Use of Metropolitan Area Census Data for Transportation Planning

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The 1960 Census of Population, made available for the first time data on availability of automobiles, workers' modes of travel to work, and on general commuting patterns. From the hundreds of other statistical items in the 1960 and earlier Censuses, six characteristics relating to population, employment, and income were selected because they are the major factors generating traffic. This paper illustrates the implications which can be drawn from these data and how they can be utilized in the forecasts upon which sound comprehensive urban and transportation planning must be based. As a means of illustrating these implications, the 212 Standard Metropolitan Statistical Areas (SMSA's), defined by the Bureau of Census, were grouped in nine population size groups.

•THE NEED for effective use of available statistical material has been intensified by the imminent requirement for comprehensive urban planning. The U. S. Bureau of Census collects and tabulates a wealth of statistical materials on metropolitan areas. The 1960 Census of Population makes available for the first time data on the availability of automobiles, workers' modes of travel to work, and general commuting patterns. From the hundreds of statistical items in the 1960 and earlier censuses, six characteristics relating to population, employment, and income were selected. These elements were chosen because they are the major traffic-generating factors (1). This paper discusses the implications of these data and the ways the data can be used in the forecasts on which sound comprehensive urban and transportation planning must be based. To illustrate these implications, 212 Standard Metropolitan Statistical Areas (SMSA's), defined by the U. S. Bureau of Census, were grouped in nine population size groups based on their 1960 populations. The number of SMSA's in each population size group and the population range of each size group are given in Table 1. In addition to presenting general implications based on size group averages and ranges, this report discusses some detailed implications of a study of the Washington SMSA census tracts (2).

SELECTED CHARACTERISTICS

Where people live, where they work, and what they do constitute the basic elements of the land-use pattern. Population trends must be understood because people must travel, produce goods and services, and participate in social activities. Basically, social and economic activity and the land-use pattern are different aspects of the same thing. Available statistical data representing this totality can be used to predict future land-use patterns which could not otherwise be known. Current data on land use are difficult to obtain and are seldom up-to-date.

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ERRATA

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On page 22:

EDMOND L. KANWIT and DAVID M. GLANCY, U. S. Bureau of Public Roads

should read:

EDMOND L. KANWIT, U. S. Bureau of Public Roads, and
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In Figure 1, page 55, the family income group reading "$5,000-5,999," should read "$5,000-9,999."

TABLE 1

POPULATION SIZE GROUPS OF 212 SMSA's, 1960[a]

Size Groups	No. of SMSA's
≥1,000,000	24
500,000 - 1,000,000	29
300,000 - 500,000	28
250,000 - 300,000	20
200,000 - 250,000	21
150,000 - 200,000	26
125,000 - 150,000	23
100,000 - 125,000	19
50,000 - 100,000	22
Total	212

[a]Data derived from Ref. 3.

Population Growth

The 212 SMSA's, which contain over three-fifths of the nation's population and employment, accounted for 85 percent of the population increase in the last decade. Although growth was concentrated in the large areas, all size groups showed a substantial rate of increase, and only eight SMSA's lost population. (These areas were Altoona, Jersey City, Johnstown, St. Joseph, Scranton, Texarkana, and Wilkes Barre-Hazelton. With the exception of St. Joseph and Texarkana, they are all in the Northeast, and they also lost population in the previous decade due to the decline in coal mining and the lack of alternate job opportunities.) The most rapid growth took place in a tier of states rimming the country all through the West from the Southwest, Gulf, and South Atlantic borders and in areas of the Great Lakes. (A close examination of industrial trends and location of military installations would explain, in large measure, the geographic variations of growth.) The fast growing segments were the suburbs of the largest areas, some of which were in the Northeast. More recently the U. S. Bureau of Census has indicated some slackening in the suburban growth rate.

Table 2 indicates the rate of population change in the SMSA's between 1950 and 1960. The relation between growth rates of central cities and suburbs was closely associated with the size of the SMSA. As size declined, the rate of growth of central cities in-

TABLE 2

POPULATION CHANGE OF 212 SMSA's, 1950-1960[a]

Size Group	Percent Population Change								
	Central City			Suburbs[b]			Entire SMSA		
	Avg.	Highest	Lowest	Avg.	Highest	Lowest	Avg.	Highest	Lowest
≥1,000,000	2.8	71.4	-13.0	55.6	115.7	17.2	24.0	85.5	7.4
500,000 - 1,000,000	21.4	311.1	-12.6	57.2	124.4	- 4.0	36.1	121.1	- 5.7
300,000 - 500,000	13.7	112.0	-14.9	46.1	546.7	-42.0	28.1	297.9	-11.5
250,000 - 300,000	21.4	368.4	-14.7	20.6	63.5	-44.9	21.0	88.1	- 3.6
200,000 - 250,000	30.6	319.9	-11.2	28.8	140.3	-79.8	29.7	98.9	- 8.9
150,000 - 200,000	19.3	79.4	- 9.3	28.6	106.7	-13.6	23.2	72.0	- 3.0
125,000 - 150,000	21.9	161.6	-10.7	35.4	164.6	-25.1	26.9	163.0	- 1.6
100,000 - 125,000	26.0	340.3	- 6.5	14.6	56.8	-24.9	21.5	61.0	0.6
50,000 - 100,000	28.9	188.4	1.4	12.1	87.9	-40.2	24.6	162.6	- 6.4
Total	10.7	368.4	-14.9	48.6	546.7	-79.8	26.4	297.9	-11.5

[a]Data derived from Ref. 3.
[b]Area of SMSA surrounding Central City, which U. S. Bureau of Census terms SMSA ring.

TABLE 3

POPULATION CHANGE OF CENTRAL CITIES OF 212 SMSA's, 1950-1960[a]

Region	Population Change (%)		
	Within 1950 Area	From Annex-ation	Entire Central City
Northeast	-3.3	0.1	3.2
North Central	-1.6	5.9	4.3
South	5.2	23.3	28.5
West	14.5	16.9	31.4
Total	1.4	9.3	10.7

[a]Data derived from Ref. 4.

creased progressively in relation to that of the suburbs, so that in SMSA's of less that 100,000 the rate for the central city exceeded that in the suburbs.

In the 212 metropolitan areas, the central cities (as a group) gained almost entirely through annexation. Of the 5.6 million added, only 767,000 lived in the cities as defined in 1950 and 4.9 million were in annexed territory. Thus the decentralizing trend is obscured by annexations to the central city. Only 84 of the areas had increases in the central city of greater than 20 percent including annexation. Although annexation resulted in a gain of more than one million in all SMSA's with more than one million inhabitants, the 1950 area of the central cities actually lost almost 200,000 inhabitants.

The greatest numerical increases to central cities from annexation occurred in the South and West; in the South this amounted to four-fifths of the increase in the central cities between 1950 and 1960, and in the West over one-half. Table 3 indicates the role of annexation in central city growth by region between 1950 and 1960.

The growth of suburbs by size group varied directly with the size of the central city. The central cities of 56 of the areas lost population, but this was compensated by sufficient suburban growth to leave only eight SMSA's with overall decline in population. The suburban areas of 122 of the SMSA's increased in population during the decade from 20 to 80 percent. The Fort Lauderdale-Hollywood suburbs gained 547 percent, Tucson 368 percent, and Las Vegas 165 percent. In eleven additional areas, the gain in population was over 100 percent in the suburban portion of the areas. Some cities, like Phoenix, annexed their most rapidly growing suburbs.

The detail that can be obtained on an individual metropolitan area can be seen in Figure 1 which shows that although Washington, D. C. lost population, one tract gained between 60 and 100 percent and seven tracts gained between 40 and 60 percent. This figure also shows that 20 suburban tracts lost more than five percent of their 1950 population during the past decade.

Generalizations grossly misrepresent the varying populations in small component areas, a matter of considerable importance to transportation planners. Recent estimates of the U. S. Bureau of Census indicate not only a reversal of population growth for the central city of the Washington SMSA, but also that the SMSA is now the fastest growing metropolitan area in the nation.

Population Density

In 1960 the average population per square mile of land area for all of the 212 metropolitan areas was 364, or slightly more than seven times the average density of the country as a whole. For example, the Jersey City SMSA had an average of 13,572 inhabitants/sq mi, whereas the Reno SMSA had only 14 inhabitants/sq mi. Thirteen SMSA's had average population densities of less than 50 inhabitants/sq mi. (This extreme variation in density among SMSA's is an indication, of course, of the limitations of whole counties as a basis for defining such areas. The area of San Bernardino in California, for example, is larger than any of the New England States except Maine and nearly ten times the size of the New York SMSA. In short, in those parts of the country where counties are large, counties include large rural areas, and are much larger than the urbanized areas.)

Table 4 indicates the average 1960 population density for the central city, suburbs, and entire SMSA for each size group and the highest and lowest value within each size

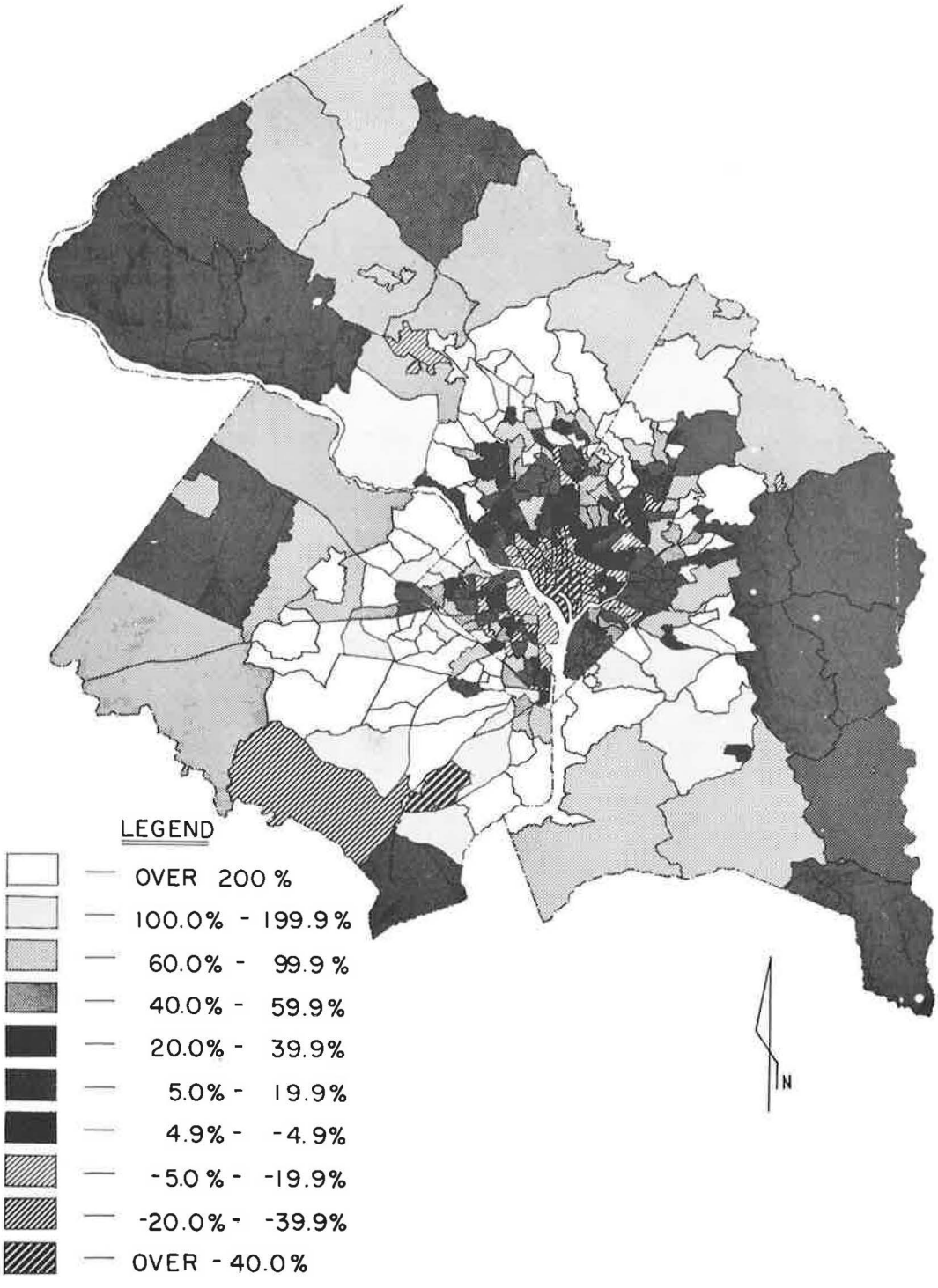

Figure 1. Percent change in population, Washington, D. C. SMSA, 1950-1960.

TABLE 4

AVERAGE DENSITY OF 212 SMSA's, 1960[a]

Size Group	Inhabitants (per sq mi)								
	Central City			Suburbs			Entire SMSA		
	Avg.	Highest	Lowest	Avg.	Highest	Lowest	Avg.	Highest	Lowest
≥1,000,000	9,247	24,697	2,428	609	2,245	113	1,134	4,977	243
500,000 - 1,000,000	4,150	21,239	1,009	133	12,871	22	272	13,572	30
300,000 - 500,000	3,970	10,486	1,326	159	1,218	39	301	2,040	61
250,000 - 300,000	3,751	15,428	1,406	65	689	6	124	1,168	29
200,000 - 250,000	3,518	12,926	1,537	125	287	26	252	880	115
150,000 - 200,000	3,302	7,031	1,716	95	1,714	25	209	2,005	36
125,000 - 150,000	3,091	7,959	768	55	665	7	136	1,535	16
100,000 - 125,000	2,795	6,723	1,427	46	659	12	119	1,270	38
50,000 - 100,000	2,350	5,683	680	16	617	—	69	2,206	14
Total	5,336	24,697	680	183	12,871	—	364	13,572	14

[a]Data derived from Ref. 3.

group. Considerable variability in density occurs among central cities and among suburban areas. New York City had an average density of 24,697, whereas Lewiston-Auburn had only 680 persons/sq mi in its central city. The range of density for suburban areas went from a high of 12,871 for the suburbs of Jersey City to a low of less than 1 inhabitant/sq mi for the San Angelo suburbs in Texas.

The density pattern is related to the period when the major development of the area occurred; older cities have multi-family structures and vertical expansion to accommodate close-in industry and mass transportation. The automobile made possible the development of land at lower densities than in the older central cities and also some suburban development of the Northeast. New cities and suburban areas which developed after the advent of the automobile have grown and continue to grow at lower densities.

Figure 2 shows the pattern of densities of the Washington SMSA. Six central city tracts had average densities of over 50,000 persons/sq mi, but a majority of the tracts in the area had densities of less than 1,000 inhabitants/sq mi. Enclaves of high density in the suburban areas are discernible.

Differences in density not only reflect regional differences, administrative boundaries, and historic periods of growth, but also have significant influence on the urban transportation planner's choice of the most effective mode of transportation. Thus, public transportation can be supported only in areas of high density.

Participation in the Labor Force

The mature noninstitutional population, i.e., 14 years and over, is divided into those at work or seeking work (the labor force) and those not in the labor force. The latter are composed of housewives, students, retired persons, and others who do not work for pay or profit. The labor force, in turn, is divided into the employed and the unemployed; members of the armed forces are, of course, excluded from the civilian labor force. The U. S. Bureau of Census has rigorous definitions of employed, unemployed, and labor force, which all students in the field should understand.

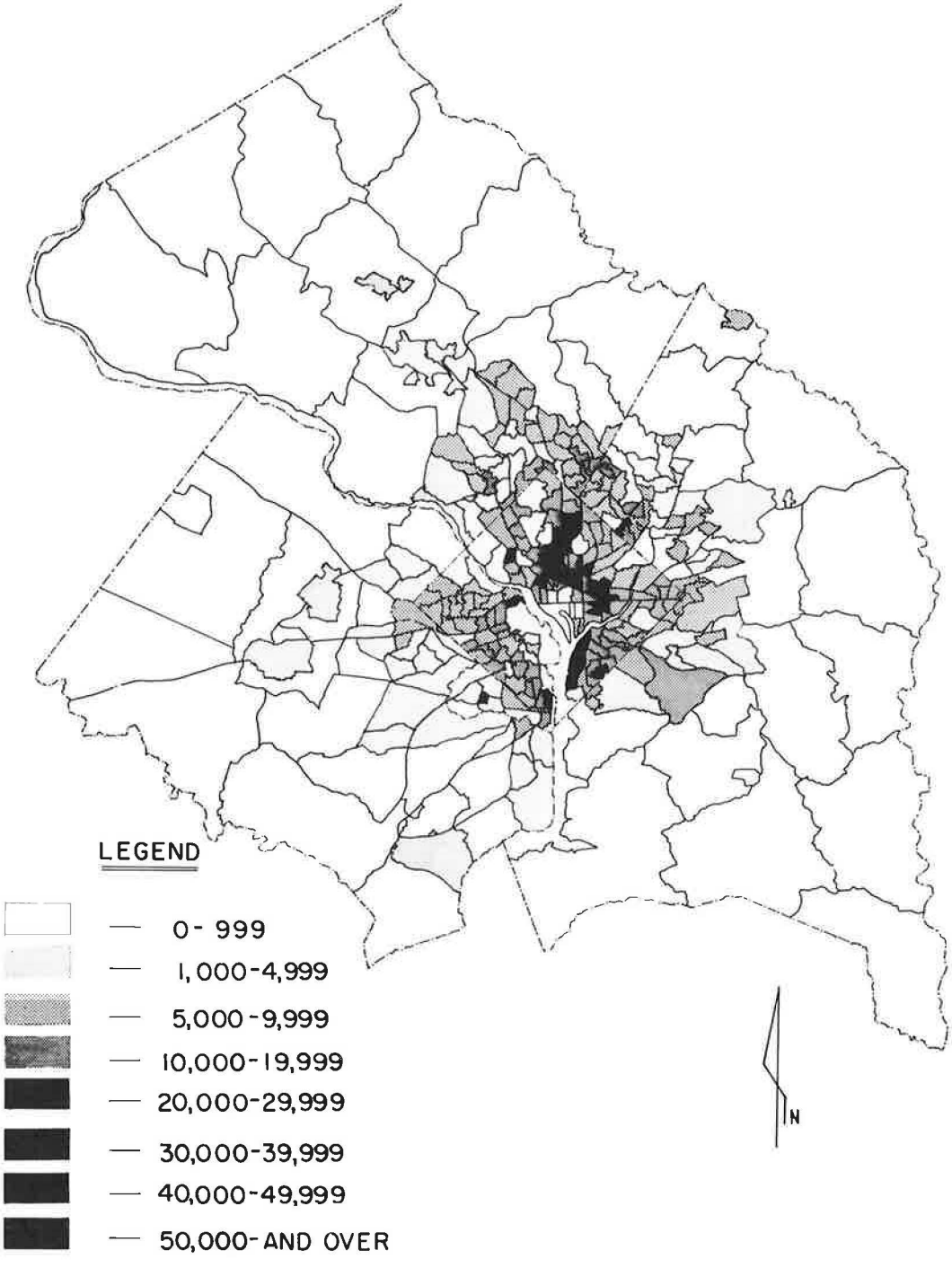

Figure 2. Population density, Washington, D. C. SMSA, 1960.

TABLE 5

U. S. LABOR FORCE PARTICIPATION RATES[a]

Year	Labor Force (%)		
	Male	Female	Total
1920	85.9	24.1	55.8
1930	83.4	25.1	54.6
1940	80.9	27.4	54.1
1950	82.4	31.9	56.8
1960	77.4	34.5	55.3

[a]Percent of noninstitutional population, ≥ 14 yr, working or seeking work.

The size of the labor force reflects the size of the population 14 years old and over from which it is drawn and the extent to which the component age-sex groups seek work. The propensity of these groups to enter the labor market, in turn, is primarily affected by employment opportunity, varying social customs in rural and urban areas, and to a lesser extent by income, education, and racial and national origin characteristics.

Labor force participation rates since 1920 show an increasing tendency of women to work and a decline in male rates. These rates, given in Table 5, are based on the noninstitutional population 14 years of age and over. They reflect increased utilization, earlier retirement, prolonged education, and greater job opportunities for women. As might be expected, significant differences in labor force participation exist among areas, in suburbs and central cities, and these differences affect the transportation planners work by yielding differing travel peak-loads in the journey to work.

The extent of participation in the labor force does not change rapidly, but it can be influenced by both cyclical and secular economic factors. With the maturation of the vast crop of post-war babies, coincident with growing automation, past trends which have brought rapid increase in female labor participation may not continue indefinitely.

TABLE 6

DISTRIBUTION OF LABOR FORCE, 1960[a]

Size Group	Labor Force (%)				
	Manufacturing	Wholesale & Retail Trade	Government	Other Ind. Groups & Armed Forces	Unemployed
≥1,000,000	28.1	17.3	10.7	37.3	6.6
500,000 - 1,000,000	24.2	17.8	12.3	37.9	7.8
300,000 - 500,000	27.1	17.6	12.3	53.3	7.7
250,000 - 300,000	30.0	19.8	14.0	28.3	7.9
200,000 - 250,000	25.9	16.8	11.9	36.0	9.4
150,000 - 200,000	26.3	17.3	12.2	36.9	7.3
125,000 - 150,000	24.7	16.9	11.5	36.6	10.3
100,000 - 125,000	26.2	18.6	12.5	36.5	6.2
50,000 - 100,000	22.1	18.3	9.6	39.4	10.6
Total	27.1	17.5	11.4	36.7	7.3

[a]Data derived from Ref. 3.

TABLE 7

REGIONAL CHARACTERISTICS OF EMPLOYMENT, 1960[a]

Region	No. of SMSA's	SMSA's with More than Avg. U. S. Employment (%)		
		Manufacturing	Wholesale & Retail Trade	Government
Northeast	47	87.2	17.0	12.8
North central	58	69.0	60.3	22.4
South	77	29.9	80.5	48.1
West	30	16.7	80.0	73.3
Total	212	51.4	60.8	36.8

[a]Data derived from Ref. 3.

Table 6 indicates employment by major industry groups for the three largest components of each of the population size groups. It indicates the relative importance of the three largest industry groups in employment: manufacturing, wholesale and retail trade, and government.

Table 7 gives departures from national norms, indicating the proportion of SMSA's exceeding the United States average employment in three key industrial groups. The dominance of manufacturing continues in the Northeast, the originating region of American industrialization. The influence of Federal government policy in developing areas in the South and West appears clearly since the rate at which western areas exceed the national norm in government employment is six times that at which the Northeast exceeds the national norm. Trade probably represents more of a residual effect than an intrinsically significant factor, although many southern and western areas have not developed beyond the essential function of being distribution centers.

Median Family Income

Median family income was selected as the best single measure of income with regard to transportation demand, as most travel is determined by family needs and desires. The income data are for the year preceding the Census and are based on a 25 percent sample. The reported income excludes nonrecurrent income such as inher-

TABLE 8

MEDIAN FAMILY INCOME, 1959[a]

Size Group	Income ($)					
	Central City			Entire SMSA		
	Avg.	Highest	Lowest	Avg.	Highest	Lowest
≥ 500,000 - 1,000,000	5,921	6,942	5,029	6,618	7,577	5,758
300,000 - 500,000	5,982	7,024	4,450	6,151	7,417	4,490
250,000 - 300,000	5,834	6,340	3,816	6,065	6,776	4,908
200,000 - 250,000	5,782	6,621	4,438	5,805	6,707	4,540
150,000 - 200,000	5,441	6,865	3,603	5,407	6,702	4,292
125,000 - 150,000	5,632	7,728	3,807	5,674	8,745	3,216
100,000 - 125,000	5,832	7,662	3,995	5,820	7,010	4,419
50,000 - 100,000	5,667	7,035	3,958	5,539	6,916	4,274
Total	5,850	7,433	2,935	5,255	8,002	2,952
	5,945	7,728	2,935	6,324	8,745	2,952

[a]Data derived from Ref. 3.

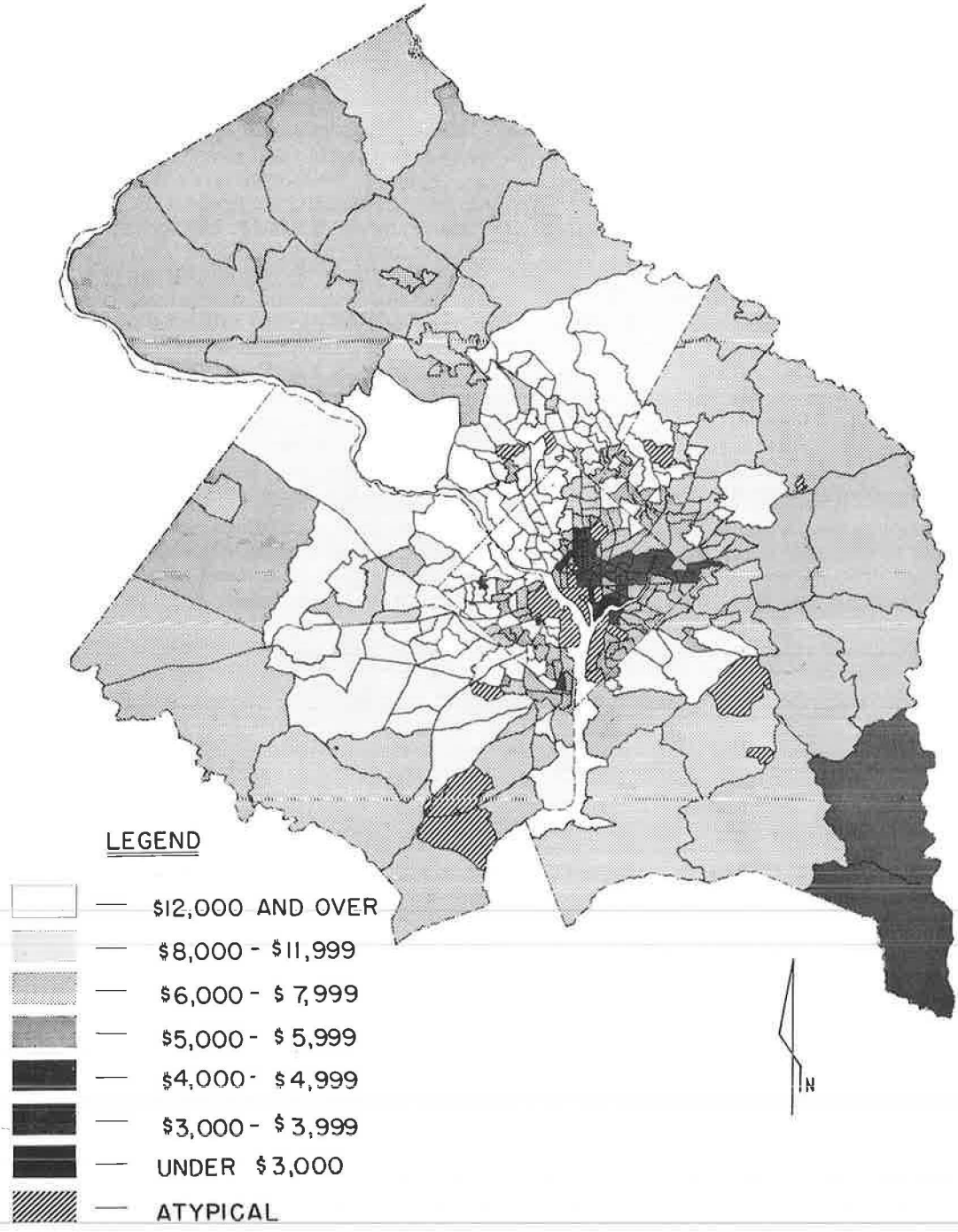

Figure 3. Median family income of individual tracts, Washington, D. C. SMSA, 1959.

itance, gifts, income from sale of property, and insurance payments. It includes wages and salaries, income from self-employment, and from rents, dividends, interest, pensions, social security and annuities.

The attraction toward urban areas becomes clear when the 1959 median family monetary income for the nation as a whole is compared with that of the urban and rural areas. The U. S. median income was $5,660, the urban area median was $6,166, and that of rural areas only $3,228.

Table 8 indicates that, generally, the central city median family income is lower than that for the entire SMSA. (In two areas in Tennessee it was significantly lower, reflecting the low income typical of Appalachia.) Higher income families have been moving to the suburbs to take advantage of more space and privacy. Migration to the central cities of low-income families from rural areas and the entrapment of low-income families in the central cities by land development patterns and customs contribute to the income differentials. These patterns are apparent in Figure 3, which shows the median family income of the individual tracts in the Washington SMSA.

Data on more than present income, however, are needed. The change in income in real terms and the change in distribution of income must be examined to gain a clearer picture of the effects of income on transportation. Figure 4 shows these for the period 1949 to 1959 for the District of Columbia and for its suburbs. (The Washington Consumer Price Index was used to convert 1949 dollars into 1959 dollars. The national consumer price index is only a rough measure for such a conversion for the 212 SMSA's and individual area indices are available only for a limited number.) The changes for the suburbs are more distinct than those for the District itself, but the outward moving pattern of income is discernible.

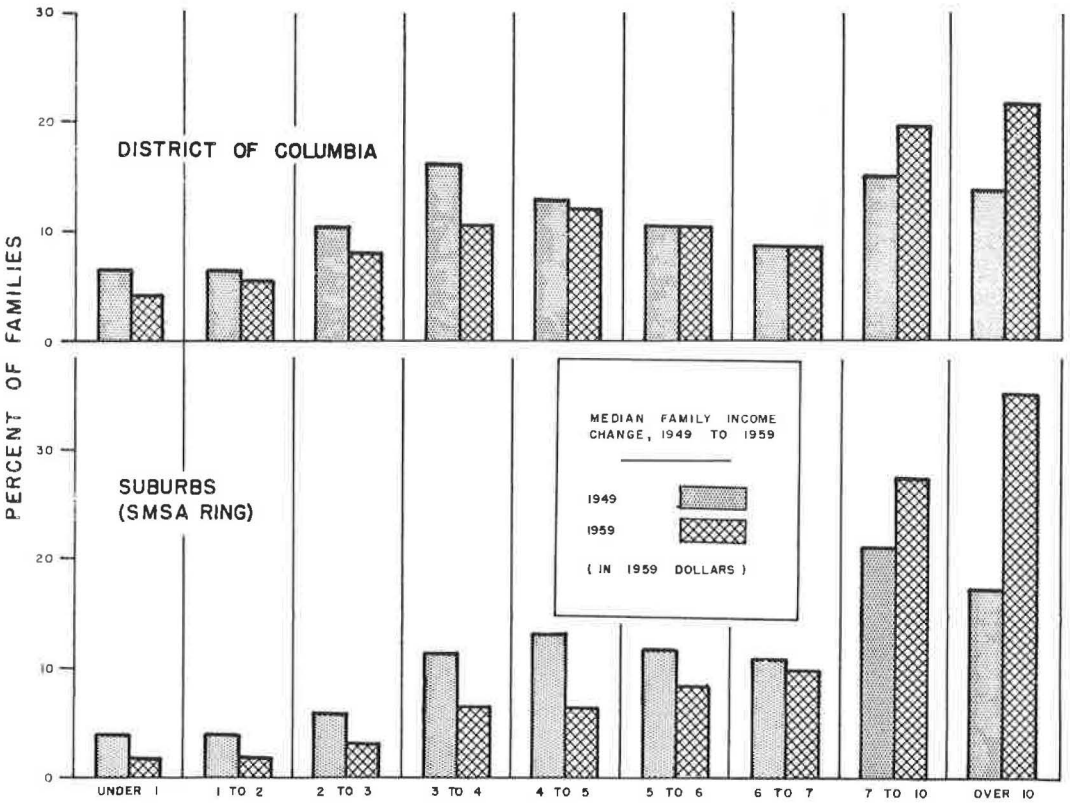

Figure 4. Median family income groups, 1000's 1959 dollars, Washington, D. C.

Automobile Availability

More than half of the 62 million automobiles reported as available in the 1960 census were in metropolitan areas. The count of automobiles available represents the number of passenger automobiles, including station wagons, owned or regularly used by any of the occupants of the housing unit. Passenger cars were counted if they were owned by a member of the household or if they were regularly used and ordinarily kept at home, such as some company cars. Taxis, pickups or larger trucks, and dismantled or dilapidated cars in an early stage of being junked were not counted. It was only in the size group of one million or more inhabitants that any differential by population size group of automobile densities was noted. Otherwise, significant differences in automobile densities characterized individual areas, but the differences were intra- rather inter-group as indicated in Table 9.

Among all size groups, automobiles were more numerous in relation to both population and housing units in the suburbs than in the central cities. The differential was greatest between central cities and suburbs in largest metropolitan areas and tended to narrow rapidly to areas of about 200,000 in population. Thereafter, the differential rose slightly but remained at a stable level for smaller population size groups.

An interesting study of the use of public transportation by Professor Leo Schnore in Traffic Quarterly, October 1962, shows that three factors—size of city, population density, and age—account for most variation in the use of public transportation. Within a particular area, the availability of various means of transportation, the distance from the central business district, and income are also determinants. The interrelationships of all these factors are the key to forecasting transportation demand.

The net effect of population shifts in the United States on automobile density is complex. While the census reports greater automobile density in rural areas than in urban areas, it would not be correct to conclude that urbanization, per se, is tending to reduce automobile densities. The reason is that almost the entire increase in population in recent years has either taken place in the suburbs where automobile densities are even greater than in rural areas or in the annexed portions of central cities, which are generally suburban in character and in automobile density.

The automobile density pattern of the tracts in the Washington SMSA is shown in Figure 5. When Figure 5 is compared with Figure 4, a strong positive relationship appears between automobile availability and income. In Figure 6 the central city and suburban tracts are plotted using these two elements as coordinates. Least-square zones of central tendency for both the central city and the suburbs were computed and plotted. Analysis of the tracts in the District outside the zone revealed that the majority of the tracts below the zone were locations in which walking was a major mode of travel to work and tracts above the zone were locations where public transit service was limited. (Many believe that race is a factor in automobile ownership. This, however, is not apparent in the Washington SMSA statistics. Analyzed on a basis of income, no difference in automobile availability appears according to the racial composition of the various Census tracts once income is taken into account.)

Other analyses must be made of automobile availability to determine effects on transportation planning. In Figure 7 the percent of households with none, one, two, and three or more autos available is shown by income groups for the District of Columbia and its suburbs. Here the relationship between auto availability and income is more pronounced. In planning for mass transit, the captive ridership, i.e., households with no autos available, is important, but multi-car households are also important.

The influence of income on auto availability varies among metropolitan areas. Figure 8 shows the striking differences between areas, using the central cities of the five largest SMSA's as examples. At the $3,000 annual family income level, only

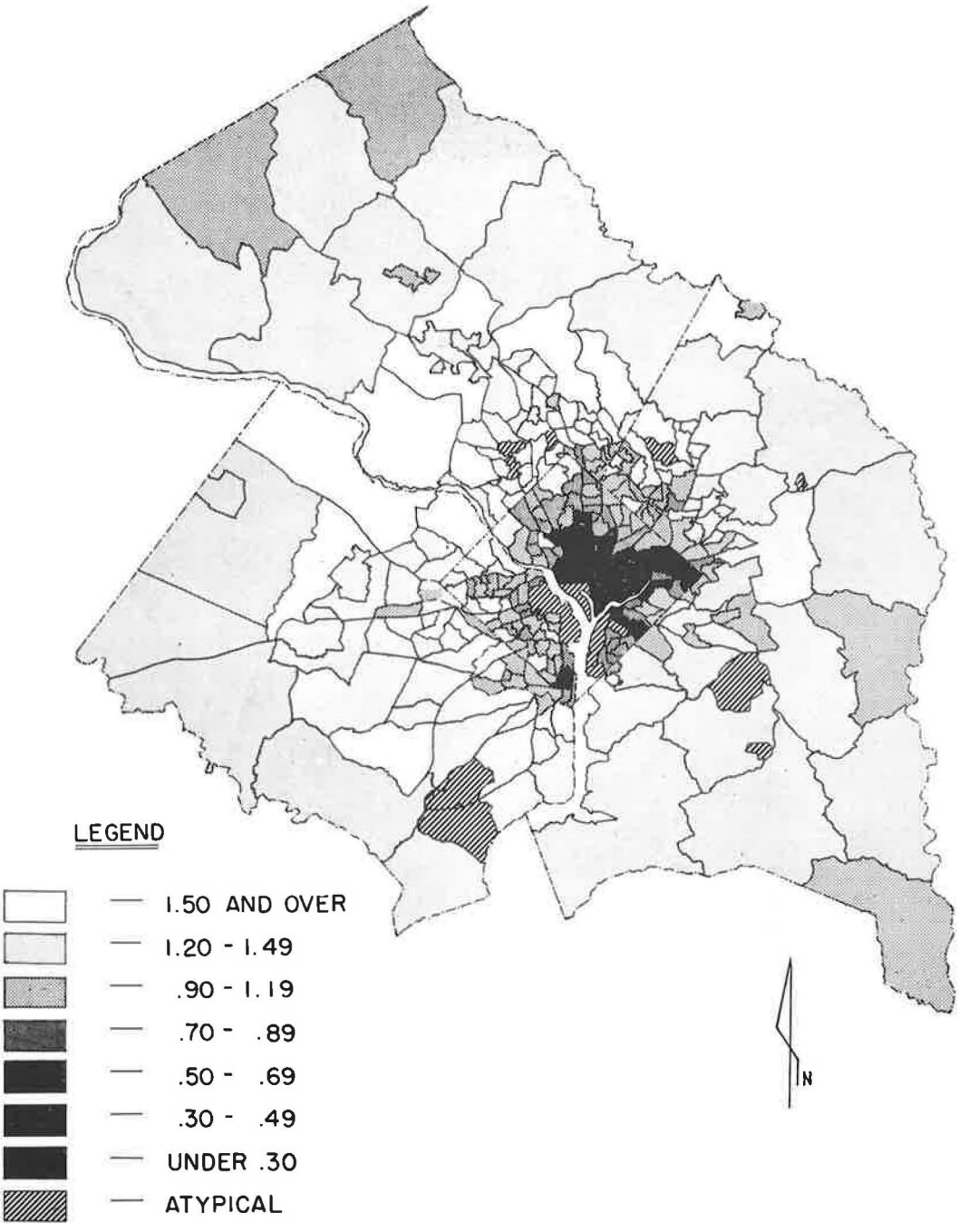

Figure 5. Average auto availability per household, Washington, D. C., 1960.

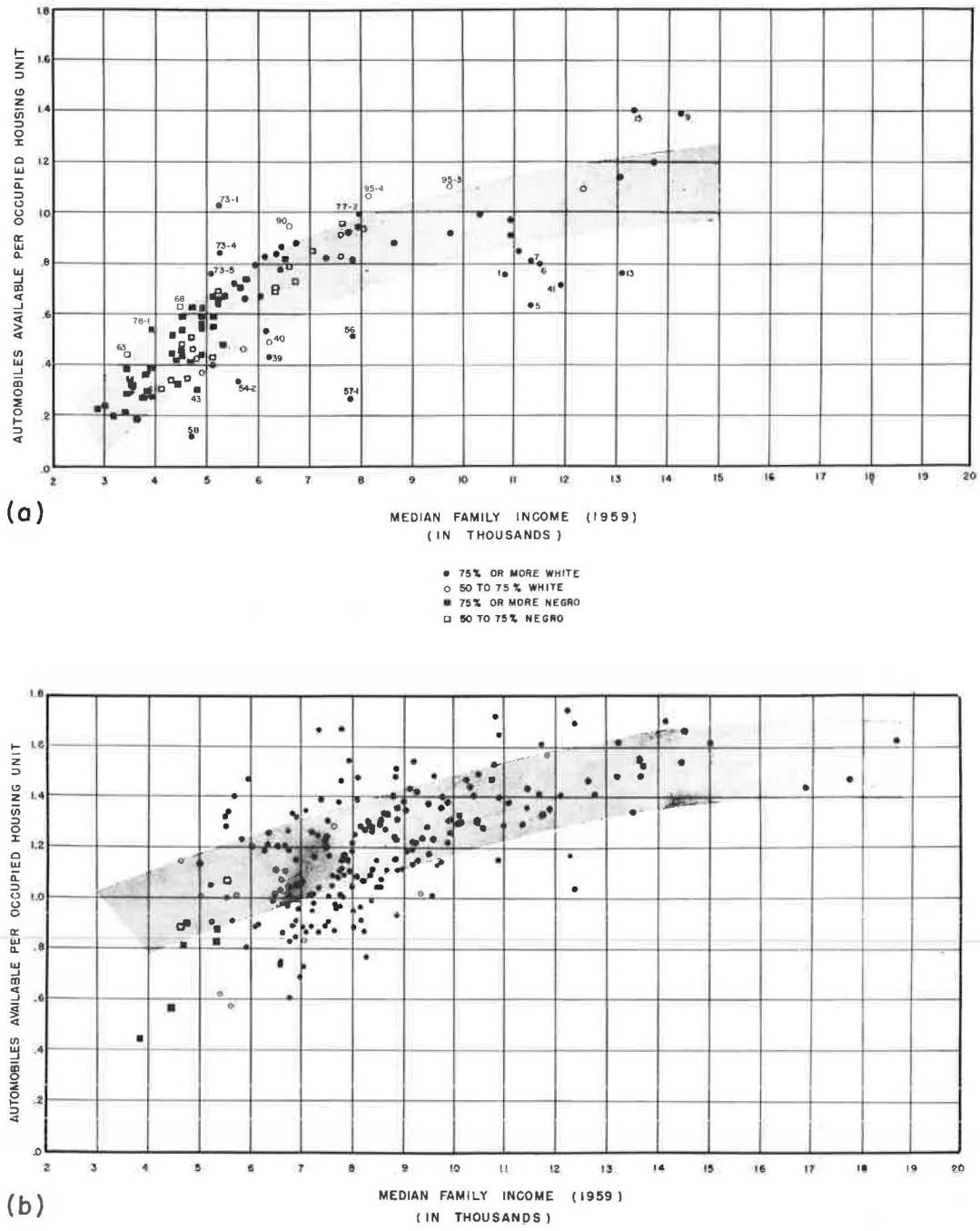

Figure 6. Automobiles available per occupied housing unit (1960) by median family income (1959); (a) District of Columbia, (b) Washington SMSA ring.

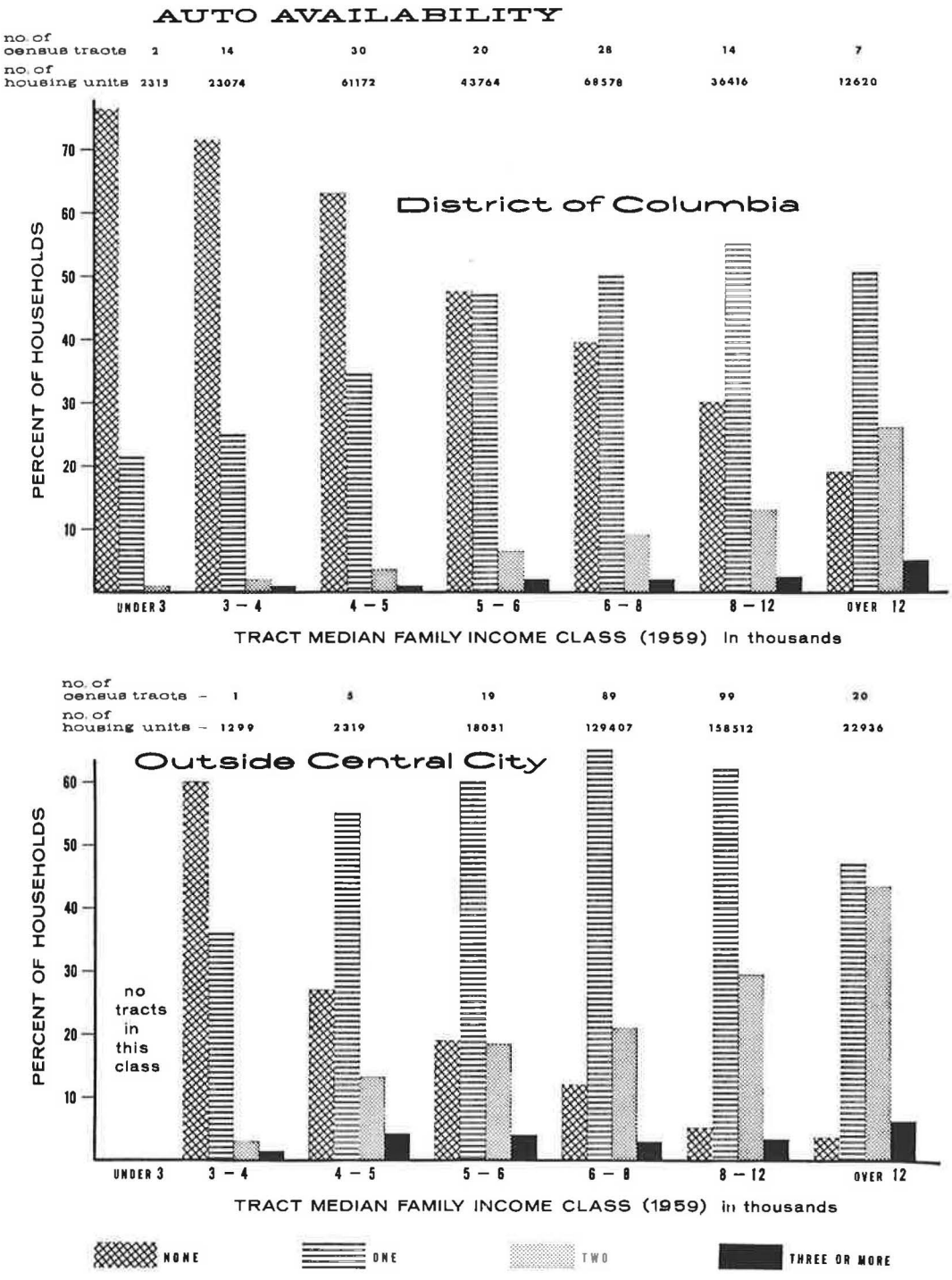

Figure 7. Percent of households with none, one, two, and three or more autos available by income groups for District of Columbia and its suburbs, 1959.

TABLE 9

AVERAGE AUTOMOBILE AVAILABILITY PER OCCUPIED HOUSING UNIT, 1960[a]

Size Group	No. Cars per Unit								
	Central City			Suburbs			Entire SMSA		
	Avg.	Highest	Lowest	Avg.	Highest	Lowest	Avg.	Highest	Lowest
≥1,000,000	0.75	1.15	0.47	1.20	1.32	1.01	0.96	1.21	0.64
500,000 - 1,000,000	0.95	1.24	0.64	1.22	1.43	0.75	1.07	1.33	0.70
300,000 - 500,000	0.96	1.17	0.72	1.20	1.40	0.96	1.08	1.23	0.93
250,000 - 300,000	1.00	1.27	0.74	1.16	1.35	0.94	1.08	1.25	0.91
200,000 - 250,000	1.01	1.16	0.62	1.15	1.35	0.97	1.07	1.19	0.90
150,000 - 200,000	0.98	1.29	0.46	1.19	1.50	0.88	1.07	1.34	0.84
125,000 - 150,000	1.01	1.26	0.77	1.21	1.35	1.02	1.08	1.27	0.85
100,000 - 125,000	1.04	1.32	0.80	1.20	1.38	1.00	1.10	1.29	0.92
50,000 - 100,000	1.05	1.35	0.76	1.21	1.55	0.99	1.09	1.37	0.78
Total	0.85	1.35	0.46	1.20	1.55	0.75	1.01	1.37	0.64

[a]Data derived from Ref. 5.

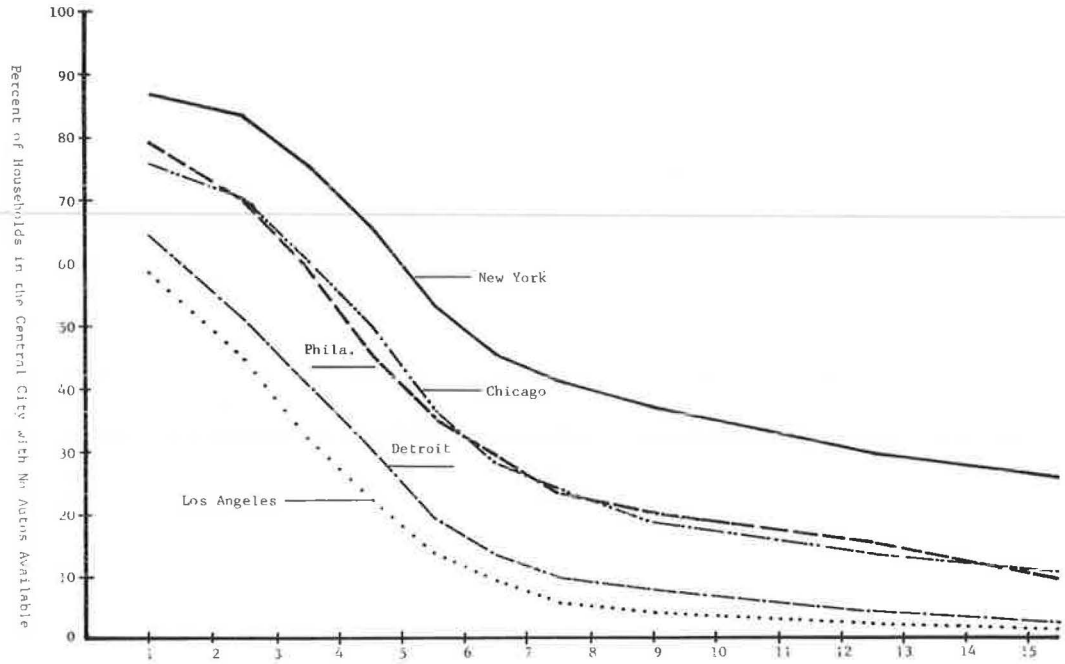

Figure 8. Income for families and unrelated individuals by households (thousands of dollars), 1959.

three-eighths of the households in the Los Angeles central city are without a car, whereas in New York City four-fifths are without. At the $10,000 level, both percentages decrease: only 3 percent in Los Angeles but still more than one-third in New York City. Thus, it is apparent that income is a determinant of auto availability only in conjunction with other factors, such as population density, availability of public transit, and vehicle operating cost, including garaging and insurance. Although there is an apparent general relationship between income and auto availability, other factors determine where in the family of curves the curve for a specific area will fall.

Work Trip Modes of Travel

As might be expected, the pattern of private automobile or carpool use was similar to that of automobile availability. Except in the over one million population size group, the differences due to size were slight. But unlike auto availability, and again except for the largest size group, there were only slight differences between the central cities and the suburbs. There were, however, considerable intra-group differences, with high percentage use in the newer southern and western metropolitan areas and lower use in the older eastern areas. The interrelationship of density of development and auto usage is thus apparent.

The average percentage use of automobiles on the work trip is given for the nine size groups in Table 10. The average percentage of use of private cars by central city workers on the work trip ranged from a high of 87.7 percent in Lawton, Oklahoma, to a low of 20.2 in New York City. In the suburban areas it ranged from 88.8 percent for the Muskegon-Muskegon Heights suburbs in Michigan to 23.0 percent for the Lawton suburbs. (Lawton, the site of Fort Sill is atypical and includes a very large proportion of work at home. Public transportation is insignificant.) The range narrowed somewhat, but is still wide, when entire SMSA's are compared with the high at 86.8 for the Odessa SMSA in Texas and a low for the New York SMSA of 30.9 percent.

The pattern of car usage within a metropolitan area is shown in Figure 9. Only three suburban Washington tracts reported having car usage in the 40 to 50 percent range with the remainder all over 50 percent. A majority of tracts were reported to have over 80 percent usage. The District of Columbia, on the other hand, had no tract with

TABLE 10

AVERAGE PERCENTAGE USE OF PRIVATE AUTOMOBILES OR CARPOOL BY WORKERS ON WORK TRIP, 1960[a]

Size Group	Central City			Suburbs			Entire SMSA		
	Avg.	Highest	Lowest	Avg.	Highest	Lowest	Avg.	Highest	Lowest
≥1,000,000	47.8	77.2	20.2	75.5	87.8	63.2	61.3	81.5	30.9
500,000 - 1,000,000	68.0	85.9	39.0	78.4	88.3	40.7	72.8	83.8	41.2
300,000 - 500,000	70.0	83.8	54.2	80.0	88.8	39.3	74.9	84.7	66.2
250,000 - 300,000	71.7	85.0	44.9	76.0	86.1	63.0	73.9	83.9	65.0
200,000 - 250,000	72.3	82.4	41.6	75.2	83.9	50.7	73.6	79.4	62.1
150,000 - 200,000	70.4	84.9	32.0	77.7	87.2	57.4	73.4	81.3	60.1
125,000 - 150,000	73.8	85.3	61.3	77.9	88.8	57.3	75.3	83.4	64.0
100,000 - 125,000	74.7	84.7	58.7	76.4	87.4	45.6	75.3	84.8	62.9
50,000 - 100,000	75.6	87.7	61.5	63.7	85.7	23.0	73.0	86.8	58.4
Total	58.3	87.7	20.2	63.7	88.8	23.0	66.8	86.8	30.9

[a]Data derived from Ref. 6.

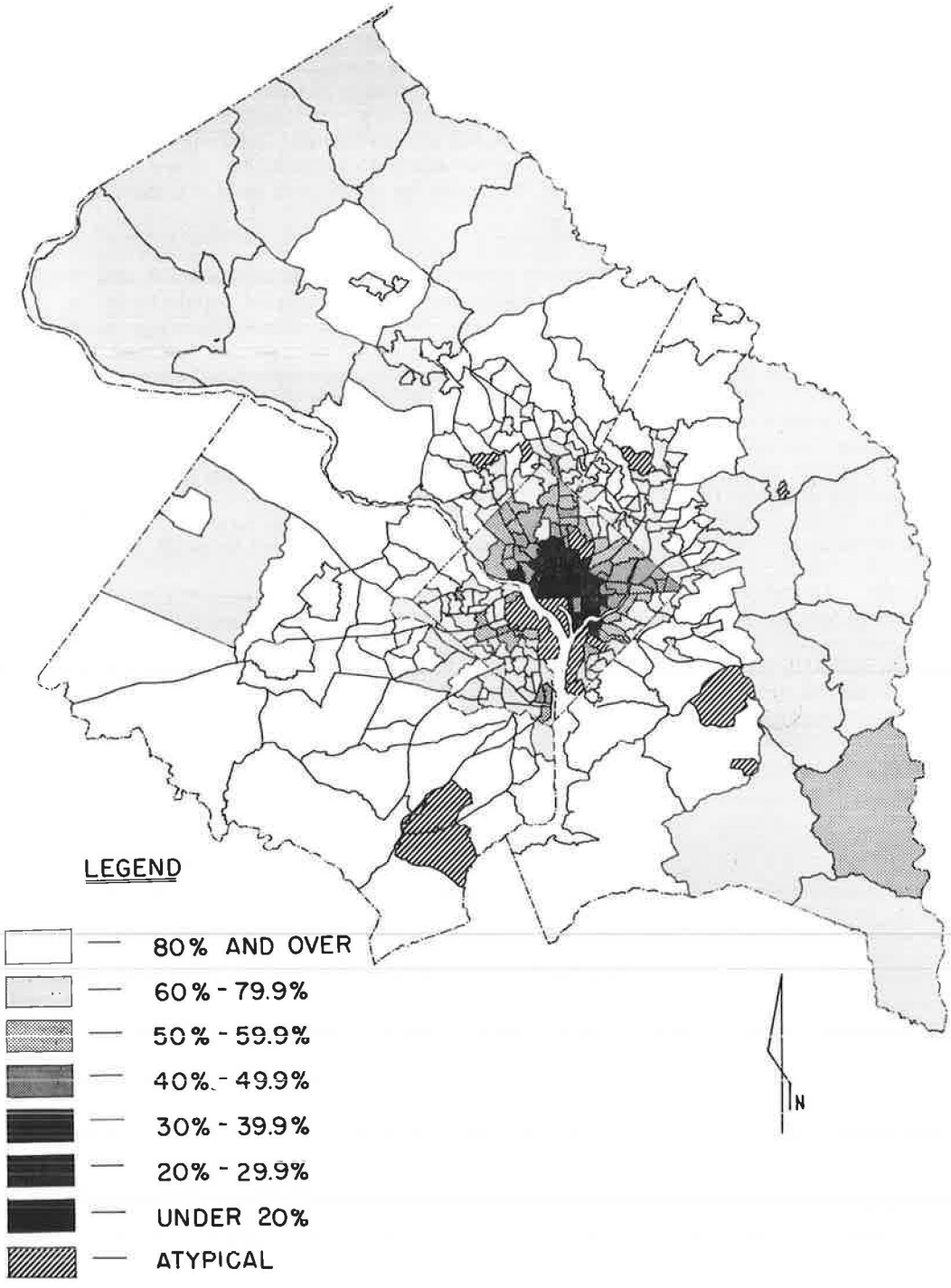

Figure 9. Pattern of car usage within Washington, D. C. SMSA, 1960.

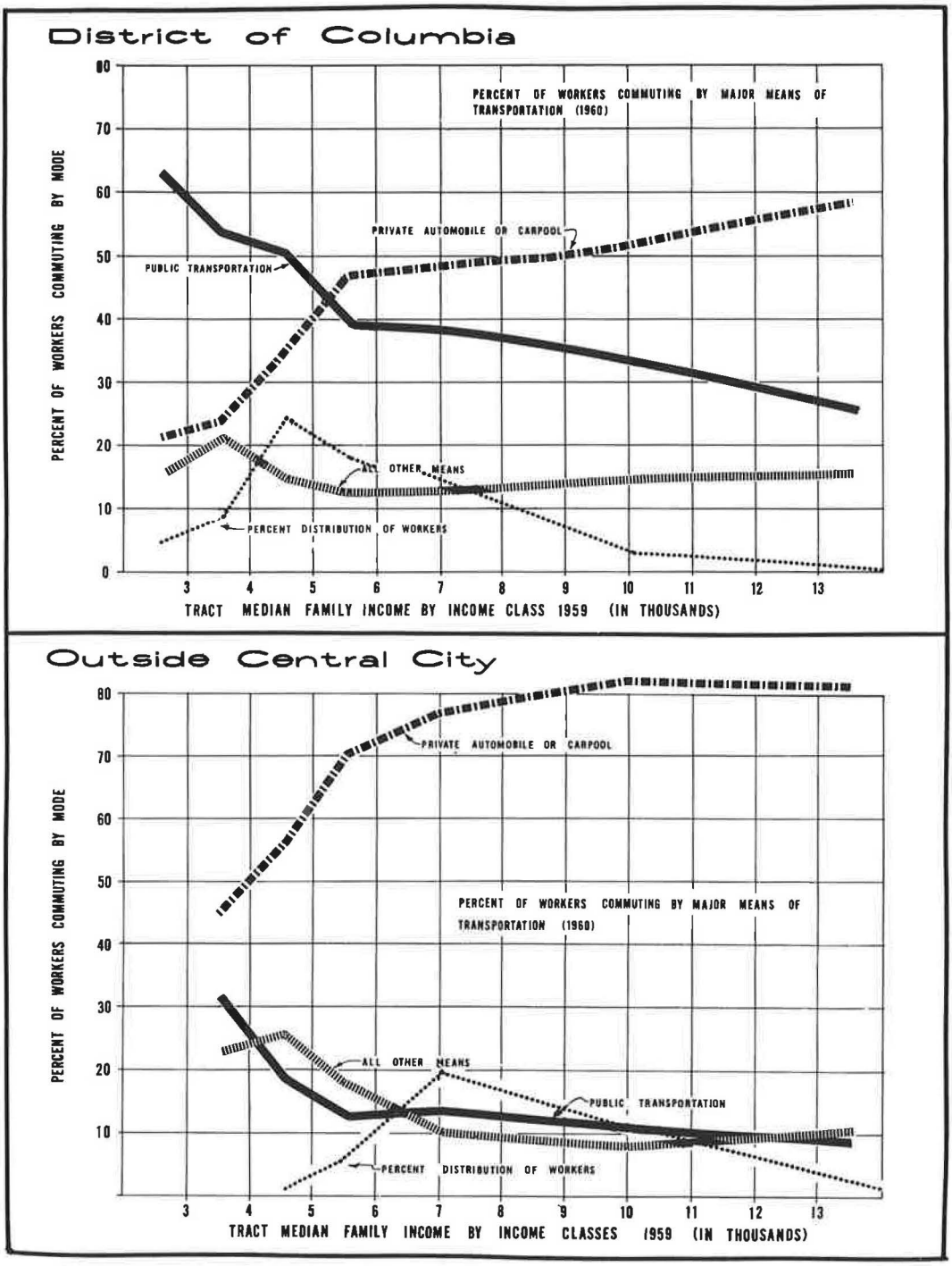

Figure 10. Relationship of auto usage to income, central city and suburbs of Washington SMSA, 1959.

usage of car on the work trip over 80 percent, but it had 15 tracts with less than 20 percent auto usage.

Auto usage, like auto availability, is interrelated with income. Figure 10 shows this interrelationship for both the central city and the suburbs of the Washington SMSA. (This type of analysis was first presented in a paper at the 1962 Annual Meeting of the Highway Research Board. In that paper, the Scissors phenomenon in central cities was illustrated with graphs showing transportation usage of central city workers in the Norfolk and Richmond SMSA's in Virginia.) The direct relationship between auto usage and income and the inverse relationship between public transit usage and income are even more pronounced in the suburbs than in the central city. The differential between the central city and suburbs can be partially explained by the availability of public transportation.

Commuting Patterns

The data collected for the first time in the 1960 Census make possible the study of general commuting patterns in metropolitan areas. The residence of workers is reported on a tract basis. The place of work was collected and reported on the basis of central city and suburban cities and counties. (It is hoped that the 1970 Census will collect and report place of work by Census Tracts. If this is done, a great deal more can be learned.) From these data the number and percent of workers commuting into the central city, out from the central city, and from outside the SMSA can be tabulated. Table 11 indicates the average percent of workers commuting by size groups and the range of percentages. Here again the differences are mostly intra-group rather than inter-group.

The apparent inverse relationship of commuting out from the central city with population size can be understood more fully when the relationship of jobs to resident workers is examined. Table 12 gives these ratios and their ranges for each of the size groups. Although the relationship between jobs to resident workers ratios and size is not as pronounced, there is a definite decrease in the central city ratios as size decreases. In other words, the location of employment centers is a major determinant in worker commuting. Thus, to predict future commuting patterns, the

TABLE 11

AVERAGE PERCENT OF WORKERS WHO COMMUTE TO WORK, 1960[a]

Size Group	To Central City			From Central City			From Outside SMSA		
	Avg.	Highest	Lowest	Avg.	Highest	Lowest	Avg.	Highest	Lowest
≥1,000,000	15.5	27.4	7.5	5.6	14.4	3.1	2.4	27.1	0.4
500,000 - 1,000,000	17.2	34.1	2.6	7.3	19.2	3.0	3.1	18.9	0.1
300,000 - 500,000	19.3	29.8	2.3	7.5	19.0	4.5	3.4	10.1	0.8
250,000 - 300,000	15.2	30.0	3.4	7.8	17.6	2.4	2.7	7.2	0.4
200,000 - 250,000	17.0	31.9	4.5	8.2	25.6	4.5	2.9	11.0	0.4
150,000 - 200,000	14.5	30.7	2.9	9.1	20.1	3.4	4.6	18.7	0.4
125,000 - 150,000	17.4	32.0	5.8	10.1	17.9	4.0	4.5	20.5	0.2
100,000 - 125,000	14.2	21.3	2.4	11.0	27.1	3.5	2.5	8.5	0.5
50,000 - 100,000	6.9	13.9	1.7	10.9	21.6	5.3	2.9	11.8	0.4
Total	16.1	34.1	1.7	6.6	27.6	2.4	2.8	27.1	0.1

[a]Data derived from Ref. 6.

transportation planner must first be able to forecast the changes in the locations of employment centers as well as the changes in residential locations of workers; i.e., forecasts must consider both ends of the work trip.

Commuting into the central city is generally more critical than reverse commuting, or commuting out from the central city. The reason, of course, is obvious. As workers commute into the central city their paths converge, adding to the peak-period congestion. Figure 11 shows the pattern of commuting from the Washington suburbs into the District of Columbia. The pattern of commuting into each of the suburban counties and cities can be determined in the same manner.

The highest auto use in commuting is in the distant suburbs. However, when Figure 11 is compared with Figure 10 it becomes apparent that close-in tracts in the Washington SMSA having a high percentage of workers commuting into the central city also generally have high auto use for the work trip. Transportation planners in forecasting future travel demands must relate the patterns of travel with the modes of travel. The Census data are useful in improving the planners' gravity model by pointing up factors which influence trends in travel.

CONCLUSIONS

From available statistical data, past trends can be determined. If the influence of factors on these trends can be understood, rational forecasts of present and future needs for transportation facilities can be made with greater reliability than those made previously.

When analyzing metropolitan area statistics, the environment of the area must be considered. By environment is meant not only the physical and political situation but also the social values of the area and the time period in which its major development occurred. Environment can and does change, however, as the far-reaching effects of government policies on aid to Appalachia, military production, and the war on poverty are now demonstrating.

An area whose major development occurred after the advent of the automobile, which had a seemingly unlimited supply of reasonably level land, a mild and pleasant climate, and many institutions of higher learning will have a pattern of growth far different from

TABLE 12

RATIOS OF JOBS TO RESIDENT WORKERS, 1960[a]

Size Group	Central City			Suburbs			Entire SMSA		
	Avg.	Highest	Lowest	Avg.	Highest	Lowest	Avg.	Highest	Lowest
≥1,000,000	1.19	1.55	0.96	0.73	0.85	0.53	0.97	0.99	0.70
500,000 - 1,000,000	1.19	1.56	0.66	0.68	1.46	0.26	0.95	1.00	0.69
300,000 - 500,000	1.24	1.70	0.86	0.66	1.38	0.39	0.95	0.98	0.87
250,000 - 300,000	1.15	2.17	0.87	0.76	1.37	0.49	0.96	0.98	0.89
200,000 - 250,000	1.17	1.60	0.90	0.71	1.14	0.40	0.95	0.98	0.85
150,000 - 200,000	1.09	1.48	0.86	0.68	1.27	0.29	0.92	0.98	0.68
125,000 - 150,000	1.12	1.67	0.81	0.61	1.33	0.33	0.92	0.98	0.66
100,000 - 125,000	1.05	1.24	0.81	0.76	1.83	0.30	0.95	0.98	0.81
50,000 - 100,000	0.95	1.12	0.75	0.78	1.68	0.32	0.91	0.97	0.69
Total	1.18	2.17	0.66	0.71	1.83	0.26	0.96	1.00	0.66

[a]Data derived from Ref. 6.

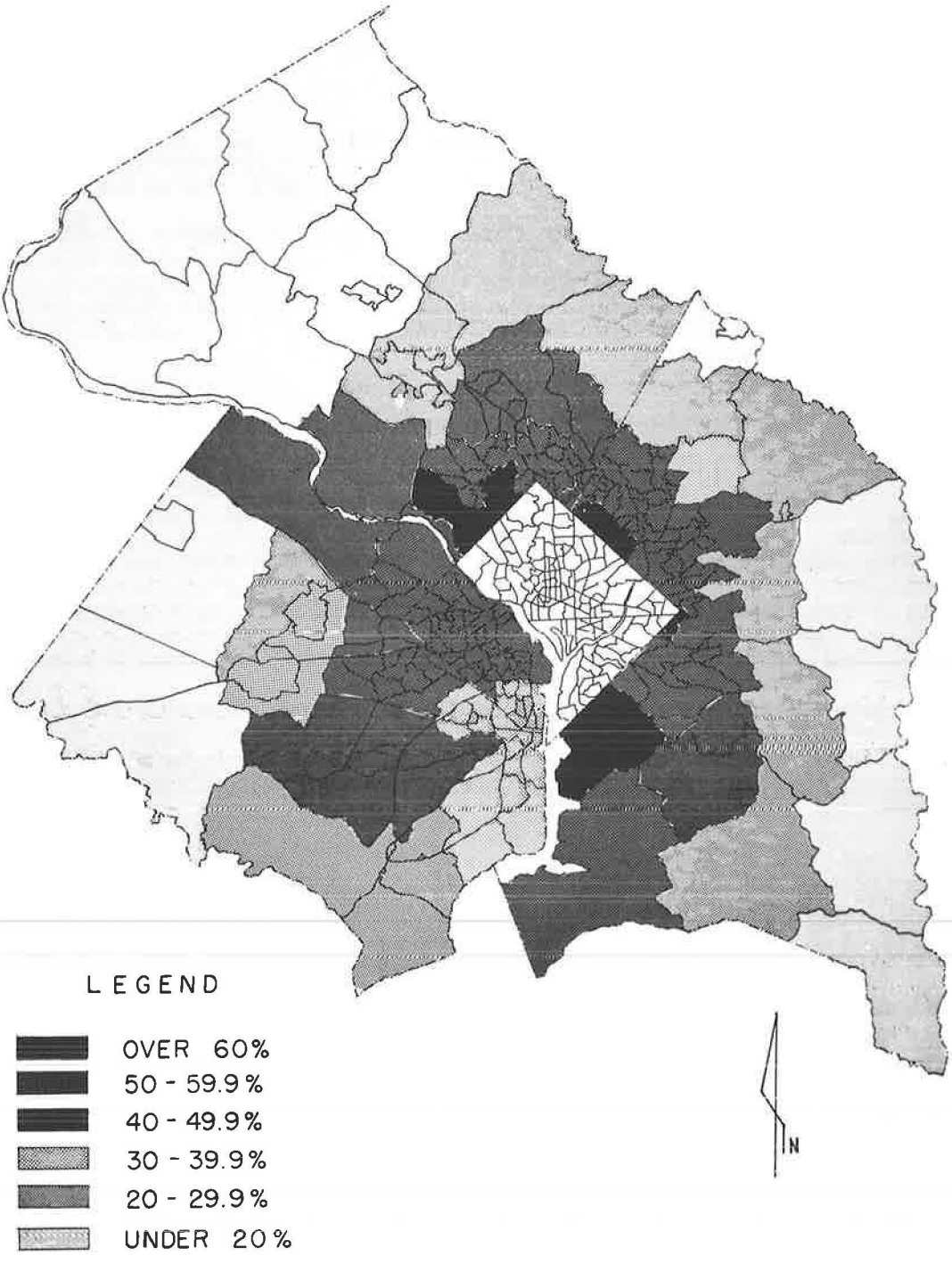

Figure 11. Pattern of commuting from Washington suburbs into District of Columbia, 1960.

that of an area developed before the advent of the automobile and whose principal resources oriented it toward a single industry.

The former area would likely have been developed at low density. Such development, oriented to private auto travel, would probably not have much public transit available and employment centers would probably be decentralized. With its high educational base and advantageous physical environment, it would likely have attracted the development of a diversified industrial base, including some of the exotic electronic, space- and missile-oriented industries. It would have a high participation of women in the labor force and thus high family income and a high percentage of multi-car ownership and use. The commuting pattern would be highly diffuse with a great deal of cross-commuting. Its population would likely be younger and growing more rapidly. Its future growth in all ways, however, would depend greatly on public policy with regard to defense spending and other factors.

The latter area would likely have developed at relatively high density with its development oriented to the terrain, public transit, and employment center location. The participation of women in the labor force would be low. The area's population would probably be older, its family income lower, its percentage of families with no autos available higher. Its future growth would depend on its locational advantage and on the technological developments and implementation of automation in its one major industry.

These two extremes are exemplified by the Los Angeles and Pittsburgh metropolitan areas. There are many gradations between these two, however. Among the 212 SMSA's, areas of rapid, moderate and slow growth can be identified, but further analysis must be made of their socio-economic peculiarities, their economic base, and their potential for future growth. History is not likely to recur precisely.

Effective use of the Selected Statistics by Standard Metropolitan Statistical Areas for Use in Transportation Planning, published by the U. S. Bureau of Public Roads, October 1964, together with other available statistical material, will improve the forecasts needed for transportation planning both on the national and the metropolitan area level.

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