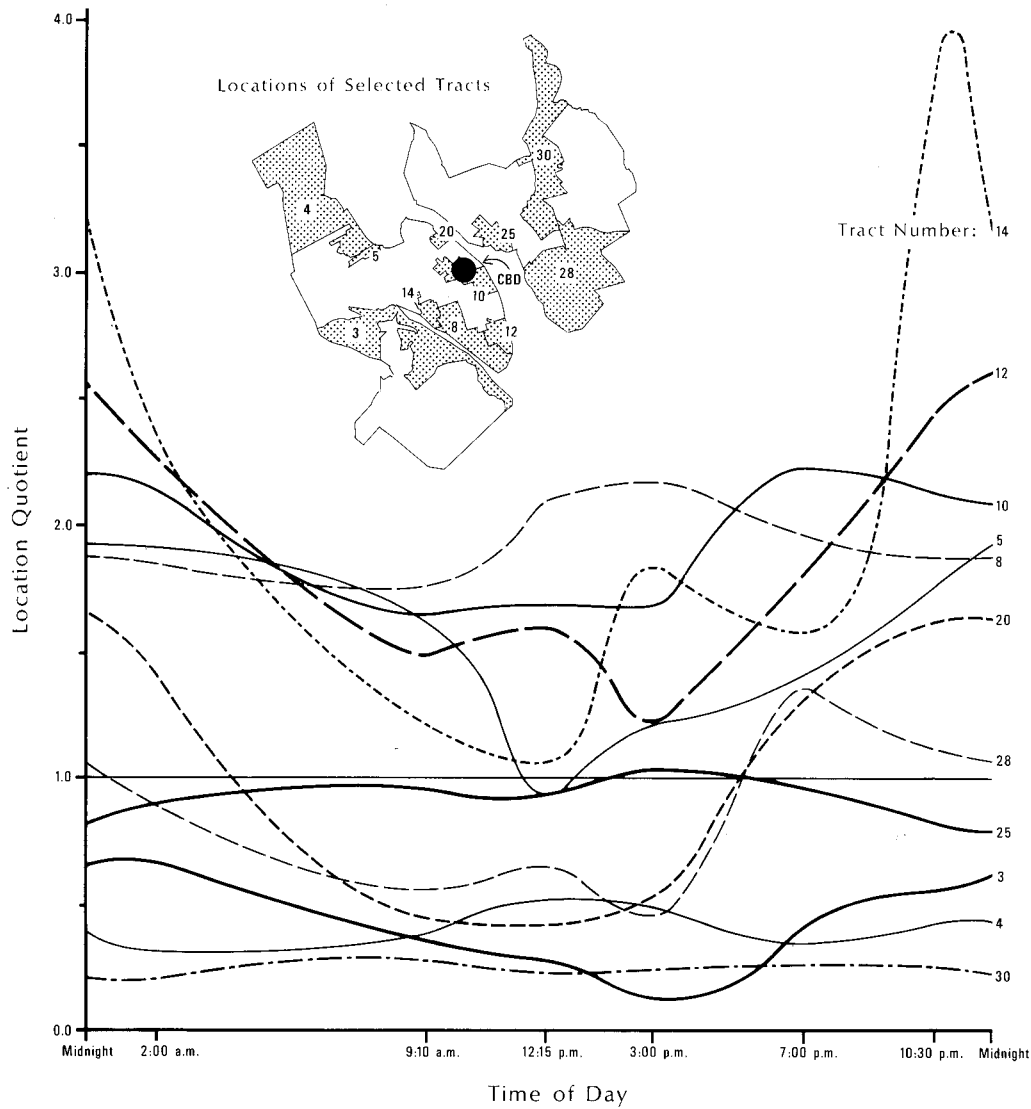


Figure 3

Another curve which stands in sharp contrast to the general pattern relates to respondents who have children in their households. It has one of the highest rises and falls in amplitude, possibly reflecting the limitations in flexibility of movement associated with child rearing and the anchoring of daily life more completely about the home and workplace. In contrast, respondents without children show a sharp rise in spatial concentration in the early evening hours. This concentration peaks in the very early morning hours when married respondents are most highly dispersed—reflecting the general tendencies of these contrasting groups to seek different residential areas. Although the graphing of regression coefficients through time allows for speculation with respect to such associations among subpopulations, other more direct measures of these associations are preferred.

DISSIMILARITY INDEX

The dissimilarity index is used widely in urban sociology and urban geography as a measure of residential segregation [25; 27]. In this example it is used to compare the diurnal changes in the spatial correspondence between eleven pairs of subpopulations. For each pairing, the dissimilarity values are plotted against time (Figure 7). A value of 0.00 indicates that the two subpopulations are distributed amongst the PCTs such that their proportional representation in each tract is exactly the same. The male and female comparison comes closest to this norm, with dissimilarity values ranging between only 10 and 15 percent throughout the day. At the other extreme, the owners and renters of homes are the most highly segregated of the subpopulations, varying from 38 percent dissimilarity at 12:15 p.m. to 50 percent dissimilarity at 2:00 a.m.

In general, the curves in Figure 7 show remarkably similar forms—one long wave over a 24-hour cycle. However, three types of situations are apparent.

First, the spatial integration of many groups (those based on marital, age, income, and mobility statuses) is most evident in the middle of the day when the spatial dissimilarity in their distributions among tracts is lowest. However, the opposite occurs for the male-female and the employed-unemployed comparisons. They are more highly segregated in daytime than at night. A third variant of curves is illustrated by the sharp, early-evening increases in the spatial separation between auto- and non-auto-owning respondents, and between the 18 to 29 and 30 to 49 age groupings.

All three variants of the dissimilarity curves are related to differences in the average life styles and movement behaviors of subpopulations and to their needs to occupy land use and activity areas of the appropriate specialization. However, in order to place this in a more explicitly spatial context, more direct measures of movement behavior are needed.

CENTROGRAPHIC ANALYSIS

A general comparison of the average mobility behavior of subpopulations is provided through centographic analysis [19], particularly by observing shifts in their mean locations over time. Thus, the locations of all members of each subpopulation were recorded for the six times, and the mean location of its respondents was mapped, as shown in Figure 8. Since all of the mean locations for subgroups occur within a small area (approximately 0.66 square kilometers) to the northwest of the Halifax business district, little can be concluded from a comparison of the absolute locations of mean centers. However, the relative position of a subgroup on the map does make intuitive sense. For example, the locations of the unmarrieds, home renters, non-auto households, and university-educated subgroups are to the south, in close proximity to the area's two principal universities, Dalhousie and Saint Mary's. It is also instructive to compare these groups according to the extent

Diurnal Variations in the Spatial Concentration of Unmarried Respondents in Halifax-Dartmouth, Canada.

(Based on Location Quotients for Pseudo-Tracts)

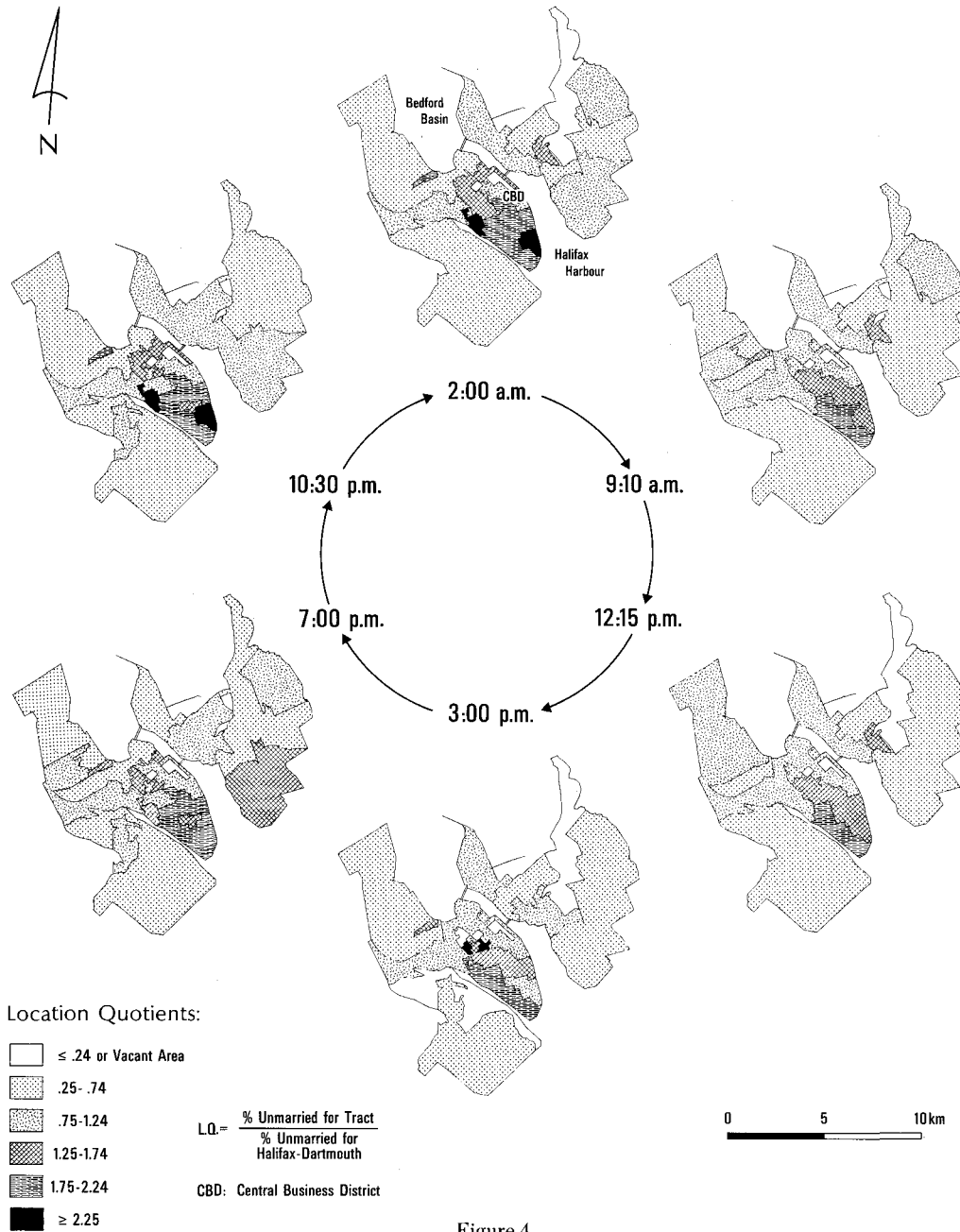


Figure 4

of movement in their mean centers between times. Thus, for example, the average territorial coverage of non-auto owners, unmarried respondents, renters, and those between the ages of 18 and 29 may be interpreted as much less than for some of the other groupings, for instance married respondents and those between the ages of 30 and 49. Owing to the level of aggregation, these measures reflect only the mass movement of subgroups and cannot in any way be related either to actual networks or to individual movement behavior. Nonetheless, as summary measures of movement patterns at the subpopulation level, they do permit general comparisons between groups and allow for specific observations about the changing spatial patterns of individual subpopulations.

THE DISAGGREGATION OF SUBPOPULATIONS

The preceding discussion has illustrated the utility of simple spatial statistics to describe general patterns of movement, concentration, dispersal, and segregation of subpopulations for different times of the day. Now, greater attention must be directed to establishing the relevance of such analyses for understanding urban ecological structure and human behavior. The remainder of this paper addresses the latter of these concerns.

Single-characteristic subpopulations, as used in the previous section, can be questioned as to their behavioral relevance. For instance, the identification of one subpopulation consisting of unmarried males between the ages of 18 and 29 who are unemployed provides more information about individuals than do the four separate, single-characteristic groups. Although this falls far short of capturing the full complexity and variation among respondents, it is assumed to be a more behaviorally-relevant level of aggregation. Hence, subpopulations based on a multiple of characteristics are designated and analysed as to their average space-time patterns. The basis for subgroup designation was suggested by Clark, Elliott, and Harvey [6]. They illustrate the use of time diary and survey data to group respondents by a simple concatenation of single-trait codes to form compound groupings. For example, four variables, each characterized by one of two possible states, results in 16 possible subpopulations.

Based on an *a priori* judgment as to the importance of various characteristics in the determination of role-group differences, the variables, sex, marital status, employment status, and child-rearing responsibilities were combined to form the 16 categories listed in Table 5. Other researchers, notably Brail and Chapin [2], Harvey, Elliott, and Procos [15], Hanson and Hanson [13], and Hummon [16] have recognized the importance of these vari-

TABLE 4

GENERAL CHARACTERISTICS OF SELECTED TRACTS

Tract Number	Description
3	Affluent and middle-income suburban residential areas; yacht club
4	Middle-income suburban residential; undeveloped land; Mount St. Vincent University
5	Mostly rental residential units; young population, lower-middle income
8	Affluent and stable residential area—mostly single-family housing; St. Mary's and Dalhousie Universities; Point Pleasant Park
10	Parts of Halifax central business area; public institutions; commercial docks; middle to high density residential areas; low to middle-income; student accommodations
12	Mixture of income groups, subdivided houses, apartments and restored homes; port facilities, container terminal, Canadian National Railway marshalling yards
14	Affluent single-family residential area; three private boat clubs
20	Blue-collar area, single-family housing
25	Dartmouth central business area; shipyards, ferry terminal; rental flats and single family homes; lower-middle income
28	Shearwater Canadian Forces Base; two oil refineries and industrial park; two major hospitals; lower-middle income residential areas—single-family homes
30	Scattered population distribution varying from lower-middle income in the north to more densely-settled, higher-middle income areas in the south

Note: Descriptions based on 1971-72 evidence. Tract locations are shown on map insert in Figure 3.

Diurnal Variations in Density Gradients for Subpopulations.
 (Based on Linear Regression of Subpopulations in Pseudo-Tracts
 with Distances from the Centre of Halifax to Tract Centroids)

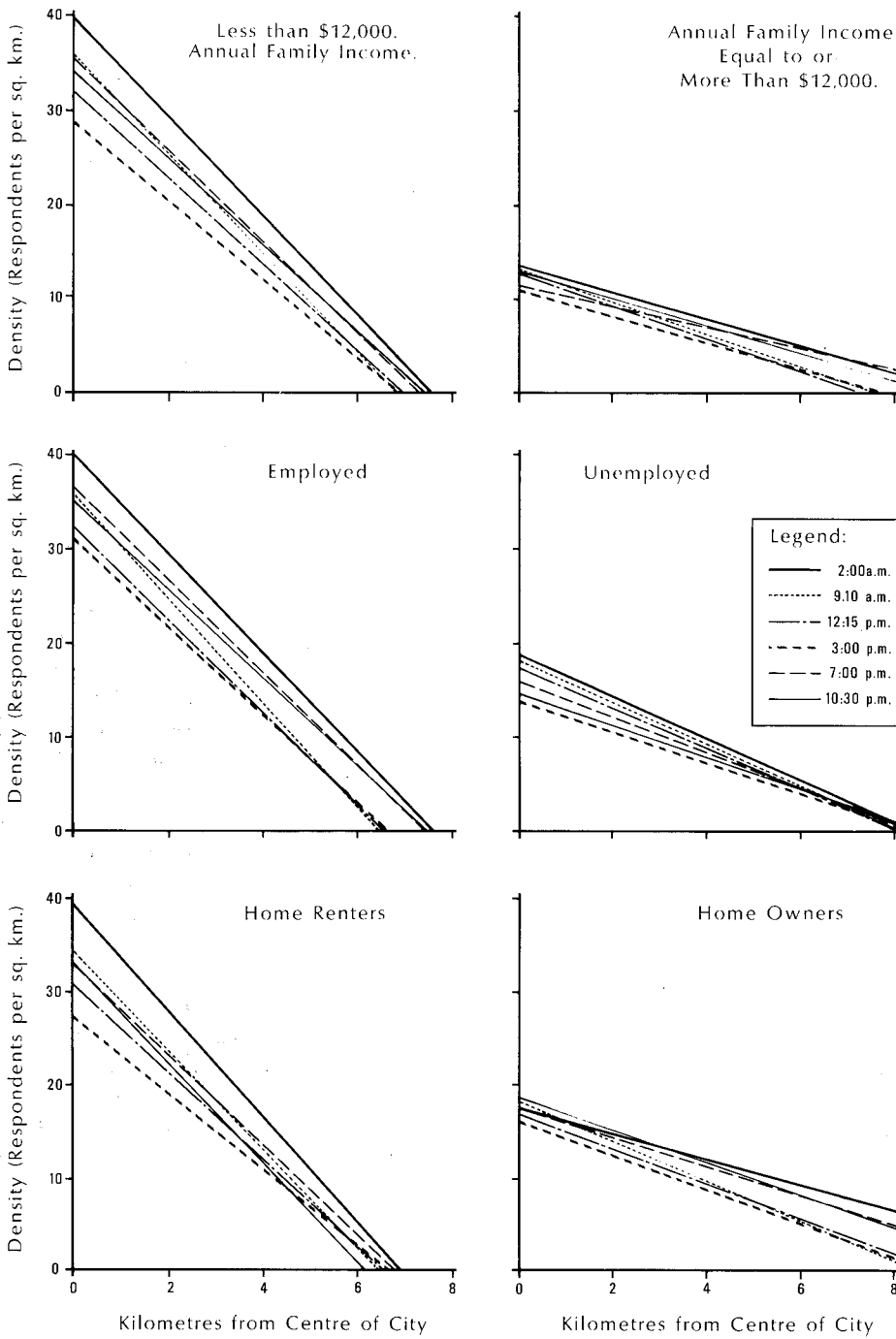


Figure 5

Diurnal Variations in Density Gradients for Selected Subpopulations, Halifax-Dartmouth, Canada.

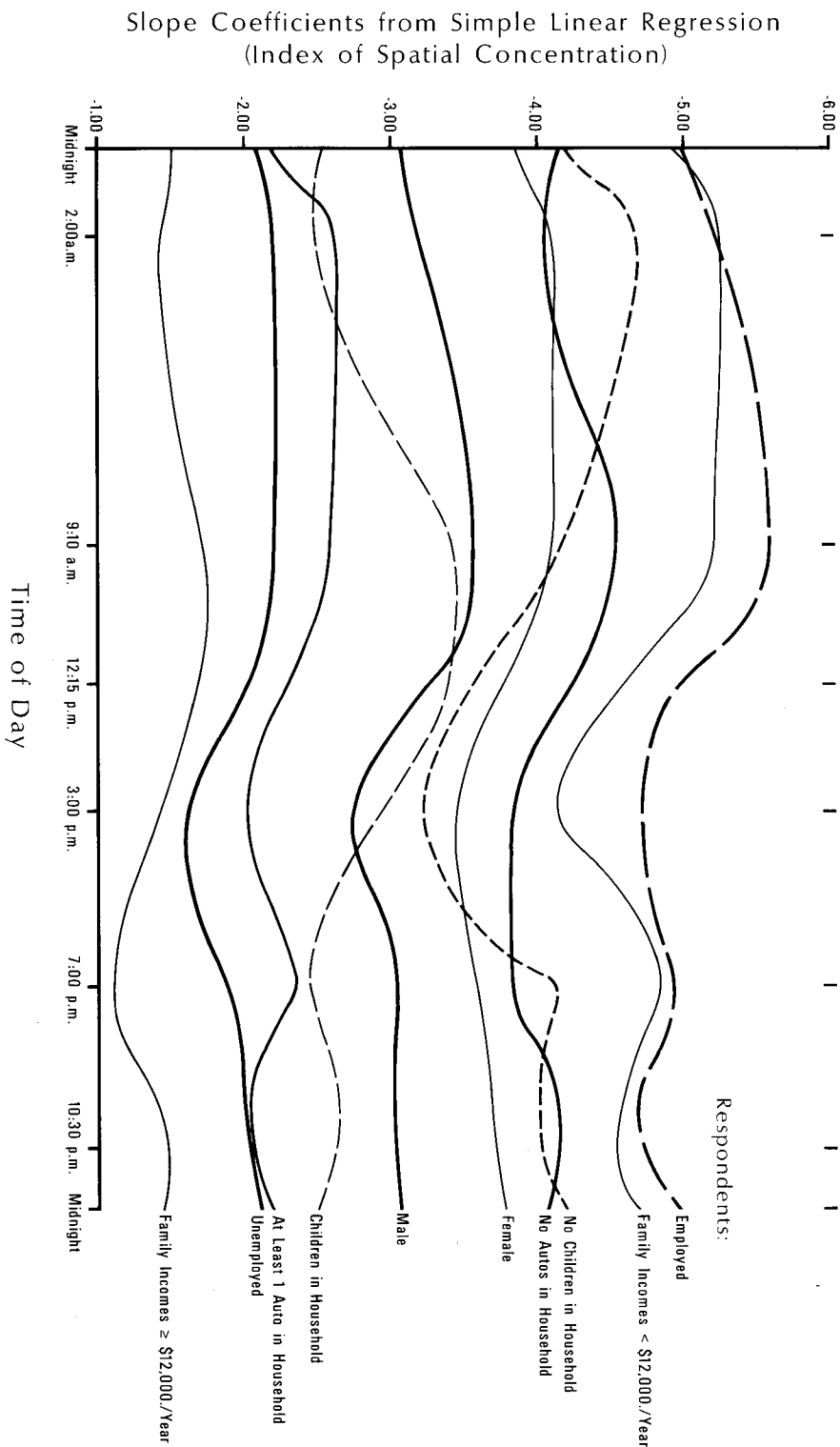


Figure 6

Diurnal Variations in the Spatial Correspondence of Subpopulations.

(Based on 32 Pseudo Census Tracts for Halifax-Dartmouth, Canada.)

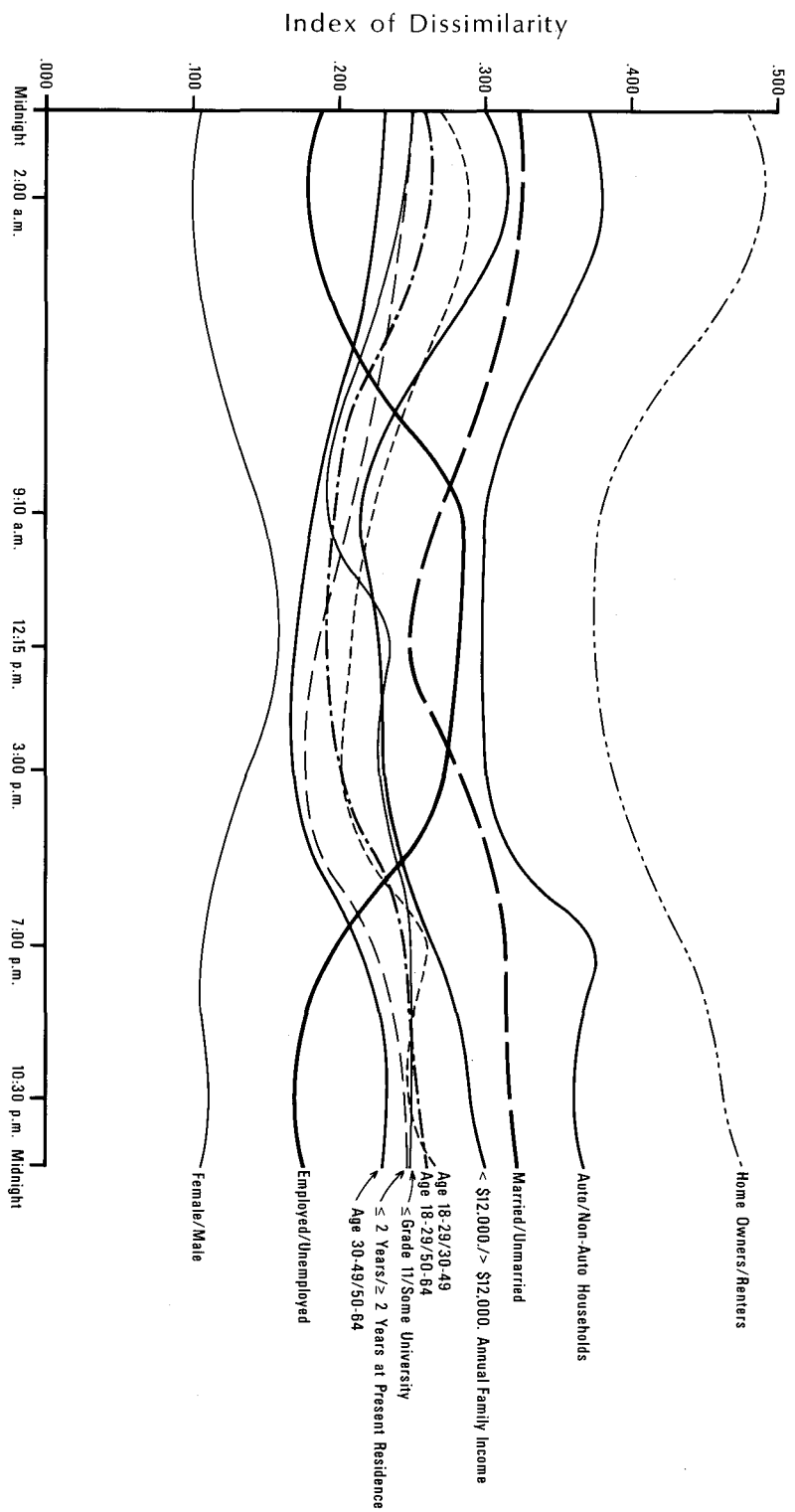


Figure 7

Diurnal Variations in Mean Locations for Subpopulations in Halifax -Dartmouth, Canada. (Based on Centrographic Analysis)

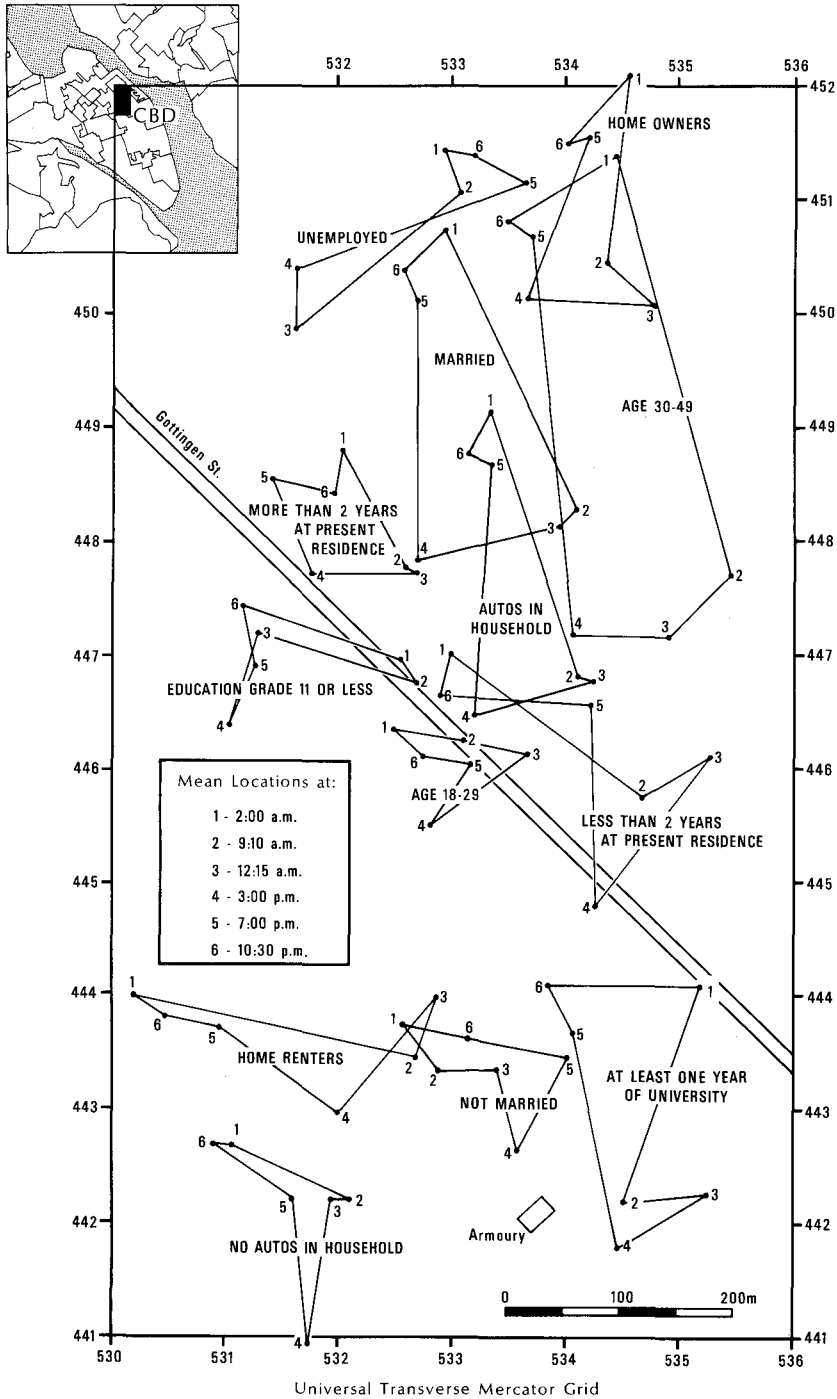


Figure 8

ables in their analyses of behavioral patterns. In addition, their importance has been underscored by Hägerstrand [11, 12] and time-geography researchers [21] because of their bearing on capability and coupling constraints. For instance, employment status will influence income levels and the ability to choose among activity options; and jobs, children to care for, and marriage all require the allocation of time and, frequently, the physical occupancy of specific spaces in order to discharge contractual and socially-defined obligations.

Although other characteristics, such as age or income, allow for important role differentiation and distinctive behavior patterns for respondents within the subpopulations designated in Table 5, the need to maintain groupings of sufficient size for descriptive analyses precluded

any further disaggregation of the Halifax data. However, even though, for this reason, the term "role group" must be used advisedly, it is expected that this refinement in the classification of respondents will permit a useful approximation of diurnal patterns in the city's social and demographic geography.

SPACE-TIME PATTERNS OF SELECTED ROLE GROUPS

In Figures 9 through 12, location quotients, density gradients, and dissimilarity values are used to describe space-time patterns for nine of the role-groups listed in Table 5. A greater number of female than male groupings met the minimally-acceptable sample size of 75 respondents. Although this reflects in part a slight bias in the sampling (55 percent females), an

TABLE 5
ROLE GROUPS

Category	Description	Sample Size
FWNE	Female, Married, No Children, Employed	87
FWNU	Female, Married, No Children, Unemployed	85
FWCE	Female, Married, Children, Employed	138
FWCU	Female, Married, Children, Unemployed	310
FSNE	Female, Single, No Children, Employed	134
FSNU*	Female, Single, No Children, Unemployed	27
FSCE*	Female, Single, Children, Employed	50
FSCU*	Female, Single, Children, Unemployed	24
MWNE	Male, Married, No Children, Employed	129
MWNU*	Male, Married, No Children, Unemployed	11
MWCE	Male, Married, Children, Employed	349
MWCU*	Male, Married, Children, Unemployed	32
MSNE	Male, Single, No Children, Employed	77
MSNU*	Male, Single, No Children, Unemployed	21
MSCE*	Male, Single, Children, Employed	37
MSCU*	Male, Single, Children, Unemployed	30

*Categories with sample sizes less than 75 were excluded from the analyses. Twenty of the 1561 sample respondents were eliminated because of absence of information on at least one of the four variables.

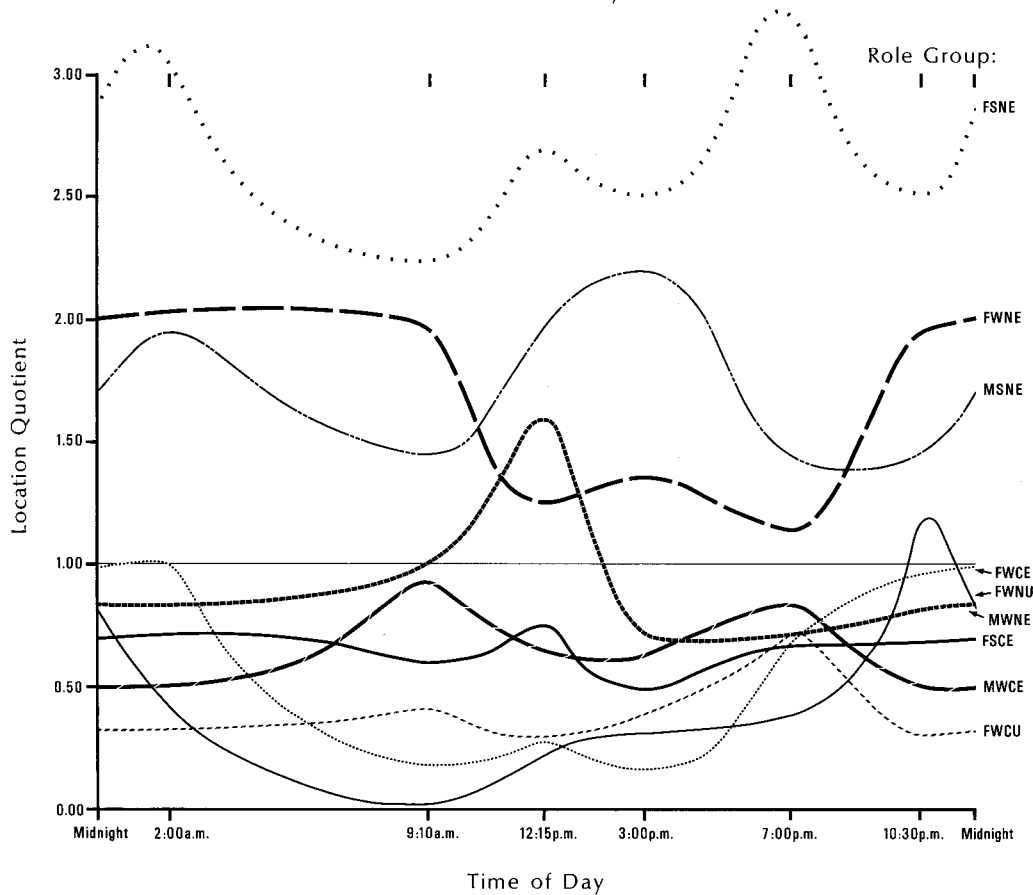
analysis of the Multinational Time Budget data [24] by Harvey, Elliott, and Procos [15] reveals that, in modern western social systems, females have greater heterogeneity in role differentiation than do males. Thus, in this case, whereas male respondents tend to be clustered in three categories, females are more evenly distributed amongst the designated role groups.

In Figure 9 location quotients are used to illustrate diurnal changes in the mix of role groups occupying a single PCT. Tract 8 is the principal locus of Halifax's higher educational establishments—St.

Mary's and Dalhousie. In addition, it incorporates stable, upper-middle income residential areas and is in close proximity to a large hospital complex and to the central business district. Some homes provide rental rooms for students.

The most obvious differentiating feature of this tract is the dominant presence of people who have no parenting responsibilities. The FSNE, FWNE, and MSNE groups are the only ones with values exceeding 1.0 for all six study times. Furthermore, the tract's share of employed married men with no children (MWNE) increases above the city aver-

Location Quotients for Selected Role Groups in Pseudo-Tract 8, Halifax-Dartmouth, Canada.



Legend: F=Female, M=Male, W=Married, S=Single, C=Children, N=No Children, E=Employed, U=Unemployed

Figure 9

age during the lunch period, and the proportion of married, unemployed women with no children (FWNU) rises appreciably during the early evening hours—possibly in association with social commitments or with night courses and cultural events sponsored by the universities. But, in all instances, parents are underrepresented in Tract 8.

In contrast to Figure 9, Figure 10 provides a broader geographic coverage of diurnal changes in one aspect of the city's social geography. The space-time patterns of employed women who differ by marital status and child-care responsibilities (FWCE and FSNE) reveal sharp differences. In general, the unmarried group is highly concentrated on the peninsula (tracts 8 and 10) and displays significantly greater volatility in its daily space-time pattern. As examples, tracts 5 and 12 are virtually abandoned by this group during the day, whereas their relative concentrations at night are two or three times the city average. Tract 5 shows the same pattern for married respondents (FWCE), but at much lower levels. It is an example of a temporally-specialized region; being nearly void of occupants during the day; it serves the utilitarian role of providing nighttime accommodation. In contrast, the distinctly suburban tracts (3 and 4) and the central tract for Dartmouth (25) are strong on family orientation. Tract 25 provides some attraction (employment and shopping opportunities) for single women during the day, but not in the evening. In fact, of the 11 tracts in Dartmouth, only one (number 27) has representation of the FSNE respondents above the average for the study area for all six study times. Tract 4, in Halifax, shares this strong family orientation. However, there is an influx of both married and unmarried women during the day—most likely associated with the scheduling of activities at Mount St. Vincent University.

Further confirmation of the dominant significance of child-care responsibilities on daily space-time patterns is provided

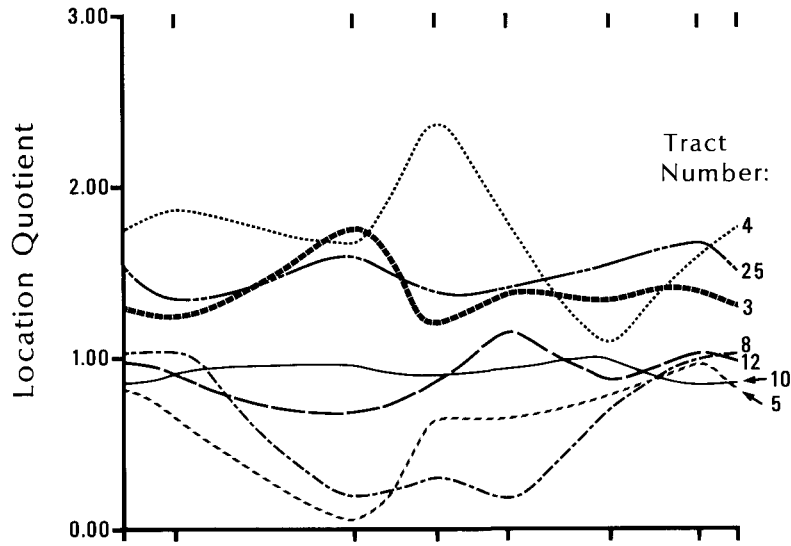
by an interpretation of the trends in density gradients in Figure 11. For example, compare the curves for employed, married males with children (MWCE) and those without (MWNE). Whereas the former is most highly concentrated during the day, the latter is most highly concentrated at night. An equally sharp contrast occurs among single, employed females. Those with children (FSCE) are the most highly dispersed of all subpopulations whereas those without (FSNE) have the highest overall levels of spatial concentration of all groups. With the exception of the FSCE group, all of the female groupings are most highly concentrated in the mid-morning period and are at their lowest densities in the late afternoon or early evening.

The final analysis, based on the measure of spatial dissimilarity of paired role groups (Figure 12) allows for a differentiation of space-time segregation patterns. In those instances where segregation by residential location is dominant, nighttime dissimilarity values exceed the daytime values. For example, married men, with and without children (MWCE and MWNE), are much more highly segregated from single men and women (MSNE and FSNE) at night than during the day. In contrast, the dominance of daytime segregation levels over nighttime levels reflects segregation based more on role differentiation than residential location. The most obvious examples relate to differences in child-care responsibilities and employment status (MWCE/FWCU, FWNU/FWCE, and MWNE/FSCE). Even employed parents, males and females, show a tendency towards greater daytime segregation as they pursue jobs in various parts of the urban region.

Finally, in reinforcement of previous observations on their high degrees of spatial concentration, the single, employed female (FSNE) is decidedly the most segregated subpopulation of those investigated. They are most segregated from married women with children (FWCU and FWCE). However, during the day

A Comparison of Diurnal Variations in the Spatial Concentrations of Female Role Groups.

Married, Employed, With Children:



Single, Employed, No Children:

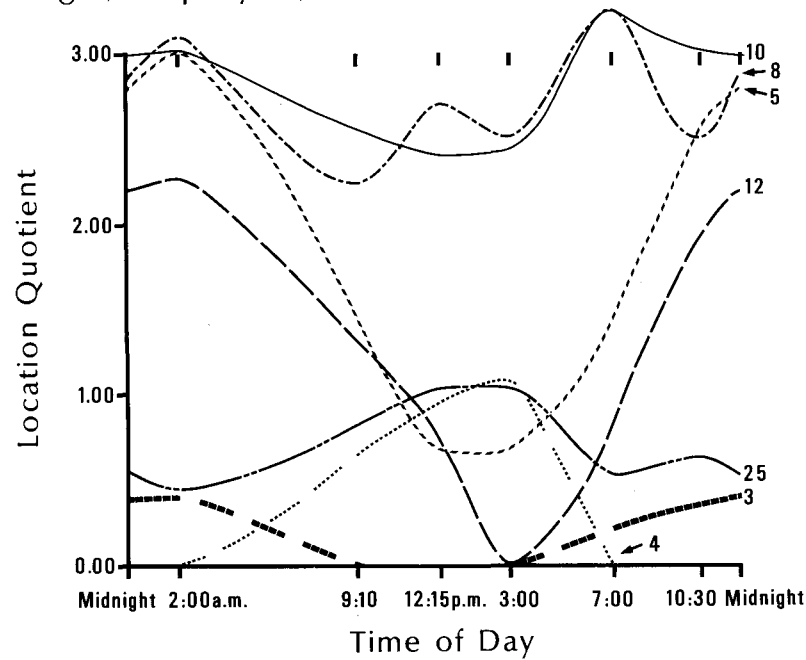
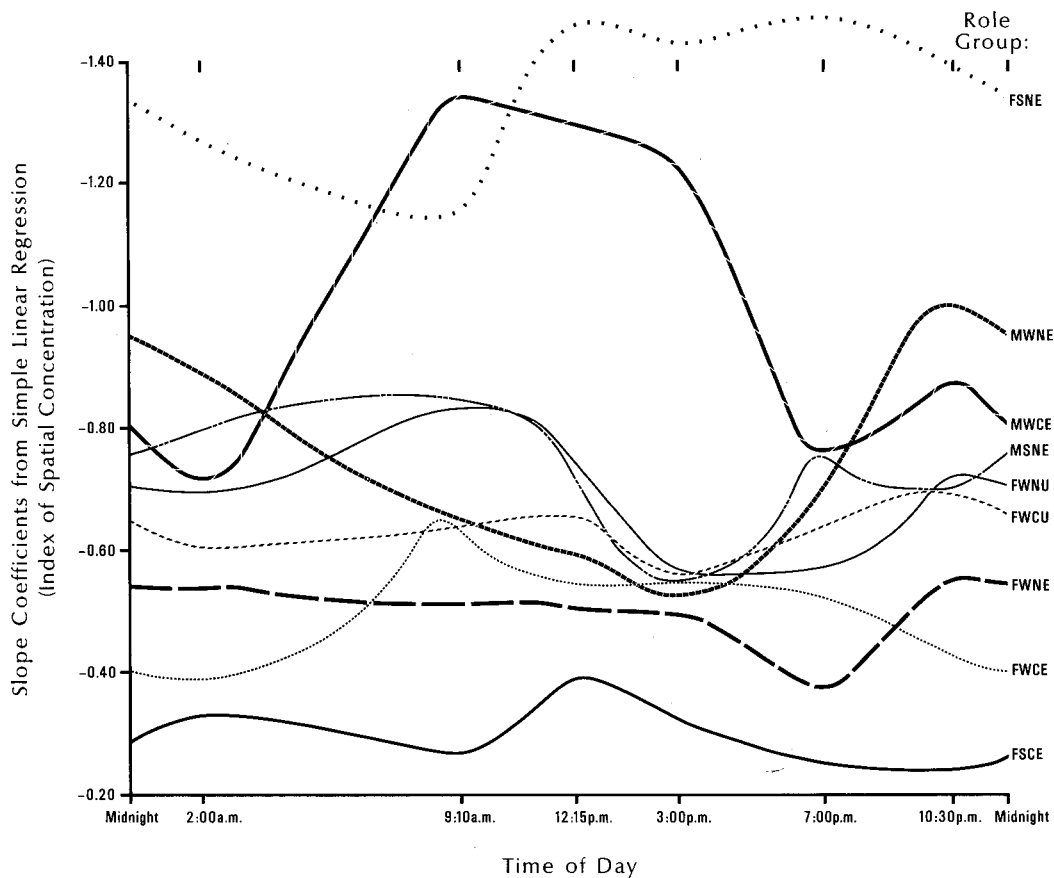


Figure 10

Diurnal Variations in Density Gradients for Selected Role Groups,
Halifax-Dartmouth, Canada.



Legend: F=Female, M=Male, W=Married, S=Single, C=Children, N=No Children, E=Employed, U=Unemployed

Figure 11

their segregation levels with married males (MWCE and MWNE) drop to levels comparable between those of married males with married females. Again, this supports the view that diurnal variations in segregation levels result from both residential and role-group differences.

CONCLUSIONS

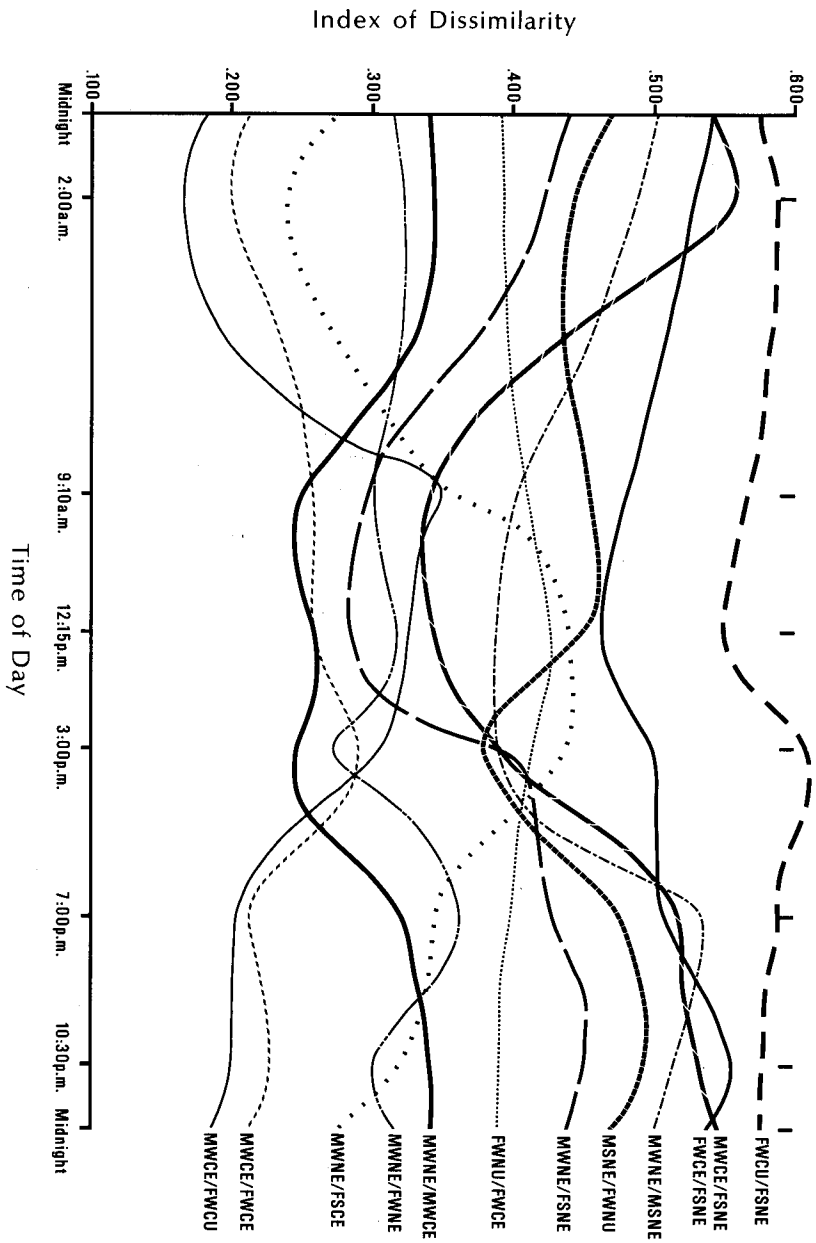
Although the need for information on the space-time patterns of urban demography has been recognized for a long time, the expense and complexity of gathering this information has largely precluded the description of such pat-

terns and, possibly for this reason, has resulted in little incentive for theoretical work. The space-time budget for Halifax in 1971-72, along with somewhat similar surveys in Hamburg, Germany [7] and Uppsala, Sweden [13], represents one of the few outstanding examples of a data set that is matched to the requirements for detailed space-time description. However, there remain serious questions as to how such complex, multifaceted data sets can be analyzed to yield information of substantive value for applied and theoretical purposes.

In this study, efforts to aggregate simul-

Diurnal Variations in the Spatial Correspondence of Role Groups.

(Based on 32 Pseudo Census Tracts for Halifax-Dartmouth, Canada.)



Legend: F=Female, M=Male, W=Married, S=Single, C=Children, N=No Children, E=Employed, U=Unemployed
 Figure 12

taneously the sampled individuals by space units for different times and by respondent characteristics were confronted with restrictions owing to sample size. Even with a sample of more than 1500, the combinatorial aggregation of respondents was limited to defining role groups according to the combinations of four individual characteristics, spread over 32 space units for six times.

Whereas the grouping of space units was directed to defining regions according to their ecological mix of permanent residents, the grouping of respondents was based on presumed differences in role type and behavior. The empirical exploration at two different levels of respondent aggregation was an important part of this study design. The results have confirmed the views of Clark, Elliott, and Harvey [6] and of Hanson and Hanson [13] that efforts are needed to define subpopulations that are relevant to behavioral analysis. For example, the differentiation of males and females, according to marital status, child-care responsibility, and employment, resulted in considerable variations in space-time patterns—variations that reflect important organizational principles in the functioning of an urban socioeconomic system.

An unescapable conclusion from this analysis is that urban socioeconomic systems are more complex than most of the urban-social-ecological literature would suggest. Since this lends support for the use of multivariate analytic approaches, the authors [10] have followed up the experiment of Taylor and Parkes [26] by applying a principal-axis factor analysis to the Halifax data. In combination with the insights derived from the use of simple spatial statistics in this paper, it provides a broader contextual framework for future analysis of the spatio-temporal patterns of individual behavior. Burnett and Hanson [3] and others have made important contributions in the descriptive analysis and theoretical understanding of individual travel behavior, but the relationships of such behavior to the tem-

poral dimensions of urban ecological structure represent a research area that has been largely ignored. The availability of large-scale, space-time diary data sets (however limited in number) represents an opportunity for closing an important gap in our understanding of the human geography of cities.

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