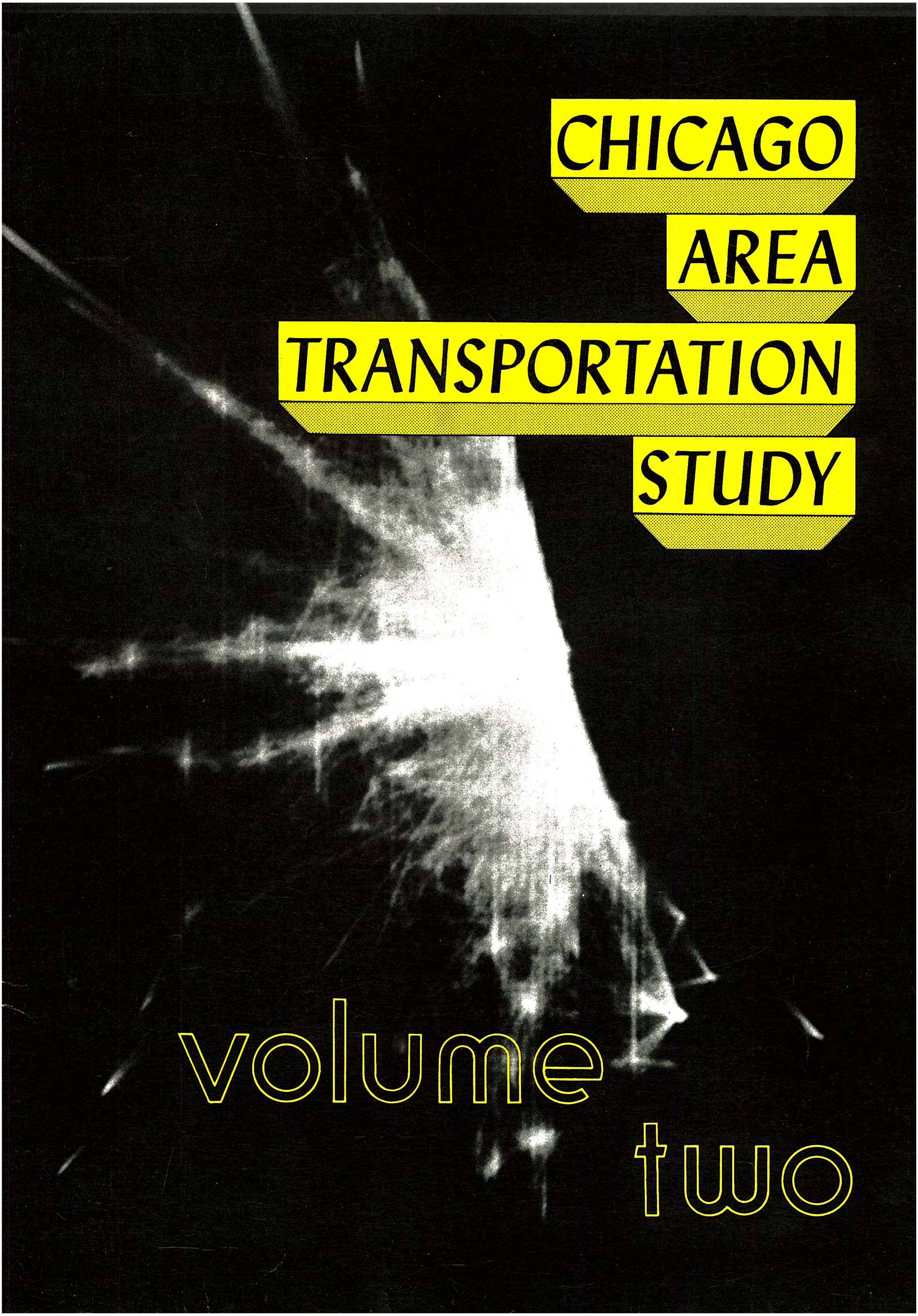
CHICAGO AREA TRANSPORTATION STUDY



volume two

COVER DESIGN

The cover design is a display of the desire lines of all person trips made on an average weekday in the Chicago area in 1956. The display was prepared on the Cartographatron, an electronic apparatus capable of rapidly translating travel data on magnetic tape to lines or dots on a cathode ray tube. Details on this machine are given in Volume I, pages 97-99.

The design represents the traces of 10,524,731 person trips made on an average weekday. These traces represent a combined total desire line length of 53,767,000 miles. The lightest areas are regions of greatest travel density and the pattern gives a quick illustration of the density of travel paths in the metropolitan region. Outer points of concentration represent large zones outside the cordon line or artificial points of entry.

The "fingers" of marked traffic density reflect the pattern and intensity of land development of the region.

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CHICAGO AREA TRANSPORTATION STUDY

FINAL REPORT
In Three Parts

Volume II
Data Projections

JULY 1960

STUDY CONDUCTED UNDER THE SPONSORSHIP OF

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Chapter I

INTRODUCTION

This second volume of the report of the Chicago Area Transportation Study is concerned with estimating the amount, kind and location of travel likely to take place within the Chicago area in the year 1980. Estimating future travel demands is a prerequisite to the preparation of a long-range plan for improving transportation facilities, which is the Study's basic objective.

The estimates reported here are based primarily upon data from the inventories of the metropolitan region which were taken in 1956. The inventories were taken to explain the characteristics of current daily travel and the findings are reported in Volume I. The third and final volume of this series will be devoted to the development of a comprehensive transportation plan designed to satisfy, as well as possible, the future demands for transportation services which are estimated here.

THE PROBLEM

Public works in democracies are often undertaken in reaction to crises. Floods, fires and droughts can bring about major projects which otherwise would have been put off. While urban transportation seldom has a catastrophic breakdown, there are successive, intense problems such as repeated traffic jams, financial difficulties of public transit, or particularly bad accidents. Quite often, new public improvements in transportation are conceived and built in response to such immediate problems, rather than in accordance with a long-term program.

Planning transportation facilities on the basis of crises is extremely dangerous. Reactions to immediate pressure do not always provide the best long-term solutions, nor are they likely to provide the maximum return for the money invested. Furthermore, the stakes are very high. Express highways cost from four million to fifteen million dollars per mile and rapid transit facilities from two million to twenty million dollars per mile. They produce great changes in the urban landscape. Mistakes can be costly and long lasting in their effect.

Public and private losses caused by inadequate or poorly located transportation facilities are very hard to estimate. The average traveler in the Chicago area spends about one and one-half hours each weekday in motion. About twelve cents of every dollar spent by Study Area residents is for personal travel and nine cents of this amount is for travel within the Study Area. Currently, an estimated 1.5 billion dollars is spent each year for local travel by the 5.2 million persons living in the Study Area. Even small savings in time and cost, when multiplied by millions of travelers and extended over decades, can produce extremely large benefits.

All of the problems of transportation today will be made more acute by the growth of the Chicago area. It is estimated that Study Area population will increase fifty-one per cent by 1980. The residents of the future will consume more goods because they will be wealthier than the current population. They will own more automobiles per capita, and they will travel more. Travel will thus increase faster than population. It is estimated that the number of trips and the total mileage traveled in the Chicago area will nearly double by 1980.

The problem, therefore, is to anticipate future demands for travel over a sufficiently long time period. Plans then can be carefully prepared to provide new or enlarged and improved facilities to satisfy progressively the growing travel demands. If these new facilities are based on the desires of travelers, they are more likely to be in equilibrium with travel needs over a longer period. The return on the community's investment in terms of efficient, safe and fast travel will be much greater if improvements are planned and built as part of an entire system rather than as unrelated projects. A forecast of future travel is thus an essential ingredient for the layout and planning of future transportation networks.

PLAN OF REPORT

This volume covers the central portion of the Study's planning process, which is diagrammed in Figure 1. The inventories provide the foundation for the work of forecasting. The chapters of this volume follow the steps of the diagram within the two major blocks covering the forecasting of land use and of travel.

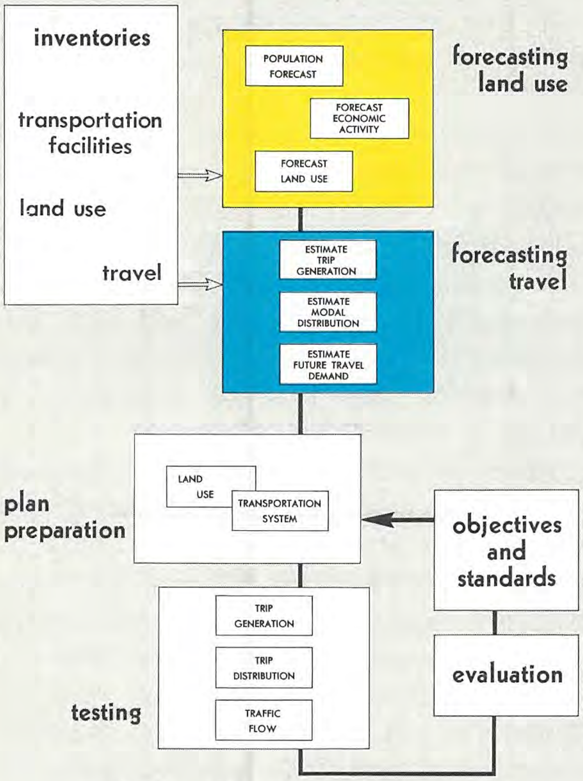


FIGURE 1—THE PLANNING PROCESS

This volume concentrates on the two boxes representing the forecasting portions of the planning process.

Chapter II considers the most likely population size of the area by 1980. Also included are the outline and measurable effects of the constantly growing and changing economy of the region. The number of people, their wealth and their economic activity provide part of the factual base from which travel estimates are made.

Chapter III describes the projection of future land use. This projection distributes people and economic activities over the urban landscape. The resulting mosaic of land uses determines the origins, the destinations and the linkages of future travel.

The remaining chapters are concerned with describing the future travel demands. These grow out of the population, economic and land use projections. Chapter IV is concerned with the estimation of trips by their place of origin. Chapter V then considers the classes of trips —dividing people into probable transit or automobile users—and estimating the total vehicle trips. Chapter VI is concerned with converting trips into travel by estimating the number of journeys going from each origin zone to every destination zone. Given the distribution of travel demand, both in person and vehicle miles, the scale of future needs is established. A planned network of facilities must be fitted carefully to serve the volume and location of these travel demands.

CONSIDERATIONS IN MAKING FORECASTS

Reliability of Estimates

It is not expected that the forecasts made in this volume will agree *exactly* with the actual conditions of 1980. There is, therefore, a real problem of insuring the reliability of the forecasts. Fortunately, there are several ways in which this can be done.

One way of insuring reliability is to explain the processes by which the forecasts were prepared. This is essential because there is now no generally accepted theory of how metropolitan regions grow and change. Lacking this theory, special effort has been made to identify each assumed active ingredient and relate it to other aspects of urban growth. Care is taken to spell out the relationships of population growth to economic growth, to shifts in living patterns and thus to land uses. The land uses and the activities they represent have been shown to be the crucial elements identifying travel patterns. This step-by-step description of estimates provides the reader with a means of evaluating the results.

A second form of insurance is the internal consistency of the estimates. The metropolitan region with all of its myriad activities functions in an orderly fashion. The different aspects of urban life—whether economic, land use, population or travel—must relate to one another. The mileage driven by the average car, the family's income and the location of home with respect to job are all interrelated. Throughout this forecast the successive estimates which combine to produce the over-all estimate of travel demand are shown to be mutually consistent.

Third, plans are directed towards the travel needs of the estimated future population of 7.8 million persons rather than to the particular year 1980. If the population of the Chicago area should reach this point a few years before or after the target year, it will make relatively little difference. New facilities, once planned, must be programmed at a pace consistent with the rate of growth and also with available fiscal resources.

Fourth, there is a large degree of stability in forecasts resulting from the size of the population and the urbanized area already in place. Over five million people (two-thirds of the expected 1980 population) are presently here. Nearly half of the land inside the Study Area already is developed in urban uses. This large commitment, entailing great investments in structures and utilities, must continue to represent the key portion and a major determinant of the 1980 land development pattern. This is doubly important because growth is by the addition of small increments and departures from the existing pattern, therefore, cannot be very great.

The last form of insurance is continuous review. The Policy Committee which supervises the direction of this Study has determined that the work shall be designed so that the travel facts can be kept current. This, in part, is why travel has been related to population, economic growth and urban land use. These form the bases for relatively inexpensive updating of travel data. Periodically revised travel estimates allow continual review of the forecasts and plans.

Some specialists making forecasts advocate the preparation of a range of estimates based on different assumptions of population, accessibility, land development patterns and other factors. If the range is broad enough, it is bound to include the actual 1980 development. From the viewpoint of the planner, it is preferable to concentrate on a single, most probable estimate. This is essential for the purpose of this Study: preparing a plan. A single estimate, therefore, is always presented. This provides the most forceful statement of the transportation problem and concentrates attention on finding workable solutions.

These checks and reviews provide the safety margins which are essential if plans for millions of dollars worth of new facilities are to be based upon these projections.

Geographic Area and Time Period

Projections will be made principally for the Study Area. The Study Area is a part of the larger metropolitan area which consists of six counties, five in Illinois and one in Indiana. The Bureau of the Census defines this as the Chicago Standard Metropolitan Area.[1] Most official population and economic data are available for this larger area. Therefore, past trends and official estimates for this larger region are used as a framework for making estimates about the Study Area. In addition, less detailed forecasts are provided for the band of townships and cities lying within fifteen miles of the cordon line (See Map 28 in the Appendix). This buffer area must be considered because many of its inhabitants, in 1980, will be commuting into the Study Area.

The target year for making forecasts was set at 1980. The exact year was not too important since construction programs may be accelerated or decelerated to keep pace with growth. It was important to set the target year sufficiently far ahead so that a system could be planned, and a major part of that system constructed, to cope with problems substantially larger than today's. Also, it was desired to plan far enough ahead, considering the expected life of new transportation facilities, so that their design and location could take into account the volumes of travel they will be likely to carry. Planning too far ahead would have reduced the accuracy of the estimates, because, over longer time periods, technological changes loom increasingly important. Too short a period would be out of scale with the magnitude of these new facilities. The year 1980 was essentially a compromise between short and very long-range planning.

[1]See Map 27 in the Appendix for the boundaries of the metropolitan area and the cordon line.

MAP 1

WATER AND RAILROAD TRANSPORTATION ROUTES BEFORE 1860

Railroad building into Chicago between 1850 and 1860 marked it as a focal point for transportation. By 1860, Chicago had 109,000 residents, substantially less than Cincinnati, St. Louis and New Orleans, each of which had about 160,000 residents. Yet Chicago already was poised to move ahead of its competitors as an attractive location for business and industry. The new rail lines, the Great Lakes and the navigable waterways provided Chicago with excellent competitive shipping facilities. Situated at the foot of Lake Michigan, it became a natural transfer and terminal point for both eastern and western railroads. It was in position to become the shipping, bartering and service center for a vast, productive, agricultural hinterland. Besides having expanding regional markets, the strategic transportation focus of Chicago made it a target of much subsequent national and European migration. This new population was readily absorbed into a growing urban industrial economy. These factors accounted for much of Chicago's subsequent population and economic growth.

Chapter II

POPULATION AND ECONOMIC GROWTH

The Chicago region is a growing region — growing in population, in production of goods and services, in income, and in the extent of land devoted to urban uses. There is no evidence to suggest stability or decline in the next twenty years. While growth will bring new resources of production, wealth and manpower into the area, it also will intensify many urban problems, among which is transportation.

The size of the future transportation problem must be estimated carefully. It is not enough to know that tomorrow's traffic problems will be greater than today's; quantitative estimates, indicating just how large they will be, need to be made. A population forecast is the beginning point for this work. The scale of population growth determines, to a large extent, the growth of economic output and new land uses and, of course, new levels of transportation demand. Increases in travel demand frame the increased needs for new transportation facilities.

The total amount of growth is important, but it is equally necessary to mark changes in the direction of growth. For example, the make-up of the population may change. Different technology, productivity and consumer preferences will make the economic activities of the larger population different than would be expected from growth alone. Patterns of land use will not be a repetition of those of the past. All of these will affect the future travel requirements of the region. It is to identify change, as well as growth, that the population and economic forecasts are prepared.

HISTORICAL DEVELOPMENT OF THE CHICAGO REGION

Any forecast requires the examination of the history of past growth. This provides a sense of perspective. It also points out some of the forces which produced growth in the past, and these can be evaluated as to their current power and relative importance in producing future growth.

Although the site of Chicago was discovered by Marquette and Joliet as early as 1673, its history as a settlement did not begin until 1803, when Fort Dearborn was constructed. In the interim period the fate of this wilderness site was being settled elsewhere, first by the elimination of French control of Canada in 1763, and later by the War of Independence, 1775-83. From the beginning, however, the strategic importance of the Chicago portage, with its easy connection between the Great Lakes and the Mississippi River watershed, had been comprehended.

From 1803 to 1833, Chicago was little more than an Indian trading post and fort. The settlement, which was wiped out in 1812 by Indian attack, was rebuilt in 1816. Following the defeat of the Indians in the Black Hawk War of 1832, the middle western states began to open up for settlement in earnest. Chicago became a village in 1833 and had a reputed population of 350 persons. The effect of the control of Indians and the ease of transport offered via the Great Lakes-Erie Canal route brought Chicago's population to four thousand by 1837, when it became a city.

Chicago was situated astride the best transportation routes in the central part of the North American continent. It could trade easily with the eastern states and with Canada via the Great Lakes. It could trade with the region to the west, first by prairie schooner and later, on the opening of the Illinois-Michigan Canal, by water. The completion of this canal in 1848 began to bring Chicago into effective competition with New Orleans as the outlet for the products of the central plains states.

The advent of the railroads, in the 1850's, gave Chicago its major transportation advantage. As shown in Map 1, rail lines from the east to the northwest had to come south of Lake Michigan through Chicago. As a direct westward extension of the Mohawk-Hudson water level route, it was also a natural point for further construction of rail lines to the far west. By 1860, Chicago had become the center of a considerable network of rail lines.

Being in this commanding position for both rail and water transportation, Chicago grew rapidly as a regional center. It became the natural wholesaling and banking center. It processed the agricultural products of the plains states. Its growth, accordingly, was linked with the westward expansion of the nation's population.

About the same time, industrialization was a growing force behind urban expansion. Industry had an earlier start in the eastern states, but in the 1860's and 1870's it found a natural and advantageous site in Chicago. Agricultural and railroad equipment manufacturers were close to their market areas. Between 1875 and 1880 a steel industry was formed, using coal from West Virginia, limestone from the nearby Des Plaines River valley and iron ore from Minnesota.

By 1880 all the forces making for Chicago's growth were operating at full strength. These included:

a. regional and national population growth, swelled by European immigration;
b. transportation advantages—the railroads and waterways connecting the central and plains states to Chicago, and Chicago to the eastern states;
c. industrialization, reducing the dependence of a city on its hinterland and making it a creative society in its own right;
d. national policies which channeled growth into internal expansion;
e. rapid and continuous technical inventions which increased the productivity of both city and farm dwellers.

Since 1880 these same forces have continued to work in favor of the expansion of the Chicago area. Some of them have taken on different aspects and different significance. For example, regional population growth is less important now because the country is more evenly filled out than formerly. World trade looms larger now that continental expansion is nearly complete. But, in the main, these same forces can be identified today, producing growth and change in the urban region.

One should not forget the internal arrangements which were made to accommodate this growth. New housing construction methods, such as the celebrated Chicago "balloon frame," permitted large masses of people to be housed rapidly. Mass transportation was a new invention then, enabling people to congregate quickly in the market places and manufacturing establishments of the city. These and other inventions and adaptations were crucial to the management of the rapid growth problems of Chicago. If such new ideas had not been developed, acted on and translated into action, the effect would undoubtedly have been to put a brake on growth. As it was, these became available at the right time and place and Chicago grew rapidly.

From the past, then, can be seen the influence of certain forces producing growth. The evidence of the strength of these forces is the continuing population growth of Chicago and its metropolitan environs. Proper evaluation of the strength of these forces is essential in making an estimate of 1980 population.

POPULATION GROWTH

In the century between 1850 and 1950, the United States grew from 23.0 million persons to 151 million persons—about six and a half times. During the same period, Illinois grew from 851,000 to 8,700,000 persons or ten-fold. But the city of Chicago grew from 30,000 to 3.6 million—a growth of 120 times its early population! (See Figure 2.)

These different growth rates provide clues to the amount of future population increases. The largest area—the United States—has had the slowest growth rate. Smaller areas, such as Illinois and Chicago, have had much faster growth rates because they started with extremely small populations and were the targets of tremendous immigration. As they have become larger, their own growth rates have slowed. The Chicago Metropolitan area[1] and

[1]Here the term "metropolitan area" is defined as the Census Bureau's 1950 Chicago Standard Metropolitan Area, including Cook, Du Page, Kane, Lake and Will Counties in Illinois, and Lake County in Indiana. The metropolitan area includes one county in Indiana, but the Study Area is exclusively in Illinois.

the state of Illinois are now among the larger concentrations of national population, with 3.7 per cent and 5.6 per cent of the nation's population, respectively. In the future they are expected to approach the same rate of growth as the nation.

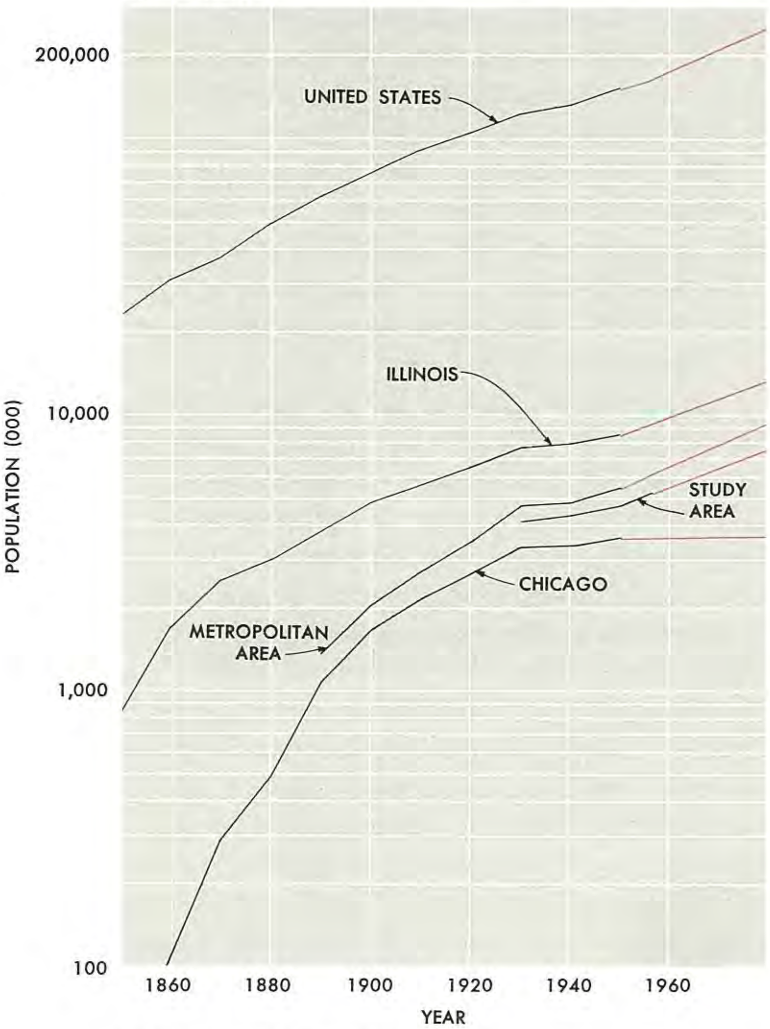


FIGURE 2—POPULATION GROWTH

See Table 37 in Appendix.

Since 1900, the rural population of the country has remained stable and growth in population has been absorbed into urban places. In the future, national population will be increasingly concentrated in cities and metropolitan places. In the past, cities gradually increased their percentage share of the national population. This was the case in the Chicago Metropolitan Area before 1930 — see Table 1. Now that urban places contain such a large portion of the national population, their growth rate will be closer to that of the nation as a whole.

TABLE 1
RATIO OF CHICAGO STANDARD METROPOLITAN AREA TO UNITED STATES POPULATION
(In Thousands)

Year	United States	Metropolitan Area	Percentage Ratio M.A./U.S.
1890	62,948	1,389.7	2.21
1900	75,995	2,092.4	2.75
1910	91,972	2,752.8	2.99
1920	105,711	3,521.8	3.33
1930	122,755	4,675.9	3.81
1940	131,669	4,825.5	3.66
1950	150,697	5,495.4	3.65
1956	167,261	6,208.0	3.71
1980 (est.) ...	259,081*	9,500.0	3.67

*See Table 37 in Appendix for source.

The same sort of relationships apply, although in a different degree, to the Study Area, as a percentage of Illinois population. In 1890, about one in every three Illinois residents lived in the Study Area. By 1950 this had increased to more than half (fifty-four per cent). This proportion will rise in the future, but less quickly. Future population growth in Illinois will be urban growth almost exclusively, and a very large part of this will be in the Study Area.

Within the metropolitan area, not all parts will expand equally in population. Over several decades, the dense central areas near the Loop have been stable, or even declining. There has been no noticeable change in the levels of density in completely built up parts of the city.[2] Therefore, it is unlikely that people will squeeze in more closely in the future. Also, there is very little vacant land remaining in the central parts of the area,[3] so that future growth must occur progressively farther out.

The Study Area will grow at a slower rate than the metropolitan area because increasing proportions of the additional population will undoubtedly settle outside the cordon line. Nevertheless, eighty-two per cent of the metropolitan area's new people will still live inside the Study Area, which is still half vacant or in agricultural use.

[2]Between 1940 and 1956 densities rose slightly within three miles of the Loop, but elsewhere have declined slightly. Partly, this is the result of declining family sizes in Chicago. For details on trends in densities, see Figure 7, Chapter 3.

[3]*Vacant Land in the City of Chicago, 1958* (Chicago: City of Chicago, Department of City Planning, 1959).

It is widely accepted that the United States will grow in population at a fairly steady rate, barring wars or major catastrophes. Being more prosperous than other regions of the world, it continues to attract immigrants, but the rate of immigration is controlled. Science has increased the average life expectancy and probably will increase it further, but the death rate of each age group is still highly predictable. The most variable factor is the birth rate. Taking a middle-of-the-road estimate of birth rates, the population of the United States in 1980 is expected to be 259,081,000.[4]

The Chicago metropolitan area probably will grow about as fast as the country because it is still in a good competitive position both regionally and as an urban center. There is no evidence of declining growth in the east north central states. Within this five state area (and also nationally) the Chicago urban area remains a transportation focus. Its railroads are carrying increasing loads. Air transportation facilities are being improved. The St. Lawrence Seaway has expanded the water transportation possibilities of the area tremendously. The new interstate highway system is improving the road facilities serving the region. The Chicago area continues as one of the strongest and most diversified industrial centers in the United States. In general terms, therefore, the Chicago area can look forward to maintaining its share of the national population growth.

Based on the above reasoning, the estimated population for the Chicago standard metropolitan area was set at 9.5 million persons by 1980. This estimate checks out well with the ratio of Chicago metropolitan population to United States population.[5] As shown in Table 1, the population estimated to be living in the six county metropolitan area in 1980, is about 3.7 per cent of the United States population of that date, as estimated by the United States Bureau of the Census. This percentage is higher than that prevailing prior to 1930 but about midpoint of the percentages since 1930.

The Study Area's share of the metropolitan population is estimated to decline slightly in the future, from eighty-five per cent in 1950 to eighty-two per cent in 1980. This is simply an extension of historical trends. (See Table 36 in the Appendix.) As a result, it is estimated that the population of the Study Area, in 1980, will be 7.8 million persons—an increase of fifty-one per cent over 1956.

This estimate seems to be reasonably in balance with estimates of Illinois population prepared by the Bureau of the Census. As shown in Figure 2, the state's population is expected to rise to 13.8 millions in 1980.[6] In that year, fifty-seven per cent of the state's residents would be living in the Study Area, in contrast with fifty-four per cent in 1950.

Clearly, these numbers are subject to estimating uncertainty but this presents no major problem since at some point *near* 1980 the population should reach this level. In a sense, planning is for this level of population and not for any particular year. Continuing administrative review can permit the rates of construction of transportation facilities to be adjusted to changes in the rates of population growth.

In summary, a single population estimate is necessary to start the process of scaling the dimensions of future transportation needs. A reasonable population forecast for the metropolitan area is for 9.5 million persons by 1980, which maintains the area's present share of the nation's population. The population of the Study Area, it is estimated, will reach 7.8 million persons by the same date.

ECONOMIC GROWTH

Within the over-all forecasting process, an economic forecast, for a number of reasons, is a necessary companion to the population fore-

[4]"Series II" projections in Table 1, page 16 of "Illustrative Projections of the Population of the United States, by Age and Sex, 1960 to 1980," in *Current Population Reports, Population Estimates*, Series P-25, No. 187. U.S. Department of Commerce, Bureau of the Census, Washington, D.C., November 10, 1958.

[5]For planning purposes a single estimate is preferred to a range of estimates. The Chicago Community Inventory has prepared official estimates for the metropolitan area for the City of Chicago, Department of City Planning. These range from 8,020,000 to 10,706,000 depending on varying assumptions as to birth and death rates, and in-migration rates. The 9.5 million estimate falls towards the center of this range. See *Projected Population in the Chicago Standard Metropolitan Area, and by Ring, to 1980,* Population Study Series, Estimates and Projections Number 3, August, 1959. A Report to the Department of City Planning, City of Chicago, from the Chicago Community Inventory, University of Chicago.

[6]See Table 37 in the Appendix for source of estimate.

cast. An economic forecast helps to estimate future employment and hence some of the demands for nonresidential land. It helps to measure the resources available for building transportation facilities in relation to the resources allocated to other sectors of the economy. It indicates possible changes in the direction of growth as a result of changing consumption patterns. And finally, these studies provide significant information useful in estimating changes in consumer demand for local transportation.[7]

Economic analysis provides another way of describing an urban region. Like the inventories of land use and travel, an economic study is a cross-sectional "cut" of an urban society—one which pictures production-consumption relationships. It describes the current level of demand for goods and services of various types as well as the interrelationships between the various producers of goods and services. These economic facts can be related to data obtained by other surveys or used to project specific future demands for mass transportation usage, car ownership or housing.

The population forecast is a first ingredient of the economic forecast. For example, if all other things remain equal, a fifty per cent increase in population means a fifty per cent increase in total regional income, and a corresponding increase in demand for goods and services. But, obviously, all things do not remain equal.

The next essential ingredient is per capita income. Per capita income is related closely to productivity; the more the average worker produces each year, the higher his real income. Measured in dollars of constant value, it is known that productivity has been rising steadily over time. Between 1929 and 1955, this rise has been equivalent to 1.66 per cent per year, *compounded*. Since 1947, the rate has been slightly higher—1.97 per cent.[8] Basically, increased productivity is the result of having better equipment and more power available per worker, greater skill in management, and a more skilled, better educated labor force.

From the present to 1980, it is estimated that productivity in the Chicago area will rise at the rate of 1.8 per cent per year, compounded. This rate is slightly conservative in the face of postwar growth, and slightly optimistic considering growth since 1929. Put in terms of average real income per consumer unit,[9] this means a rise from $7,750 in 1956 to $11,300 per year by 1980, measured in 1956 dollars. In terms of median income (half the consumer units earning less, half more) it means a rise from $5,100 to $7,400 per year. Historical data and estimates are shown in Figure 3.

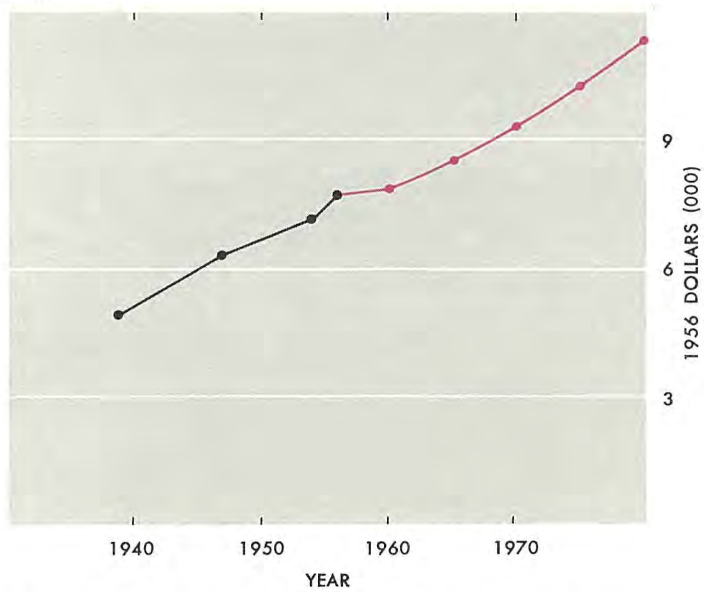


FIGURE 3—AVERAGE FAMILY INCOME IN CONSTANT 1956 DOLLARS FOR THE METROPOLITAN AREA, 1939-1956 AND ESTIMATED TO 1980

See Table 34 in Appendix.

The aggregate or total consumer income of the metropolitan area will increase because of population growth and also from a rise in per capita income. Hence it will rise faster than

[7]Under the general heading *Forecasting Economic Activity*, a series of studies and forecasts of economic activity in the Study Area, to the year 1980, was made. Details will be found in: *Economic Activity-Preliminary Report* (36,100), *Employment Data* (36,101), *Income and Taxes* (36,121), *Income-Consumption Relation* (36,131), *Consumer Expenditures* (36,132), *Regional Input-Output Analysis* (36,142), *Production and Employment Forecast* (36,143), *Increases in Productivity* (36,151), *Alternative Employment Forecast* (36,161), *Automobile Registration Forecast* (36,200) and a summary of the entire series *Economic Activity Forecast for the Chicago Region: Final Report* (36,100) (Chicago: CATS, 1956-1959).

[8]These are national rates, but available data indicate Chicago region rates are the same. See *Increases in Productivity*, (36,151) (Chicago: CATS, 1958) pp. 14-17.

[9]Consumer unit is a technical term but corresponds roughly to the family.

either. With a population growth of fifty-three per cent and a per capita income growth of forty-six per cent, aggregate income will rise 124 per cent. The aggregate consumer income (in 1956 dollars) of the region will increase to 37.4 billions of dollars by 1980, in contrast with 16.7 billions in 1956 and 8.2 billions in 1939. (See Figure 4.)

It is hard to picture the amount or effect of this projected growth in real income. One way is to consider the gain in production of the Chicago area in the preceding two decades. The total output of goods and services of the Chicago area in 1956 was about twice that of 1939. This growth has provided real gains. The average child stays in school longer. The average family consumes half again as much goods and services. More is spent for public works. In the future, the busy, booming Chicago area will be spending still more for these and other things. Retail sales will be almost double, more housing of higher quality will be built, and more young people will be going farther in school.

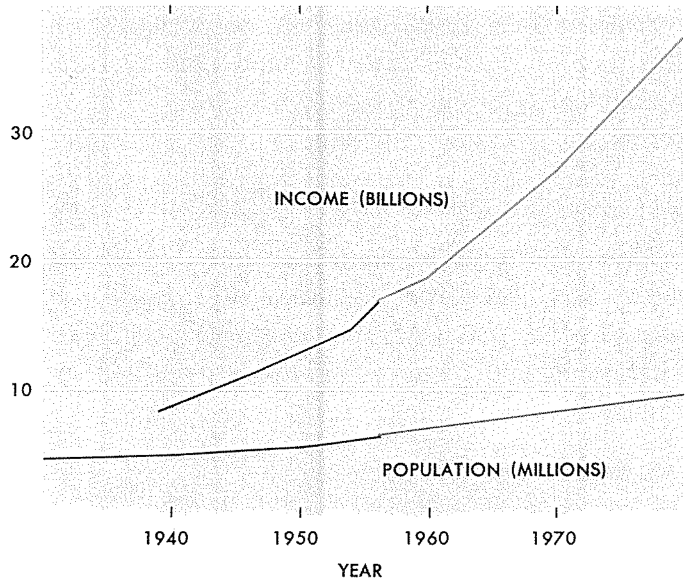


FIGURE 4—POPULATION AND AGGREGATE CONSUMER INCOME IN CONSTANT 1956 DOLLARS FOR THE METROPOLITAN AREA, 1930-1956 AND ESTIMATED TO 1980

See *Table 34 in Appendix.*

The amount of income growth will be matched by a corresponding rise in expenditures. Repeated studies have shown that consumption is a stable fraction of income—about ninety-three per cent of the average earnings being spent, while the rest is saved (or invested).[10]

With greater per capita consumption, spending patterns will change. As shown in Table 2, it is estimated that a higher percentage of the average family budget in 1980 will be spent for things like clothes, transportation, recreation and education, housing operations, and furni-

[10]About half of the savings is in the form of amortization payments on houses.

TABLE 2
AVERAGE CONSUMER EXPENDITURES PER FAMILY* BY GOODS TYPE
(In 1956 Dollars)

Goods Type	City of Chicago 1950	Metropolitan Area		Percentage of Total		
		Estimate For 1956	Forecast For 1980	Chicago 1950	Metropolitan Area 1956	Metropolitan Area 1980
Food, Tobacco and Beverages	1,713	2,011	2,712	31.1	28.1	25.8
Housing	829	1,125	1,478	15.1	15.7	14.1
Utilities	166	187	224	3.0	2.6	2.1
Housing Operation	252	366	566	4.6	5.1	5.4
Furniture and Equipment	369	460	727	6.7	6.4	6.9
Clothing	644	873	1,425	11.7	12.2	13.6
Transportation	644	935	1,512	11.7	13.0	14.4
Medical Expenses	270	374	504	4.9	5.2	4.8
Personal Expenses	116	153	217	2.1	2.1	2.1
Recreation, Reading, Education	338	466	773	6.1	6.5	7.3
Miscellaneous	65	82	116	1.2	1.1	1.1
Contributions	99	145	252	1.8	2.0	2.4
Total Consumption	5,505	7,177	10,506	100.0	100.0	100.0

*Technically, per consumer unit. A detailed description of estimating and forecasting procedures and sources appears in *Forecasting Economic Activity: Consumer Expenditures* (36,132) (Chicago: CATS, 1958).

ture and equipment. A lesser share of the budget will be spent for things like food, housing and medical care. These shifts are to be expected because it is known that as family incomes rise, smaller portions go for necessities.

In order to provide the goods and services which will be consumed by this larger and wealthier population, a higher level of production is necessary. This production must shift, of course, to accommodate the changing demands of consumers. These changing production requirements echo throughout the whole economy as each industry adjusts to the new requirements of all the other industries.

The problem of estimating these changes within an expanding economy was solved by means of an "input-output" procedure. This procedure employs the known relationships between all industries in the economy, as measured by their sales to and receipts from one another. The production requirements of each industry are then adjusted and readjusted as a function of changed and expanded future demands.

The dollar value of production of each industry, as estimated by the input-output procedure, requires a certain level of employment. This level of employment is, in turn, affected by the productivity of employees in that industry. Separate studies were made of historical trends of worker productivity in each industry. With some modifications, productivity trends established by these studies were extended to establish 1980 figures for each industry. As a general rule, manufacturing workers tended to increase their productivity faster than workers in the retail trade and service industries. This, however, was only relative, since all major industrial groupings showed increases in productivity. Application of individual industry rates to dollar output, produced an estimate of 1980 employment. (See Table 3.)

Certain dominant shifts in employment can be identified. Workers in service industries, and in government and non-profit industries, are increasing faster than in other industries. Employment in non-durable manufacturing and in the industries moving goods or providing public transportation is growing at less than average rates. This is a reasonable consequence of a society with greater real purchasing power in the average household. As incomes rise, families cannot indefinitely expand their purchases of goods. Hence purchases of food, shoes and other non-durable products will not increase as rapidly as will other expenditures. So, more money goes into services. This will be for education, lawyers, entertainment, home repairs,

TABLE 3
EMPLOYMENT BY MAJOR INDUSTRY TYPE FOR CHICAGO STANDARD METROPOLITAN AREA AND STUDY AREA —1956 AND 1980
(In Thousands)

INDUSTRY TYPE*	EMPLOYMENT			
	METROPOLITAN AREA		STUDY AREA	
	1956	1980	1956	1980
Agriculture	16.5	9.0	7.9	4.2
Durable Manufactures	698.3	1,021.6	564.3	786.4
Non-Durable Manufactures	340.6	382.8	292.7	311.4
Transportation, Communication and Public Utilities	259.0	317.1	229.8	271.0
Commercial—Retail Trade	470.4	732.5	391.9	585.6
Commercial—Services	542.4	1,112.0	488.2	961.1
Commercial—Wholesale Trade and Construction	369.5	585.3	324.9	492.4
Government and Non-Profit Industries	287.0	555.1	249.1	461.7
Manufactures	1,038.9	1,404.4	857.0	1,097.8
Non-Manufactures	1,944.8	3,311.0	1,691.8	2,776.0
Total	2,983.7	4,715.4	2,548.8	3,873.8

*A more detailed version of this table appears in Appendix Table 38.

restaurant meals, and the like. While over-all employment will grow only as fast as the population, the future will find proportionately more white collar workers and greater employment in the service industries.

The results of the economic forecast were checked thoroughly with estimates prepared by other methods. One check was to predict 1954 employment from 1947 data and then to compare the prediction with the actual employment in 1954. A second was to compare the 1980 employment forecast derived by the input-output method with a technique using the ratio of labor force to population. A third was to compare the results of the input-output forecast with separate studies of trends in individual industries. These checks all showed that the results of the economic forecast were reasonable and that they were consistent internally. As might be expected, the checks were very good (within one and two per cent) for the broader groupings of industry types and somewhat less close for the finer breakdowns. These finer details of the economic forecast were not required for preparation of the land use forecast.

In summary, the growing population has been superimposed on a growing local economy to give measurable prediction of the economic activity of 1980. People in a large urban area increasingly specialize, become steadily more proficient in producing goods and services and become, therefore, progressively wealthier. Rising real income produces changes in what people will actually buy. This, in turn, changes what the workers must turn out. All of these related facts have been fitted to produce the picture of the economy of the area in 1980.

This work is significant in sharpening the estimates of needed land for industry, of demand for personal transportation, of new residential densities, and of car ownership levels. Each of these factors, in turn, affects the nature and amount of needed transportation improvements. More improvements cost more money so that, once again, the economic forecast becomes basic in fixing the measures of ability to pay for these required improvements. As the picture of 1980 unfolds in this volume, constant reference will be made to this economic forecast.

IMPLICATIONS OF POPULATION AND ECONOMIC GROWTH

The population and economic forecasts provide the background for estimates of the automobiles and trucks that will be owned in the Study Area in 1980. These are important estimates because so much hinges on vehicle ownership and, in particular, on automobile ownership. The number of trips made daily by the average family, the total vehicle miles of travel, and usage of mass transportation, are all directly affected.

Automobile Ownership

It is clear from the economic forecast that trip making and car ownership will rise at a faster rate than population growth. Table 2 indicates that the percentage of the average consumer's budget expended for transportation is estimated to rise from 13.0 to 14.4 per cent—an increase of eleven per cent. Since the average consumer unit will spend forty-six per cent more in 1980 than in 1956, it follows that per capita transportation expenditure will rise by sixty-two per cent.

Some of this increased expenditure for transportation will go for a higher quality of transportation, which may be expressed in better equipment (e.g., better automobiles and mass transportation equipment) and in greater speed and safety. There also will be more inter-city and vacation travel. But a large share of the increase surely will go into more travel within the urban area, which is to say, more widespread car ownership and more trips per person on the average weekday.

Figure 5 shows that the number of registrations per thousand population has been rising steadily, except during the war years. This rise, however, cannot go on indefinitely. Many people (minors and the very old) cannot drive, while others have limited needs for making automobile trips. It seems unlikely that automobile ownership could exceed[11] 500 per

[11]Some western states now have vehicle registration rates (higher than automobile registrations, because they include trucks) in excess of 450 vehicles per thousand population. This corresponds to auto registration rates of the order of 400-420 per thousand.

thousand population. This, however, only establishes a crude ceiling to automobile ownership rates.[12]

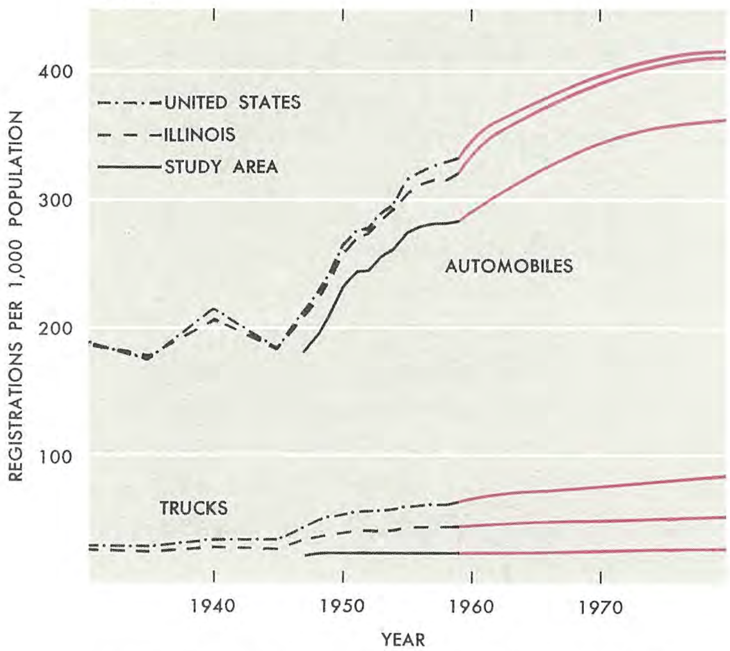


FIGURE 5—AUTOMOBILE AND TRUCK REGISTRATIONS PER 1,000 POPULATION, 1930-1959 AND ESTIMATED TO 1980

See Table 40 in Appendix.

Projected automobile ownership was established by relating automobile ownership to income. As a part of the economic forecast the number of families in each income group was projected. The percentage of each income group presently owning one and two or more cars was established. It was reasoned that as families move into successively higher income brackets they will take on the car ownership habits of persons now in those groups. There was even a slight additional factor of increased ownership within each income group which was discovered by historical studies and which helped to explain the slight increase in consumer dollars budgeted for transportation. By applying the appropriate rates to the numbers of families expected in each income group in 1980, the automobile ownership forecast was prepared.[13]

[12]Registrations are generally above automobile ownership figures for two reasons. They include business and governmental automobiles and they are a count of license plates which have been sold over a whole year, whereas true ownership is the number of vehicles owned as of one point in time. In this report most figures given are for automobiles owned by residents.

[13]Hoch, Irving, "Auto Registration Forecasts Revisited," and Hamburg, John R., "Car Ownership and Trip Making in the CATS Area" (Chicago) *CATS Research News*, Vol. 3, (1959) No. 2.

As indicated in Table 4, the number of automobiles garaged at residences is estimated to rise to 334 automobiles per thousand population in 1980, as opposed to 260 per thousand in 1956. (These rates become 283 in 1956 and 362 in 1980 if the automobiles owned by businesses and governments are included.) One-fifth of all consumer units will own two or more cars in 1980 as opposed to one-tenth in 1956. Only sixteen per cent will not have a car as opposed to thirty-two per cent today.

TABLE 4
AUTOMOBILE AND TRUCK FORECAST

VEHICLES REGISTERED—IN THOUSANDS	1956	1980	Ratio 1980/1956
Automobiles Garaged at Residences	1,341.6	2,607.5	1.94
All Automobiles*	1,461.6	2,828.0	1.93
Trucks	130.0	211.0	1.62
Taxis	5.6	7.0	1.25
All Vehicles	1,597.2	3,046.0	1.91
VEHICLES PER THOUSAND POPULATION			
Automobiles Garaged at Residences	260	334	1.28
All Automobiles*	283	362	1.28
Trucks	25	27	1.08
Taxis	1	1	...
All Vehicles	309	390	1.26
CAR OWNERSHIP BY FAMILIES			
No Car	32%	16%	
One Car	57	63	
Two or More	11	21	
Total	100%	100%	

*Includes automobiles owned by businesses and governments.

With an increase in automobile registrations of twenty-eight per cent per thousand persons and a population growth of fifty-one per cent, it follows that total automobile registrations in the Study Area will almost double by 1980. The exact estimate is for an increase of ninety-four per cent. Instead of 1,462,000 automobiles (including those owned by businesses and governments) there will be over 3,000,000 automobiles in the Study Area in 1980.

Doubling of the number of automobiles has significant consequences in establishing needs for new transportation facilities. Doubling the number of cars would double the total vehicle miles of travel.[14] If traffic is congested now, then increasing it two times obviously will raise problems of immense proportions. The anticipated gains in traffic would amount to nearly three per cent per year. The measured annual increase in actual traffic volumes over the past five years has shown an even higher annual percentage of increase. Clearly, the prospect of meeting the needs of twice the present automotive travel in twenty years will require a substantial and sustained road construction program, plus additional improvements engineered into existing streets.

Truck Registrations

In preparing the forecast of truck registrations for the Study Area, some interesting facts have been observed. The Study Area was known, from survey data, to have a very low rate of truck registrations per thousand population. This appears to be part of a tendency for larger cities to have fewer trucks per capita and smaller cities to have more. The farm states have the highest rates of truck ownership. It was observed also that trucks have become significantly larger in the past two decades. There is a lesser proportion in panel trucks and more in semi-trailers.[15] This is an evidence of increasing productivity in the trucking industry.

These facts explain the continuing slow growth of truck registrations per thousand population in the Study Area. Yet it appears likely that truck registrations will have to increase slightly faster than population in order to move the goods and provide the services required by the greater spending of the average family. Figures obtained from the economic forecast indicate that employment in the trucking industry will rise at least as fast as population. This indicates that truck registrations will rise by a similar amount—perhaps a little faster.

[14]Table 22 in Chapter VI shows that the average mileage driven by a family's second car is about the same as by its first.

[15]See Table 40 in the Appendix.

The truck forecast indicates that there will be twenty-seven trucks per thousand population in 1980 as against twenty-five in 1956. The total number of trucks in 1980, then, is estimated at 211,000 vehicles, as against 130,000 in 1956. This is an increase of sixty-two per cent, considerably less than the ninety-four per cent increase in automobiles.

The number of trucks forecast for 1980 was compared with the number of truck trips estimated for that year. The number of truck trips was estimated independently from data relating trip making by trucks to land use and to person trips. This comparison indicates that the average truck will make very slightly more trips per day in 1980 than in 1956.[16] This served as a check and indicated that the two forecasts were consistent with each other.

Mass Transportation Usage

One of the classifications of activity identified in the economic forecast was entitled "Local and Highway Transportation." This includes intercity bus travel and all local public transportation expenditures. Since intercity buses are a small portion, this classification may be related to expenditures on mass transportation and suburban rail travel.

The economic forecast is relied on for major industry groups but represents only an indication for this specific small sector of the economy. It is in this sense—as an item of interest—that the consequences of the forecast on the transit industry are reported.

The results projected were for a nine per cent decline in total consumer expenditures on mass transportation. Separate trend analysis of employment suggested an even greater decline. The economic analysis and forecast, then, anticipated fewer trips via mass transportation.

This kind of prediction is not very stable for such a small segment of the region's economy. It is likely that the car ownership estimates, being a much larger segment, would have greater significance as an economic estimate

[16]The results were 12.0 (weighted) truck trips per day per vehicle in 1980 and 11.3 in 1956. The difference can be explained by the known trend to larger body types which would increase the number of *weighted* trips per truck, per day, without greatly increasing the number of vehicle trips.

affecting mass transit usage. Actually economic studies have been used together with other information in Chapter V to provide more detailed measures of 1980 transit usage.

The economic forecast, however, has singled this industry out as being one characterized as having no future growth. In this sense it poses a problem of public policy with respect to future plans. And it presents a challenge for creative ideas for the mass transportation industry in the future.

SUMMARY

An examination of the forces that have brought about the tremendous population and economic expansion of the Chicago area indicates a high probability of still further growth. Standing in the center of the North American continent, with excellent water, rail, highway and air communications, Chicago still has the advantages of good location and transportation. With a large, diverse manufacturing base and a large marketing region, it should retain its present share (3.7 per cent) of the nation's population in 1980.

The Chicago metropolitan area should reach a population of 9.5 million persons by 1980. The smaller Study Area would have a population of about 7.8 millions. This tremendous growth is equivalent to adding all the people now living in the Boston metropolitan area to Chicago in a period of slightly more than two decades. This will create very heavy additional needs for travel facilities.

The enlarged population will be wealthier, in real terms. Per capita income is expected to rise by forty-six per cent. This is not fantastic because historical data show that in the past two decades real income has risen by more than fifty per cent. This wealthier population will have a greater capacity to absorb the charges of building the necessary transportation facilities. Aggregate income of consumers in the metropolitan area is expected to rise to over thirty-seven billions of 1956 dollars in 1980 in contrast to $16.7 billion in 1956. About one-seventh of consumption expenditures will be for personal transportation, or an estimated 5.4 billion dollars per year of which about 3.7 billion dollars will be for local travel. This indicates the very great importance of travel in the daily life of the community.

One of the significant effects of projected economic growth is increased automobile ownership. Car ownership is known to be related to income, with higher income groups owning more cars. It seems reasonable to expect that the result of higher average income will mean a higher average car ownership. There will be fewer families without automobiles, and more multi-car families as well. This, again, begins to indicate the nature of future problems — the projected twenty-eight per cent per capita increase in car ownership and the fifty-one per cent increase in population means a ninety-four per cent increase in automobiles owned. This suggests a doubling of the demand for highway travel.

Chapter III

ESTIMATED LAND USE IN 1980

INTRODUCTION

The problem dealt with in this chapter is that of making a land use estimate for the Study Area for 1980. The estimates of population and economic growth are to be combined with information obtained from the survey of existing land use to estimate the land requirements and placements of activities of the future.

Land use is a means for fixing future travel demand. The categories of land use actually are classes of the kinds of activities normally carried on in every urban area. A careful case has been made in Volume I to demonstrate that these urban activities are the sources of urban traffic. Information on the distribution of land use will serve to locate places of trip origins and destinations. In addition, knowing that certain land uses have a strong tendency to develop origin-to-destination linkages (residential to industrial, for example), the geographic arrangement of land uses is a significant clue as to how trip origins will connect with destinations to create future travel patterns.

A land use forecast is not a land use plan. Demographers, for example, specialize in forecasting population—but this does not mean that the forecast is a policy or that the projected population necessarily is suited to the resources of a region. Clearly, policies on immigration are quite separate matters. It is in the same fashion of making estimates and of applying extrapolation techniques that land usage is forecast. This forecast should prove very helpful to the agencies working on the land development policies and plans in this region. As their work progresses and official adoption of plans comes about, these forecasts can be reviewed.

In the following section, the history of growth in the Chicago region will be examined to isolate the crucial factors affecting future land development patterns. Having identified these, the procedures of the forecast will be outlined. A final section will evaluate the results for reasonableness.

HISTORICAL LAND DEVELOPMENT PATTERNS

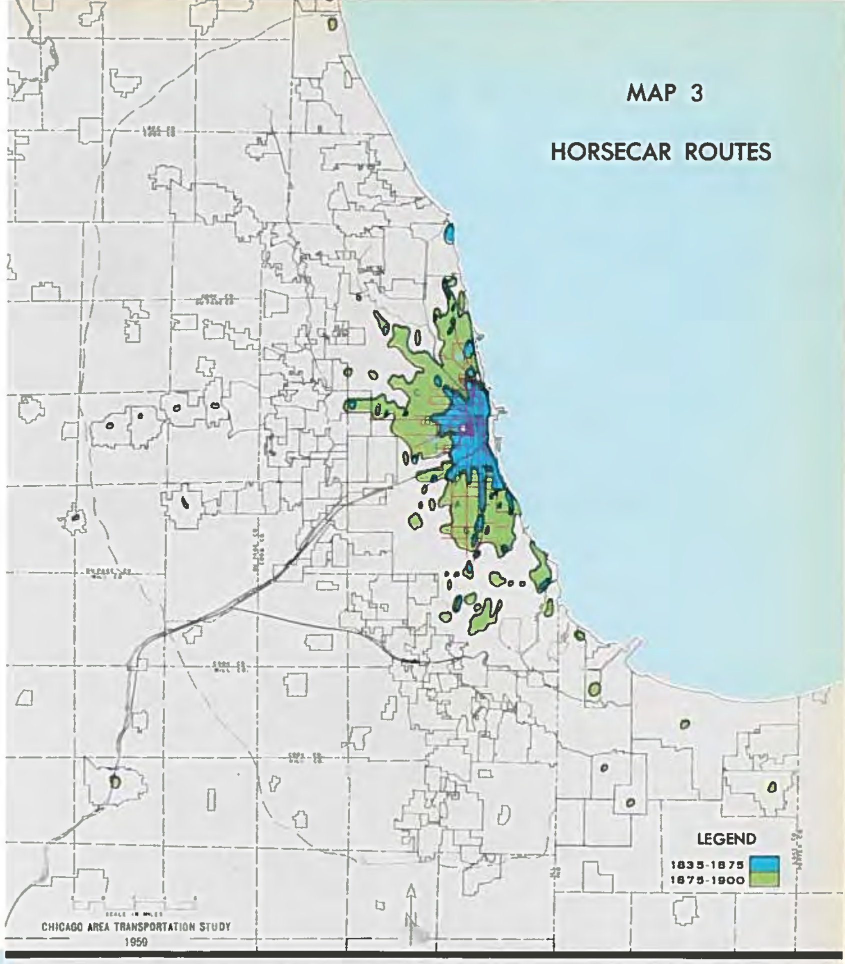
In the last one hundred and twenty years, urbanization of the Chicago region has proceeded from a small outpost of four thousand population to a teeming metropolis of over five million. As more people and their associated urban activities have packed into this growing metropolis, urban uses have steadily displaced agricultural uses of land. The outlines of successive "high water" levels of urban development are shown on Map 2. This represents more than one hundred years of constant swelling from population gains. The outlines of urban development for selected years indicate steady outward expansion. Clearly, the 1980 line will be farther out and one forecasting problem is to estimate its outline.

What has caused these particular shapes to occur at different times in the past? Four principal influences can be identified: topography or land surface and natural barriers; population size; the comparative costs of vertical and horizontal building; and the relative efficiency, speed and location of the internal transportation system.

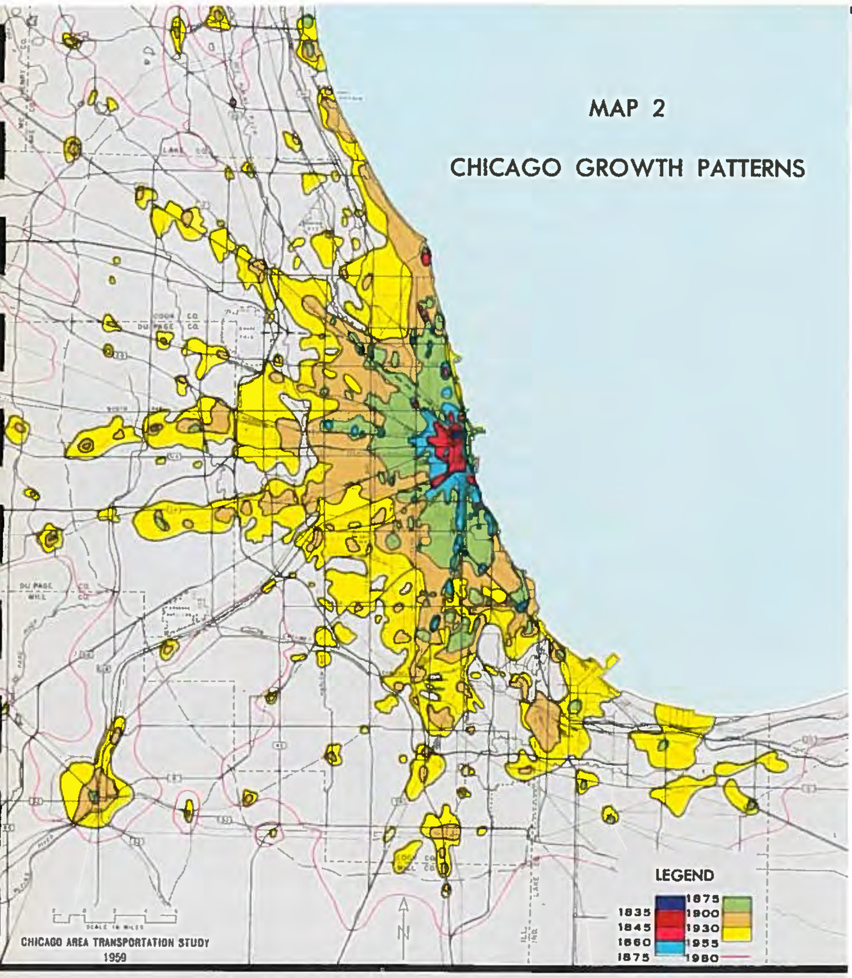
Chicago lies on a flat plain. There is only 300 feet of variation between the highest and lowest points in the entire 1,236 square mile Study Area. The only significant natural barriers to land development are Lake Michigan and the waterway system draining the area. The limits imposed at the lake shore are obvious although this has been pushed back slightly by public works. The rivers are less obvious but they, together with canals and ports, do set up certain natural barriers which have had an effect on the pattern of growth. The most significant site features, then, are the lake shore and the flat, even surface of the land. Within these limits it is reasonable that the pattern of urban development will be determined by man-made choices.

The effects of population growth are obvious. More people create increased requirements for land occupancy which have to be contained within the limits of urban development. How quickly or slowly these people and their activities will spread out on the land surface depends on the economic and social costs of building into the air as opposed to the comparable costs of travel. If travel frictions are great, there will be a tendency to pack things in tightly. If vertical building is cheap with relation to transportation, then there is a tendency to expand upwards rather than outwards. The observed densities result from an equilibrium point where the surface travel frictions and the costs of land and buildings are roughly balanced.

Chicago's early growth (1830-1859) was in the era of individual transportation. Travel was by foot or horse and buggy. The extent of development was small. By 1859, when the population had passed 100,000, some better means of travel had to be provided to serve the booming city, and so mass transportation was developed. Its first expression was the horsecar.



Horsecar lines influenced land development during and beyond their period of transit dominance (1859-1892).

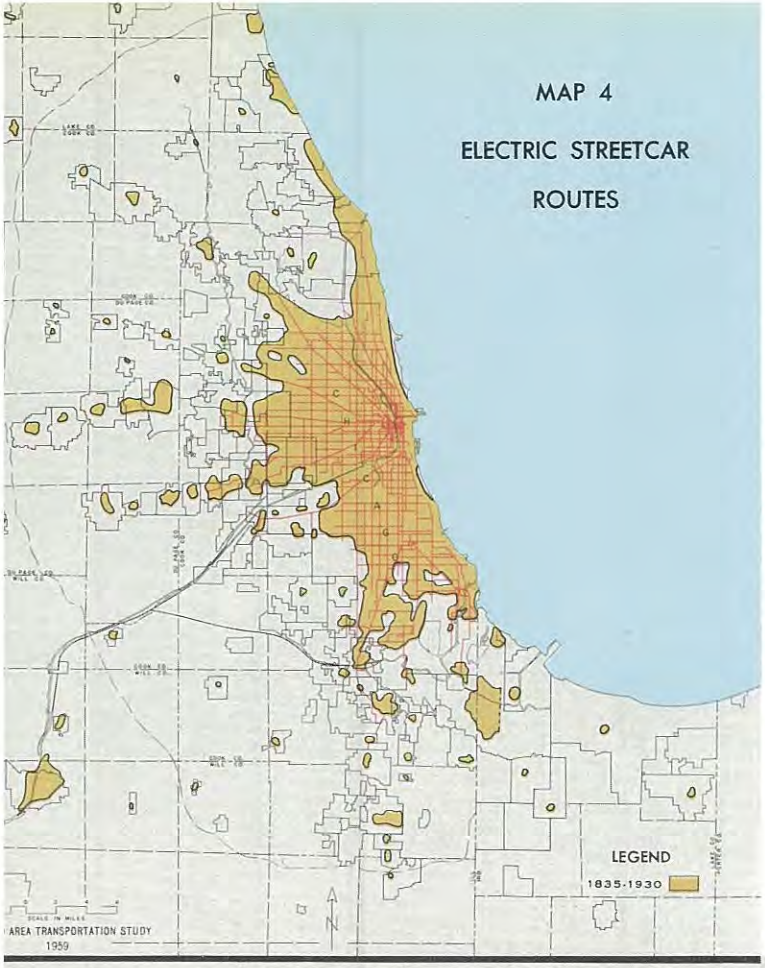


A 54 per cent growth in metropolitan population at prevailing low densities has greatly extended the urban area. The method of forecasting growth is described in this chapter.

The city's local transportation system in the era from 1859 to 1892 was dominated by horsecar lines. These lines provided frequent but slow service. The extent of the service area is shown on Map 3. Most buildings were from two to four stories in height and they were packed closely together. Technology had not, at this time, developed the basis for multistoried, steel-framed buildings.

Cable cars had a brief life between 1882 and 1906. They never extended beyond the area previously served by horsecar lines. Consequently, they did not affect the urban form greatly except, perhaps, to intensify the amount of development along their lines and at the center.

The electric streetcar was introduced to Chicago in 1892 and construction of streetcar lines was very rapid. These lines went beyond the built-up area, vastly extending potential



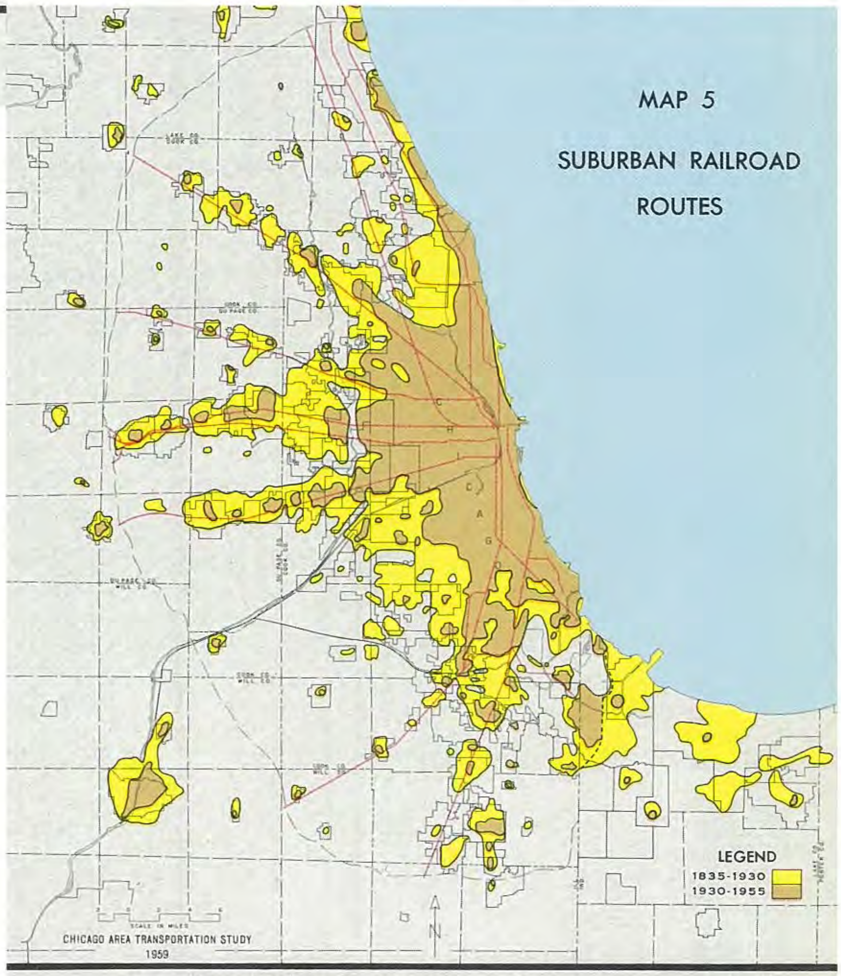
The ubiquitous streetcar was a major force in the building boom prior to and after World War I. Its full effect on land development patterns, by 1930, can be seen.

building sites (see Map 4). Speeds were increased substantially and travel frictions over the land were reduced. The streetcar improved access into the center of the city for a growing population and this, in turn, encouraged very great specialization of land use activities at the center.

This central focus was increased vastly by the construction in the 1890's of elevated rapid transit lines. These focused on an elevated loop at the Central Business District which has given this area its common nickname. These elevated structures were possible because of the steel girder. Steel also became the framework which allowed construction of the first skyscrapers in the Loop in the 1880's and 1890's. The elevated lines provided excellent access to the center of town. There is no doubt that they reinforced the development of high-rise buildings in the Loop, and vice versa.

By the turn of the century, the development of interurban electric lines and the greatly increased use of steam railroads fostered the growth of suburban places. The period from 1860-1890 was the period of greatest interstate railroad building. These lines, connected to the center of Chicago, cut service paths outward from the city with a spoke-like effect. Small villages along these lines started and thrived in this period. As commutation developed in quantity after 1900, it became increasingly fashionable and popular to live in these small suburban communities. The period since the turn of the century has been one of gradual outward extension of urbanization with the original rail lines forming the backbone of a star shaped pattern. Map 5 shows the extent of land development by 1930 and also 1955, when this influence had run its course and was beginning to be changed by greater use of the automobile.

Since 1930, the urban form has been affected more and more by the availability of the private



The effect of railroads on suburban development was marked in 1930. They have continued to influence land development even though the automobile is now dominant.

passenger automobile. As new urban development has taken place, the more rapid and more nearly universal accessibility provided by the automobile has permitted urban development to spread out. As it spreads, the pattern of development is becoming more circular and so is returning to the pattern characteristic of the times of foot travel and streetcar.

This brief review has shown that, excepting for Lake Michigan to the east, there is no major barrier to urban expansion. Historically, the pattern of land usage has been shown to be responsive to the available means of transport. Ease of access has been significant in influencing the shape of urban development and the intensity at which land is used.

ASSUMPTIONS AFFECTING FUTURE LAND DEVELOPMENT

From the historical review, the prime ingredients, which are reasoned to give particular shape and density to the future urban mass, can be identified.

The topography will remain much as it has been—flat land and Lake Michigan being the principal characteristics.

Population size has been estimated as 7.8 million persons. This number of people will have quite measurable amounts of residential and non-residential land requirements.

The relative costs of closely grouped, as opposed to less dense developments will be, in part, determined by the efficiency of the transportation system and also by the costs people associate with living and working at high, as opposed to low, densities. There is increasing consumer selection of low density residential development. Rising family incomes should increase the effectiveness of this demand since rising real income tends to increase possible choices. The trend, therefore, assuming adequate transportation, is towards less dense residential development. Similar trends are observable in commercial, industrial and public uses of land.

What is the most reasonable expectation about future transportation—the fourth ingredient? The entire history of the Chicago area has been towards higher speeds of travel as population has increased. The horsecar replaced foot travel; the electric streetcar replaced the horsecar; and the elevated train and suburban railroad added a new dimension of faster travel. Ever more journeys are now being made via the private automobile, which, excluding only the suburban railroads,[1] is the fastest means of travel. All this has the effect of speeding up the average journey.

Since this process of increasing average travel speeds has been continuous in the history of this area, one may safely assume that it will continue. In a sense it has to, since otherwise the enlarged urban area would become less and less unified, losing its ability to bring people and specialized goods and services together. This ability to assemble persons, goods and services daily is a prime advantage of urban places. To secure faster speeds, steps are being taken constantly to improve road design and to provide faster mass transportation. More than this, there has been a marked tendency towards more individualized transportation as opposed to the generally slower mass transportation. With rising real income, this trend may be expected to continue.

What about the possibility of new forms of transportation? It is quite possible that new forms may be invented and produced when there is a market for them. On the horizon are large helicopters, ducted fan and "pressure pad" aircraft, conveyor belts and other possible new forms for moving people and goods. While there will be increasing use of more specialized means of travel as the area increases in wealth and in numbers of people, the limits of air space and the costs of certain new forms suggest that the *bulk* of travel will be via presently known and used types of facilities.

Even if completely new and widely usable means of transportation were invented, their effect on land development by 1980 would be slight. This is because of timing. First,

[1]For journeys of comparable length, however, door to door travel times are roughly the same by car as by train. For average door to door travel speeds by mode of travel, see Table 47 in the Appendix.

a new invention requires substantial engineering, development and marketing time. Second, market adjustments are necessarily slow in acceptance because of current investments. Finally, the relatively slow and almost glacial adjustment of urban form means that the shape of 1980 land development is largely fixed by today's structures, building practices and transport system.

The basic assumption within which a detailed land use forecast is made is that the forces operating presently will determine largely the land development pattern expected by 1980.

THE LAND USE FORECAST — BASIC PROCEDURE

The objective of making the land use forecast is to provide a basis for estimating future travel. Future travel must be predicted at each zone so land uses must be allocated by zone, but they need not be more finely distributed geographically. Land use categories of several types are required because they generate trips at different rates and because travel linkages vary in frequency between different types of land uses. This means that area measures and indexes of intensity of use for each land use type, within each zone, are required.

The land use forecast is accomplished by a system of land accounting[2] fitting generally within a set of rules developed through observation of the existing regularities in the arrays of land use within the Study Area. There are three of these rules or regularities. One is the decline in the intensity of land development as distance (or access time) from the Loop increases. The second is the decline in the amount of land in use as a proportion of available land, which is related also to distance from the Loop. Third is the stability in the proportional amounts of land devoted to each type of land use.

These regularities are expressions of functional requirements of people and their activities. The first two are related to accessibility

[2]For a complete and detailed description of the land use forecast, see *Land Use Forecast* (32,610) (Chicago: CATS, 1960).

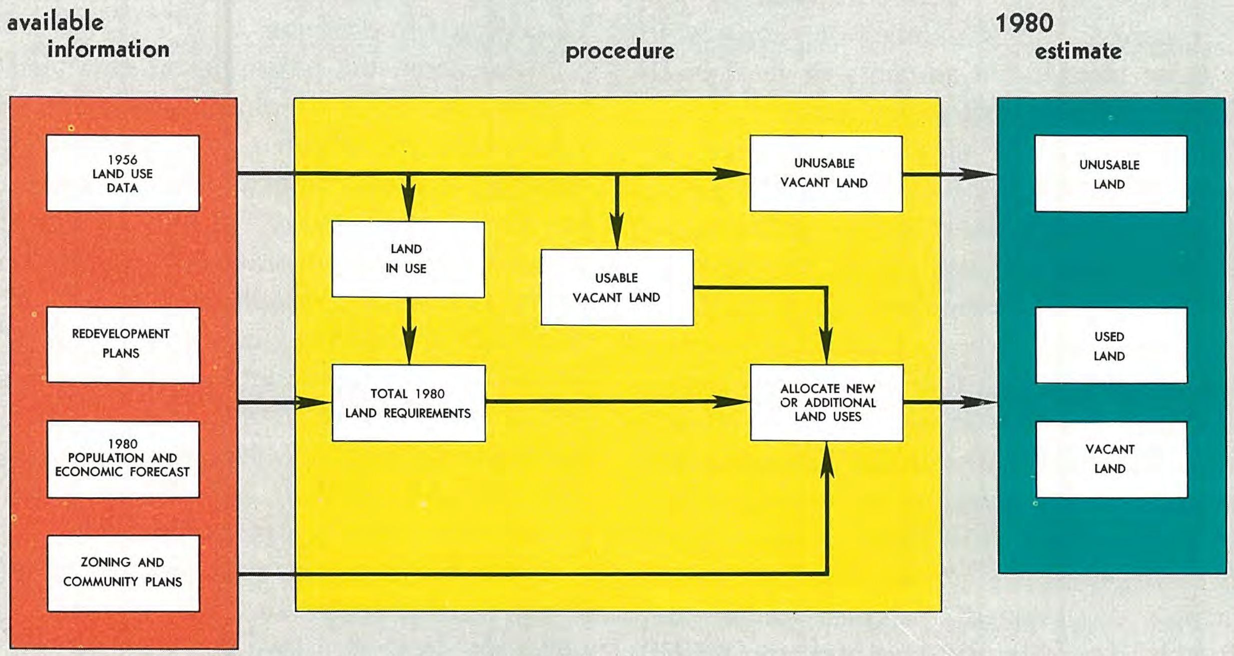


FIGURE 6—SIMPLIFIED DIAGRAM OF LAND USE ESTIMATING PROCEDURE

to the Central Area where thirty per cent of the labor force is employed and where the most specialized services are found. The land use proportions are fixed largely by the basic requirements of people: there cannot be more stores than the population can support, nor more industrial plants or public buildings. Uses have to remain in some equilibrium. Within limits, this rule *must* operate, although increasing wealth may increase the proportion devoted to residences as people establish values for greater uses of land for leisure and family living purposes.

The basic sequential steps required for making the forecast are described in Figure 6. This logic is used to distribute future land uses, maintaining accounting totals at each stage in the process. At all points, the consideration of observed rules controls the making of specific estimates.

There are, as the diagram shows, four givens: a 1956 land occupancy pattern, zoning ordinances and community plans affecting potential use of vacant land, plans for redeveloping parts of the built up area, and a demand for sites for a substantially larger number of urban activities. The problem is to define 1980 urban land uses. Obviously, presently used land will remain urban but may change somewhat in time. Likewise, vacant or agricultural lands will be converted into urban use.

CHANGES IN LAND ALREADY DEVELOPED

Use of existing urban land could change by 1980. This could come about as a result of public or private action. In the public realm, there are plans for redevelopment of particular parts of the built up area. Redevelopment plans were obtained from responsible public agencies and completion of the planned programs by 1980 was assumed.

There also will be redevelopment from private sources. Old buildings are torn down and replaced by new ones. There is continual change, as any observer can note. What is wanted for forecasting purposes, however, is not each small change, but rather the cumulative shift in land use pattern which would result from this continual activity over a period of twenty to twenty-five years. Not much is known about this. It is clear, however, that Chicago has gone through substantial rebuilding and change in the last one hundred years.

Greatest changes in Chicago's land uses have come about as Chicago grew from a small city to a metropolis. In the future, as the urban area expands, it would seem that only minor changes in density and character of land uses in the built up portion will take place. As a result, while there will be replacement of old structures and urban renewal, both public and private, these will not change the basic traffic generating characteristics of the already developed central bulk of the region.

This line of reasoning can be tested by a backward look. Fortunately there was a complete land use inventory taken for the city of Chicago in 1939-40. It is possible to compare the distribution of land uses as of that time with those recorded sixteen years later.[3] While there are a few problems in comparing two separately conducted surveys, the classifications generally are compatible.

In Table 5 the two surveys are compared. Realizing the problem of defining land use categories and of precise measurement, this shows a very striking picture. The only outstanding change has been to use up vacant land. This naturally has been greatest in the outlying parts of the city. The bulk of the formerly vacant land has been used for residences. But, as expected, there have been comparable increases also in commercial buildings, public buildings and public open space. This parallel growth of certain nonresidential areas is expected because these are needed to serve added residences. There has been little change in the other land uses. Industrial land has not increased and, since the city was almost completely platted in 1940, there has been no change in the area in streets. These comparisons support the argument that little change

[3]While building activity was restrained during World War II, the decade of the fifties has seen one of the greatest building booms in the history of the region.

TABLE 5
COMPARISONS OF 1940 AND 1956 GENERALIZED LAND USE IN THE CITY OF CHICAGO
(In Square Miles)

Miles to Loop	Residential		Manufacturing and Transportation		Commercial and Parking		Public Buildings		Public Open Space		Streets and Alleys		Vacant		Water and Unusable		Total	
	1940	1956	1940	1956	1940	1956	1940	1956	1940	1956	1940	1956	1940	1956	1940	1956	1940	1956
0- 1.9...	.82	.81	2.26	2.17	1.13	1.50	.28	.38	.95	.55	2.43	2.60	.63	.37	.23	.20	8.73	8.58
2.0- 3.9...	5.32	5.20	4.45	4.64	2.11	2.40	.66	.99	1.57	1.47	6.13	5.99	1.83	1.07	.39	.36	22.46	22.12
4.0- 5.9...	9.85	10.16	5.93	5.73	2.65	2.91	1.03	1.21	2.38	1.86	8.60	8.67	2.56	1.64	.23	.17	33.23	32.35
6.0- 7.9...	14.40	15.71	5.11	5.33	2.54	3.00	1.19	1.43	3.57	3.50	11.83	11.86	5.74	2.82	.15	.13	44.53	43.78
8.0- 9.9....	10.75	15.15	3.71	3.89	1.50	2.02	1.01	1.18	2.09	3.05	10.75	10.33	10.55	4.21	.04	.05	40.40	39.88
10.0-11.9....	4.67	9.59	4.54	4.05	.55	.95	.33	.42	.75	1.27	6.90	6.73	10.35	5.07	.05	.08	28.14	28.16
12.0 and More.....	4.78	8.38	5.12	6.03	.52	.86	.60	.54	1.36	2.15	6.25	5.67	13.98	10.01	4.53	3.63	37.14	37.27
Total	50.59	65.00	31.12	31.84	11.00	13.64	5.10	6.15	12.67	13.85	52.89	51.85	45.64	25.19	5.62	4.62	214.63	212.14

is to be expected in those parts of the urban area which are completely built up.

If existing land uses remain stable, trip generation still could change if there were a time trend changing the intensity of use. Changes in residential density, for example, could reduce or increase the number of persons living in any particular area without there being any change in the amount of land devoted to residential use. This could have a significant effect on the number of trips made to an area.

To test this possibility, the number of persons living in one-mile bands around the Loop was examined for 1940 and for 1956. Figure 7 compares population densities of Chicago, by distance ring, for both years. Figure 8 shows the total number of persons resident in each mile ring for the same two years. Since 1940, the area within four miles of the Loop has remained constant or possibly has increased slightly in population and in net residential density. Elsewhere in the city of Chicago

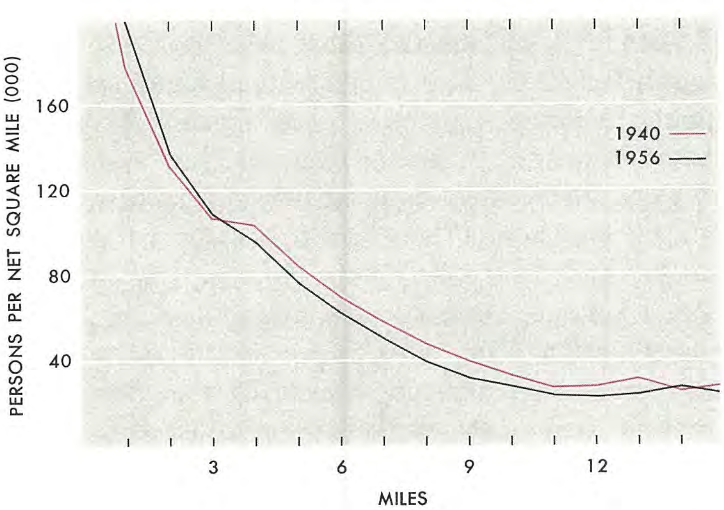


FIGURE 7—1940 and 1956 NET RESIDENTIAL DENSITY IN CHICAGO BY DISTANCE FROM THE LOOP

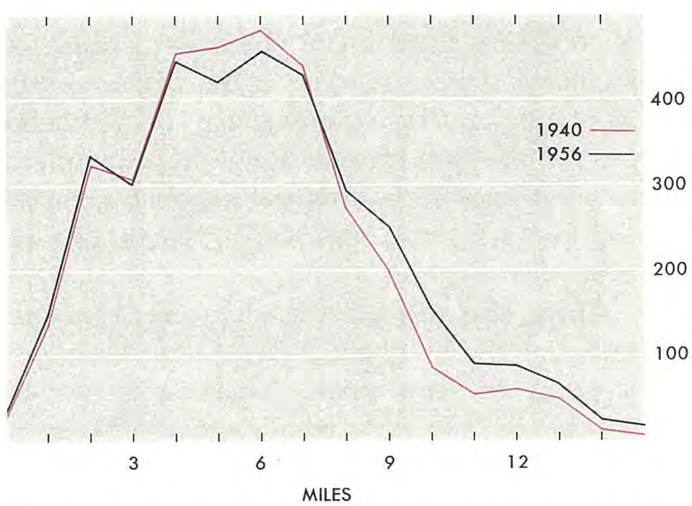


FIGURE 8—1940 AND 1956 POPULATION IN CHICAGO BY DISTANCE FROM THE LOOP

density has declined, but only because vacant land has been put to residential uses at densities lower than those that existed in 1940. This relatively slight reduction in densities has come about because post war building has emphasized single family dwellings on existing vacant lots. This indicates little change in intensity of land use once the majority of land has been occupied.

In areas presently built up, nonresidential densities are not expected to change significantly. Those nonresidential activities such as shops and schools, which are associated closely with residential activities, will tend to have stable trip requirements per acre if the population in their environs remains the same. Those which serve nonresidents as well as residents, factories for example, will still be constrained in their intensity of site use. Intensity of land uses results from an equilibrium of the values of access, as opposed to costs of more intensive site use. This equilibrium is not likely to be greatly changed in built up areas. Evidence of this is the observed stability of residential densities.

A longer time perspective of the trends of density can be inferred from historical population data. Table 6 shows the number of persons resident in each of the two mile rings of the city of Chicago for each decade since 1860. This demonstrates the tendency for a segment of the urban area to fill up and then remain quite stable. The inner ring population declined from 1900 to 1930 predominantly because of displacement by nonresidential uses. With the automobile being more universally available since 1930, it can be seen that the only changes have come in areas farther out and these because there was still an amount of vacant land to be used. Since little vacant land remains inside the eight mile ring today, stability seems the most reasonable expectation.

It was decided, therefore, to use the 1956 level of population density for any area which was completely developed in 1956. While individual blocks and even some larger sections may increase or decrease in density as a result of revised programs of public redevelopment or by private actions (see section on Central Area which follows), it seems very difficult for this to have any large scale impact over a wide area. The stability of the tremendous investment in existing buildings is great and, of course, any changes are *net* changes—that is, an old building must be torn down before a new one is erected, and this tends to dampen the impact on trip making potentials. Finally, there recently has been public acceptance of

TABLE 6
POPULATION IN THE CITY OF CHICAGO BY DISTANCE FROM THE LOOP, 1860-1956[a]
(In Thousands)

Year	Distance From the Loop in Miles					Total
	0-2	2-4	4-6	6-8	8 and over	
1860	80	32	...	...	...	112
1870	175	105	19	...	...	299
1880	230	215	55	3	...	503
1890	325	490	165	80	40	1,100
1900	350	700	270	210	95	1,625
1910	360	715	620	290	200	2,185
1920	275	715	851	500	360	2,701
1930	221	663	962	822	708	3,376
1940	198	634	968	854	743	3,397
1950	221	673	981	866	880	3,621
1956	217	645	925[b]	863	970	3,620

[a]Data from 1860-1950 from, Chicago Community Inventory, *Growth and Redistribution of the Resident Population in the Chicago Standard Metropolitan Area*, Chicago, 1954. 1956 estimates prepared from sample home interview survey.
[b]Some of this population loss is associated with recent expressway construction.

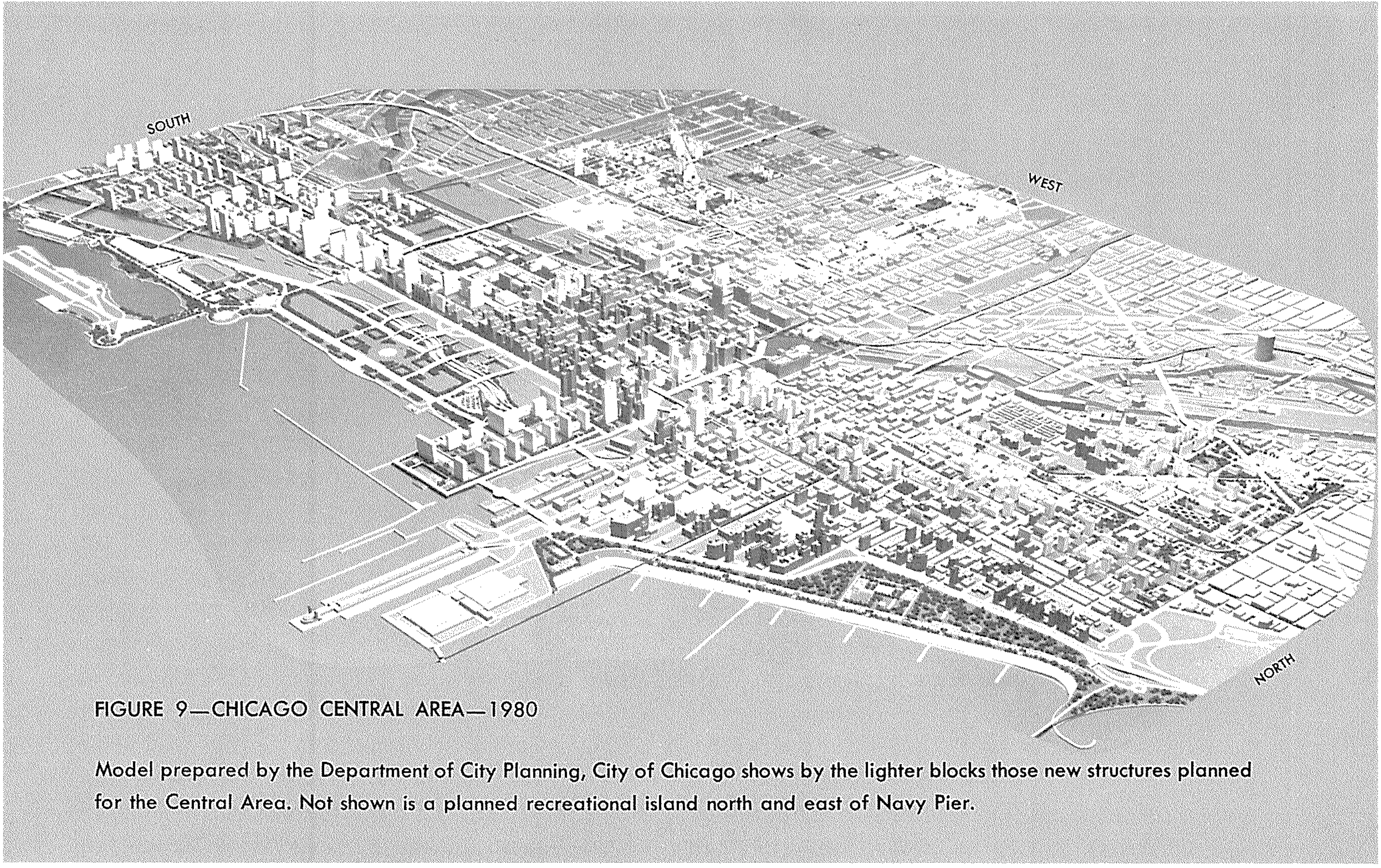


FIGURE 9—CHICAGO CENTRAL AREA—1980

Model prepared by the Department of City Planning, City of Chicago shows by the lighter blocks those new structures planned for the Central Area. Not shown is a planned recreational island north and east of Navy Pier.

zoning and housing standards together with stricter enforcement. This should prevent the excessive crowding of persons.

In summary, the expectation for 1980 is for stability in the completely built up parts of the urban region—stability in number of residents and in the intensity and proportional uses of land. The only exceptions are the major redevelopment or renewal projects. Most of these actually represent a replacement of presently outworn structures and are designed to accommodate similar land uses. An outstanding exception which requires additional attention is the rebuilding plan for the Central Area.

Central Area

The Central Area of Chicago—roughly, that area lying between North Avenue, Lake Michigan, 26th Street, and Ashland Avenue—is a special case in the land use forecast. In 1956 over one-fifth of all person trips made in the Study Area began or ended here. Any major changes in this Central Area would mean a significant change in the number of trips made to it. But of greatest importance is its controlling influence on the future usage of railroad and elevated-subway service.

Fortunately, the Chicago Department of City Planning completed a long-range plan for this area in 1958.[4] This plan was based upon studies of redevelopment possibilities and constitutes the official statement as to the planned future of the Central Area. It is a plan with a target completion date of 1980. Therefore the plan was presumed to be the future land use for this part of the region.

This plan includes substantial redevelopment of areas lying near, yet not in the Loop. The prime change, as expressed in the plan, is to build a substantial number of new high-rise residential structures, around the commercial heart of the Central Area, yet to allow for some further expansion for central commercial uses.

The net changes in land use are not great, but in this part of the region floor area use rather than land use is the most crucial measure. Fortunately, the features of the plan were carried out in substantial detail and a model was built. (See Figure 9.) From these plans, an inventory of future floor area could be obtained and classified by type of use. Floor

[4]*Development Plan for the Central Area of Chicago* (Chicago: City of Chicago, Department of City Planning, 1958).

area measurements suggested an over-all gain of the order of five per cent, with greater gains in residential use and declines in warehousing and manufacturing uses. These measures of future floor area were accordingly taken as the basis from which future trip making would be calculated.

THE DEVELOPMENT OF VACANT LAND

To complete the 1980 land use projection, the net requirement for absorbing vacant land into urban use must be estimated. This is accomplished by considering the total requirements for a population of 7.8 million, subtracting the requirements already met by developed land, and then making an allocation of additional uses to presently vacant land.

To make these future allocations of land use, all vacant or agricultural land was divided into certain major classes. First, the land that, because of drainage or other features, was unsuited for development was eliminated from further consideration. This is actually a very small area—about eighteen square miles.

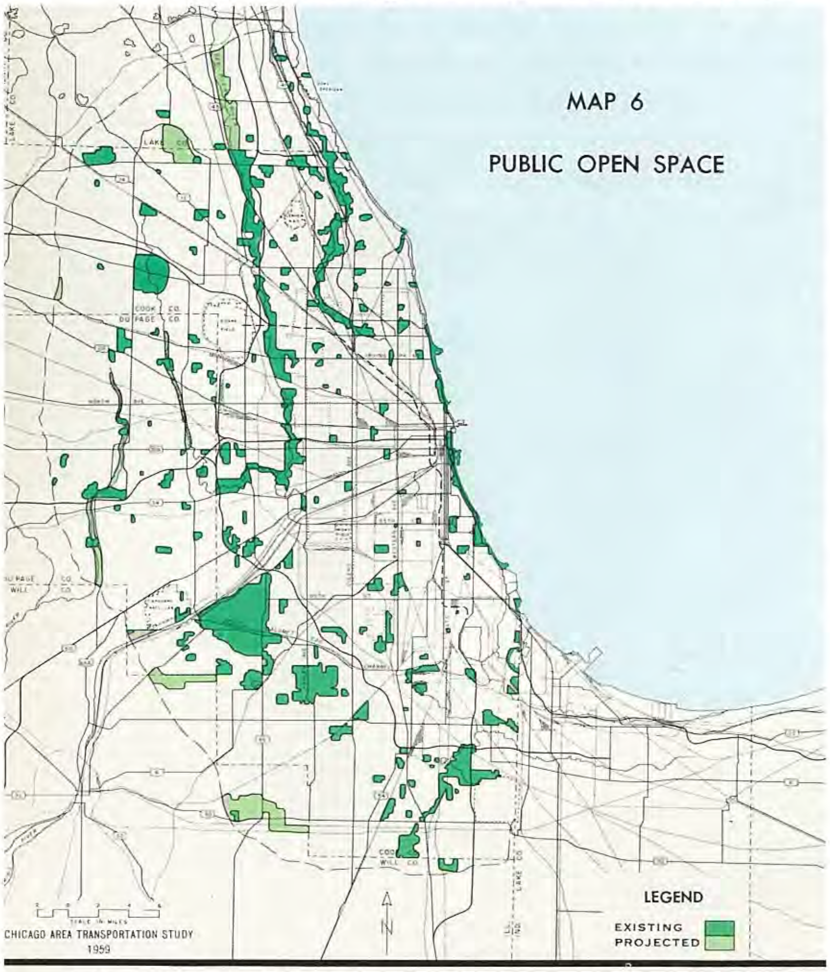
Public Open Space

Next, the major public uses were estimated. The history of metropolitan development has shown that large tracts of land should be reserved in advance of urban development for public use—principally for large parks and forest preserves. The Chicago area has been a world leader in this respect. The additions to the current supply of public open space shown on Map 6 include a number of already publicized proposals. They carry out the theme of continuous open space along stream valleys, with the acquisition of such other sites as are likely to improve the distribution of open space with respect to the future population.[5]

Manufacturing Land

The remaining vacant land was then reviewed. All land zoned for industry was considered as being available *only* for industrial development, in line with the modern practice of exclusive industrial zoning.[6] In addition, some lands currently listed with the Division of Industrial Development of the Commonwealth Edison Company (which has had long experience in maintaining detailed records on available industrial sites) were added to the above total. These were not zoned for industry but were considered to be well suited and potentially available for new industry. Finally, some small additions were made to this category of available manufacturing land by including sites in certain parts of the Study Area where there was an insufficient supply of industrial land. These sites were located strategically at places with good transportation and where they would not be likely to conflict with residential development.

Future manufacturing land is shown on Map 7 which appears on page 26. The darker shade



In the Study Area, 36 square miles of public open space are added to the 115 square miles presently in use. Additional regional parks fall beyond the cordon line.

[5] *Present and Future Distribution of Public Open Space Within the CATS Area* (43,000) (Chicago: CATS, 1958).

[6] In this text, the terms *industrial* and *manufacturing* are treated as being the same. Actually, zoning ordinances generally allow non-manufacturing activities such as trucking and wholesaling in industrial zones, but exclude residences. Practically all land in the Study Area was covered by zoning ordinances.

Slightly more than 80 square miles are designated as suitable for industry. As of 1956 about one-half the total area was vacant.

is land already in use in 1956. The lighter shaded areas are those additional lands marked out for future industrial use by the processes just described. The increased suburbanization of industrial sites is obvious. In addition, there is a greater dispersion of sites. This is a natural reflection of thinning population and more universal ease of access by truck.

Not all the potential industrial sites will be in use by 1980. This is desirable because some land should be reserved for the decades beyond 1980. Which land would be used by the target year and which held in reserve for later growth remained to be determined. This was accomplished using two measures: first, the density or number of workers expected on each acre of land used and secondly, the probability that any site or portion of any site would be used by 1980.

Density patterns, measured in number of workers per acre of land in manufacturing use, were described in Figure 4 of Volume I. This showed that density declined quite rapidly from a high point of four hundred workers per acre near the Loop, towards average suburban densities of fifteen to twenty workers per acre.

Recently constructed plants in more central locations tend to have high densities (because land values are high), but slightly lower than those of neighboring plants. It was assumed that this tendency will continue. Future suburban plants were estimated to be at generally the same density as existing suburban plants—mostly built since the war—because they will have the same accessibility, land costs, parking and other site development problems.

Figure 10 shows that in 1956 the percentage of total defined manufacturing land that actually was used[7] declined fairly regularly from a high point near the Loop to a low point at the maximum distance. The same tendency was observed in all sectors. This decline reflects the tendency for manufacturing plants to locate close to the center first and to move farther out only as the range of choice of suitable sites diminishes with ever increasing development. It was assumed that additional industrial uses would locate on potential sites in the same way, as growth continues to 1980.

[7]Percentage of use is measured in terms of workers—i.e., the present employment as a percentage of the possible employment if all presently vacant land were developed at typical future densities.

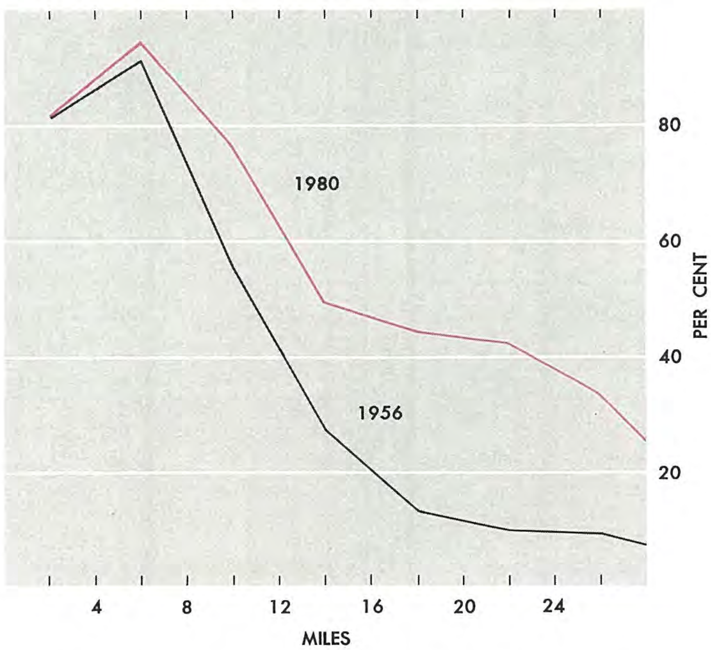


FIGURE 10—1956 AND ESTIMATED 1980 USAGE OF DESIGNATED MANUFACTURING LAND BY DISTANCE FROM THE LOOP

Within these two general rules, there still were many detailed considerations affecting particular sites and rates of growth of particular kinds of manufacturing. For example, some industrial land has excellent deep water facilities. Growth of manufacturing industries requiring such facilities was not sufficient to use all sites so that some were held out for later growth. Another consideration was future population distribution. Since industrial sites were not distributed in the same way as population, industrial sites were used selectively to distribute future jobs so as to more nearly resemble the distribution of homes. The final results of this allocation process show as the 1980 line in Figure 10. This has the same general shape as current usage, merely extending growth outward into the suburban areas.

The amount of vacant industrial land left in 1980 as a result of this allocation constitutes only 3.1 per cent of the total land area within the Study Area. It is sufficient to provide space for 500,000 more workers, or a further increase of fifty-two per cent over 1956. (This takes into account the fact that some of the industrial land was given an allocation of heavy commercial and trucking uses. This increased the total land allocated by only twenty per cent.) Zoned reserves of industrial land will be required beyond 1980 to allow for additional expansion of manufacturing. It may be that more land is zoned than will be required, but this can be adjusted by appropriate governmental action if it is subsequently proven to be desirable.

Transportation Land

Transportation land uses were considered next. Except for a third major airport, no additions were made to the 1956 supply of transportation land. This airport was placed in the southeastern part of the Study Area and required some seven square miles of land. Railroad lines and yards, which are the chief users of transportation land, are not likely to expand in the coming decades. Additional trucking and warehousing activities were placed on industrial land, since these are normally considered industrial for zoning purposes. The minor areas required for public utilities and communications (which fall within the category of transportation land) were allocated to other land uses. For example, sewage disposal systems were placed within the stream valley reservations, while telephone exchanges were placed within commercial lands. In sum, transportation land increased very slightly—the greatest gain being in airports.

Streets and Alleys

Following identification of the major bulk land uses, account had to be taken of land requirements for streets. New local streets and alleys were accounted for by subtracting a fixed proportion of all raw land not earmarked as public open space, industry or transportation uses, since these uses have less than normal street requirements. Some parts of the outer suburban area also required new arterial streets and allowance had to be made for planned express highways. By review of presently committed facilities and consideration of probable future spacing of suburban arterial streets, additional lands were withdrawn from the remaining usable totals.

Residential Land

With land reserved for public open space, industry, transportation and, finally, streets and highways, all the remaining usable vacant land could be considered as available for residential purposes and for the local commercial and public buildings activities which normally serve residences. This available land is shown in the lighter color on Map 8, page 28, while the areas now used for residences are given a darker tint. Because this is a generalized map, some vacant residential parcels are included within the area of present development and streets are not shown. On the other hand, all waterways and unusable land, and existing large public institutions, such as the Argonne National Laboratory and Fort Sheridan, are in the uncolored groupings.

The most striking quality of this map is the appearance of many areas which are *not* available for residential development; they appear like holes punched through the potential residential fabric of the area. A second striking

Present development plus reservations for future non-residential activities will force new housing into the suburban areas.

characteristic, but not a surprising one, is that vacant, residential land is almost exclusively beyond the limits of presently built up parts of the region. The location of available land and the limits of density force almost all of the expected new residential land into a limited set of possible sites.

The number of new residences to be allocated to potential vacant sites in each zone in the Study Area depends upon three things. First is the amount of land needed for the nonresidential activities which are normally closely associated with housing. Second is the density of residential land development per acre. And third is the general location of the available vacant land with respect to access and the travel requirements of people.

With residences there is a nearly constant number of nonresidential uses. These include local stores, service establishments such as beauty shops and doctors' offices, and also public buildings such as schools, village halls and fire houses, playgrounds and small parks. As residences were allocated to vacant sites, a suitable percentage of land had to be held out to provide for these local, nonresidential activities.

A second essential ingredient in fixing future residential land is the expected density. Densities were estimated on the basis of extremely regular relationship between density and distance from the Central Business District (see Figures 3 and 4 in Volume I). Estimated future densities tend to be similar to those existing today. For suburban areas close to Chicago these might be as high as twelve families per net residential acre while for outer suburban areas land was used at rates of four to five families per net acre.

Actually, densities were not considered to be uniform at particular distances from the core of the city. Careful account was taken of existing community development patterns, ranging from estate development to small single family lots. These were related to the variable levels of access to be expected. Existing communities with their installed water, sewer and other community facilities were generally expected to produce higher densities.

The establishment of expected densities and reserves for local, nonresidential land were used together to fix the holding capacity of vacant residential lands in each zone. The holding

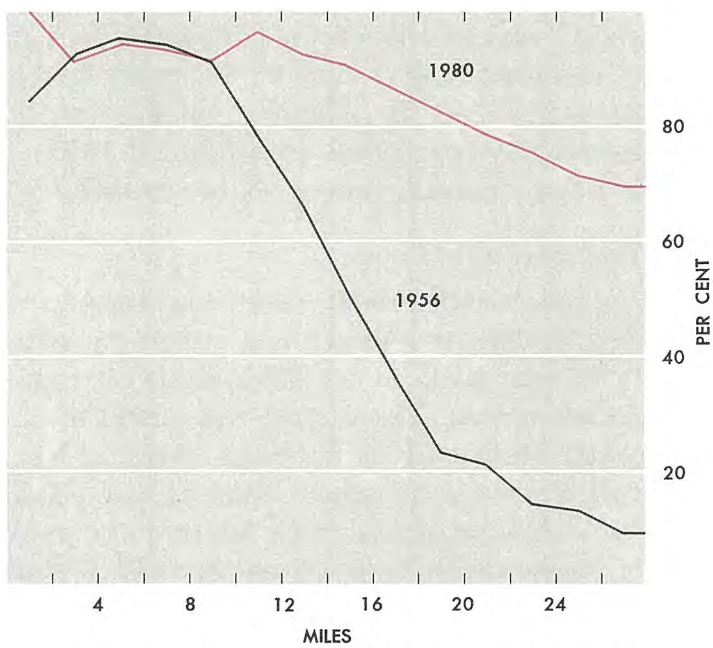
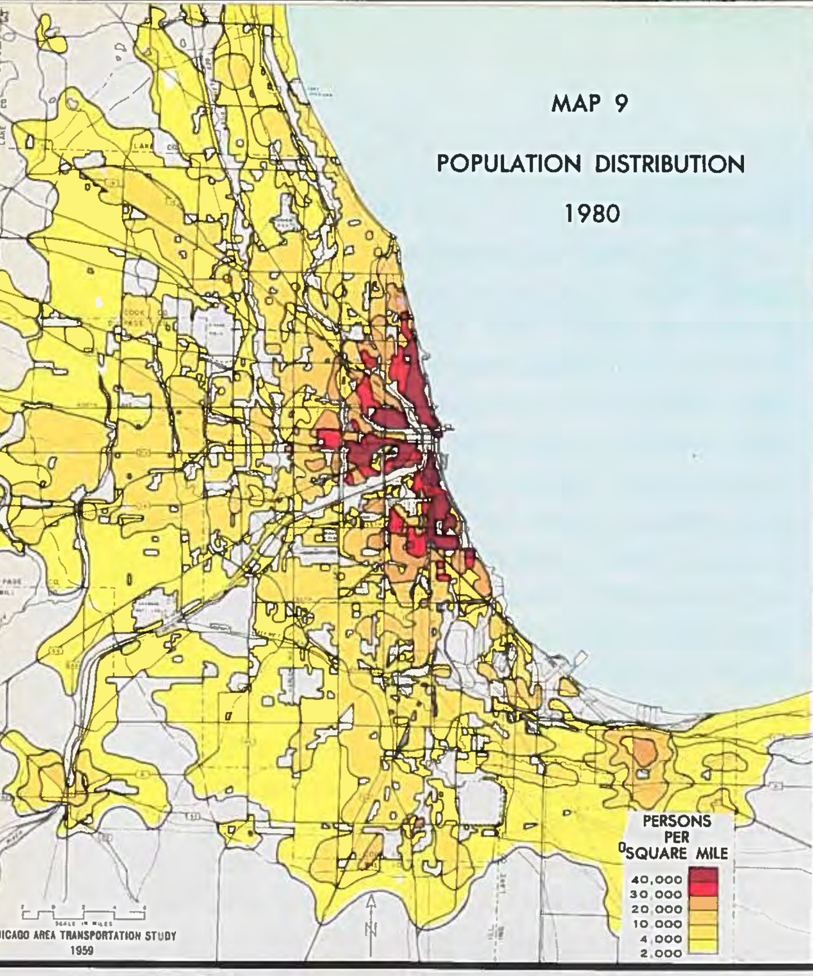
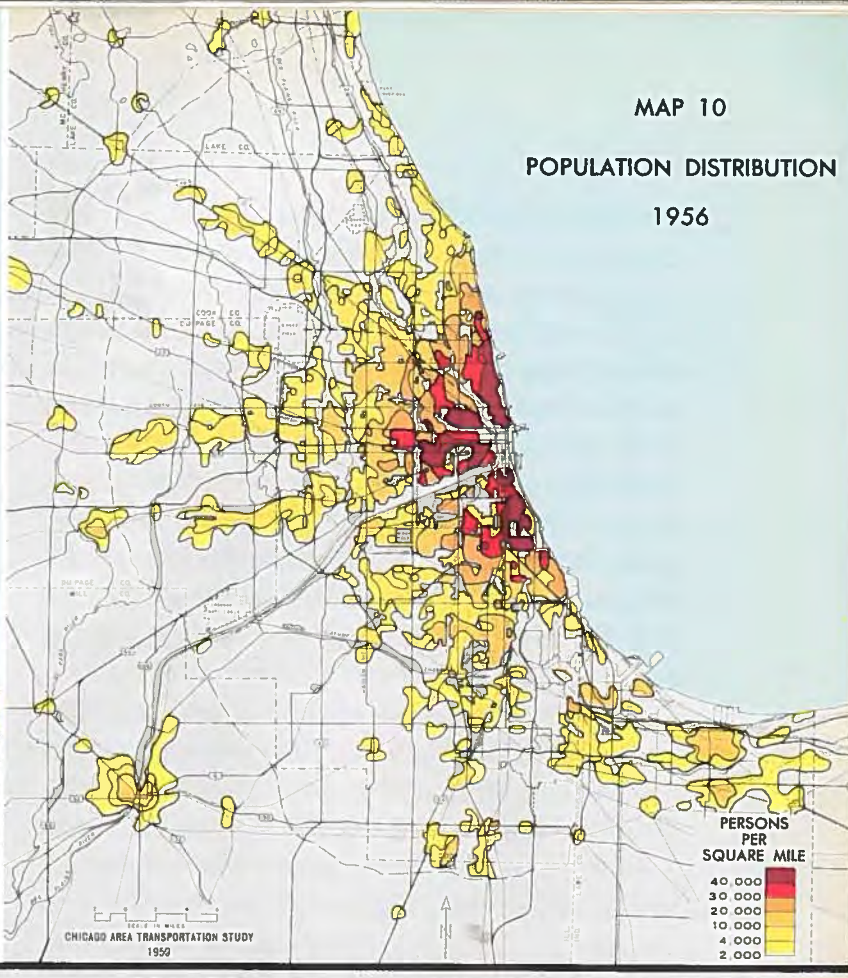


FIGURE 11—1956 AND ESTIMATED 1980 USAGE OF RESIDENTIAL LAND BY DISTANCE FROM THE LOOP



Between 1956 and 1980, 2,600,000 persons are expected to settle in the Study Area. Of necessity, they must occupy land now vacant or in agriculture use.



Of the 5,169,000 residents of the Study Area, roughly half lived at densities over 20,000 persons per gross square mile —less than 2,500 square feet of land per family.

capacity of the vacant but residential land, plus the capacity of presently used residential land, sum together to provide the measure of residential capacity for each zone. This capacity figure is the base measure needed for application of the third and final consideration to be used in estimating 1980 residential land use.

Figure 11 illustrates the third consideration —the relative attractiveness of one site as opposed to another. This shows the tendency to have progressively lesser percentages of total measured residential capacity in use at ever greater distances from the core of the city. This figure is a way of describing the transition from city to country—a transition which is becoming less and less abrupt. The most abrupt transition known was typified by the twelfth century walled city — all urban development had to be within the walls. Today, with fewer restrictions on personal choice and with flexible transportation, this transition is becoming gradual and less easily defined. Close in, some land may remain vacant because its price has increased and developers have a wider range of nearly equal choices. But the farther removed the site, the greater the chance it will not be used.

On Figure 11, the 1980 curve represents the summarized results of the distribution of residential land according to the enumerated considerations. Many detailed studies were made as each zone was separately estimated and reviewed. At common distances out, those zones lying nearer to existing suburbs were given higher priorities on utilization because of the attractions of existing community services and utilities. But, taken all in all and plotted only by distance, the results shown in Figure 11 illustrate the more gradual transition from city towards country expected in 1980. This is the natural consequence of assuming both higher speeds of travel and more uniform level of access to transportation facilities.

The residential land forecast translated to 1980 population is delineated on Map 9, and, for comparison, the 1956 population is mapped in an identical fashion on Map 10. These maps illustrate how much and how densely the residential land areas are used at both time points.

If a dot could have been placed for each residence or person, the map colors would identify areas of like dot density.

One sees immediately that, within about eight miles of the Loop, there is very little change in the location of residential population between 1956 and 1980. This is the region which was almost completely built up in 1956. No major shifts were foreseen either in density or in the percentage of land available for residential development. The only exception would be the plan of the City of Chicago for increased apartment development in the Central Area.

Farther out are the extensive changes. The population along the suburban railroad lines has expanded. Substantial growth is occurring beyond the cordon line by 1980. The expanded number of people has required that practically all zones of the Study Area contain some residences by 1980. All this is quite reasonable: estate development and the very low density suburban developments are typically farther from established suburban communities; they depend on private water supply and individual sewage disposal facilities. Developments closer to existing communities are expected to be at slightly higher densities because they anticipate eventual, if not immediate, extension of municipal water and sewage systems.

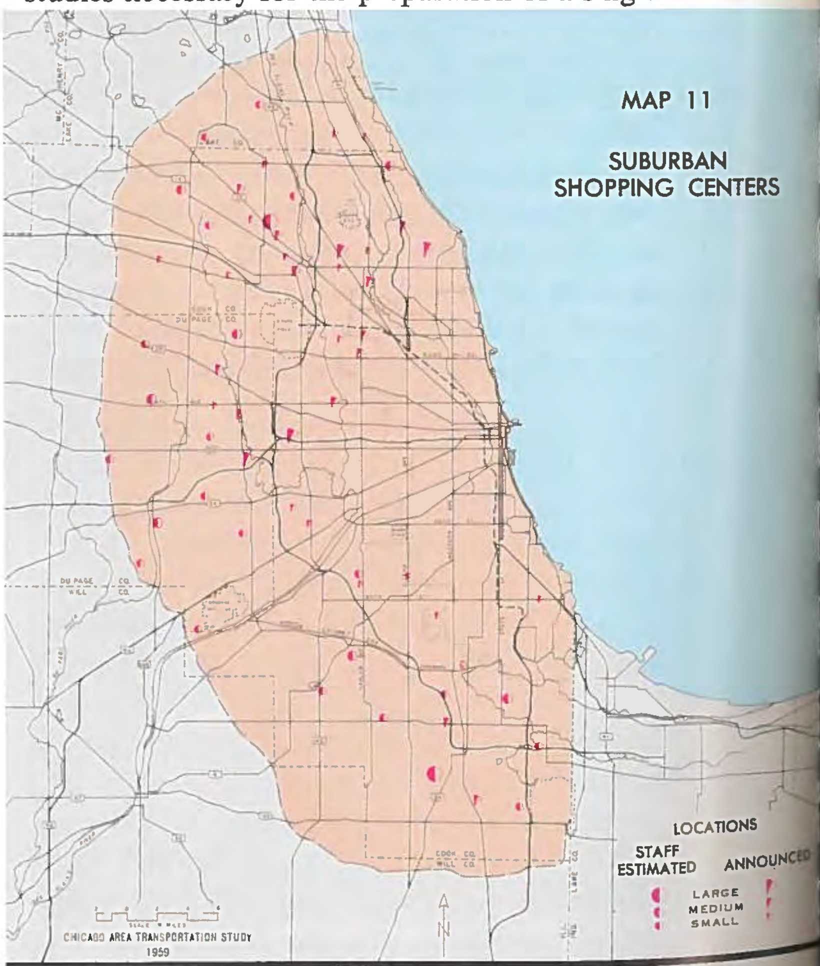
The extensive growth illustrated on these maps indicates the magnitude of future land development problems.[8] The increasing suburban population will require intensive advance planning. This forecast must be reviewed by the responsible planning agencies so that planning controls, representing the public interest, can be established to guide this expected new construction. Advance knowledge allows the several communities to prepare to meet these problems in a manner consistent with local needs and desires and with due awareness of the very real metropolitan growth pressures.

[8]Much has been written about "urban sprawl"—mostly derogatory. This is not without reason, since much new residential construction is quite unsightly, especially before the trees grow up. The fact that so much low density development *is* unattractive does not mean that it *must* be this way in the future; a forward looking urban designer could do much to provide a better and more attractive type of development. New problems require new solutions.

Other Land Uses

At this point the residences and their associated, local, nonresidential activities had been tentatively placed. But there remained certain non-local or regional uses which had to be taken into account. These included a variety of activities such as regional shopping centers, hospitals, governmental offices, public utilities and colleges. Based upon the known distribution of residences and industry, these regional activities were allocated to places where they would have appropriate local service areas. As an example, Map 11 shows the assumed allocation of major shopping centers. These activities required relatively small amounts of land and only in a few cases were residences displaced by their addition. These displaced residences were redistributed to remaining vacant land as before.

This summarizes, very briefly, the detailed studies necessary for the preparation of a single



Exact locations of shopping centers announced in 1956-1958 are identified. Estimated centers required for the population of 1980 are shown at approximate location.

estimate of 1980 land uses. There remains, however, the evaluation of the final results.[9]

RESULTS REVIEWED

The proportional usage of land in 1956 can be compared with that expected in 1980. This is perhaps the most significant test of the forecast. It is important to know whether the proportional distribution of land in the several uses, when accumulated for an entire region, represents a reasonable distribution of land use types. If changes are occurring, they must be shown to be brought on by the shifting requirements of people and urban activities.

Table 7 indicates that residential land has the largest increase in proportional usage. This is expected, for the increased income of families will be expressed in more generous residential sites and more single family dwellings. The average family in the Chicago area in 1956 lived on three thousand square feet of land; that family's counterpart in 1980 will live on five thousand square feet of land. One easily can observe that larger lots are associated with higher incomes and that most new dwellings are built as single family types today. Even with this increase, the 40.9 per cent of land devoted to residential purposes in the Chicago area of 1980 will be less than exists in some cities today. The Detroit region, for example, in 1953, had forty-six per cent of all developed land in residential use, while the Pittsburgh region records forty-seven per cent as of 1958.[10]

There is a decline in the percentage of land in public open space. The Chicago area has had an unusually large amount of public open space (14.2 acres per thousand population). This has resulted from the significant, long-range program of the Cook County Forest Preserve District in advance acquisition of land. This agency, however, has completed a major portion of its program of land purchase so that the proportion of population to public open space will shift by 1980. Furthermore, with increasing automobile ownership and higher incomes, it can be expected that more of the recreational needs of Chicago's population will be satisfied by public and private recreational areas at some distance outside the Study Area—by state parks and weekend cottages.

Transportation land also shows a percentage decline. This occurs because of the unusually large amount of land now used by railroads. It is unlikely that there will be an expansion in railroad rights-of-way in the future, so that the proportion of transportation land in use will fall.

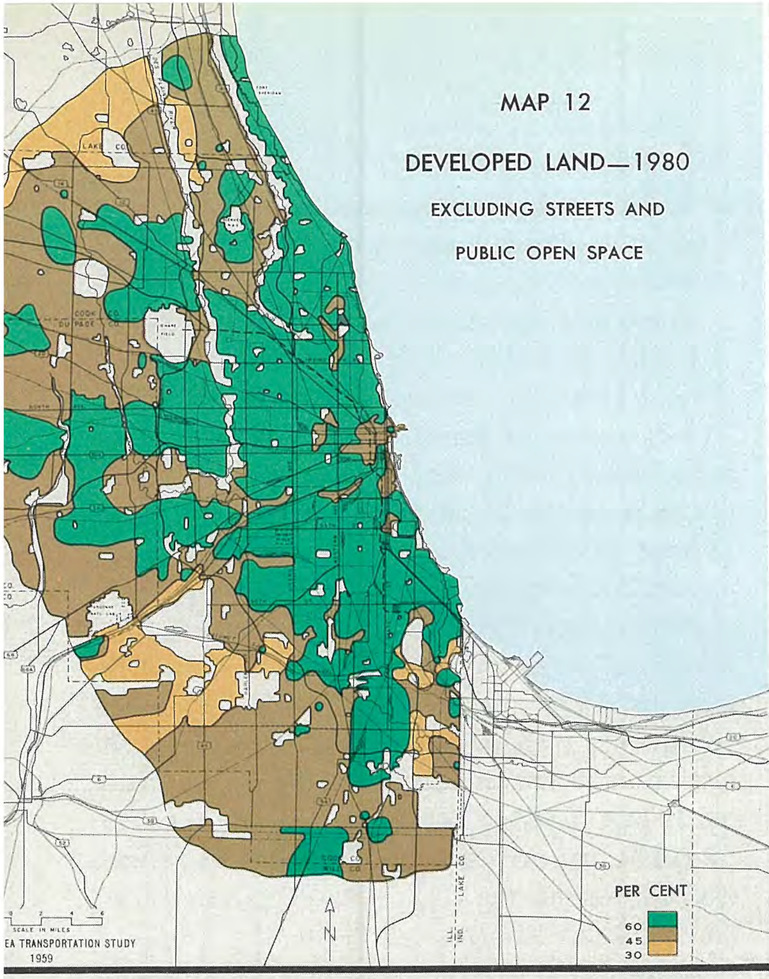
The percentage decline in transportation is nearly offset by a percentage increase in the area devoted to streets. While much of this increase is due to lower densities, some is from

[9]For a further evaluation, see *Land Use Forecast* (32,610) (Chicago: CATS, 1960).

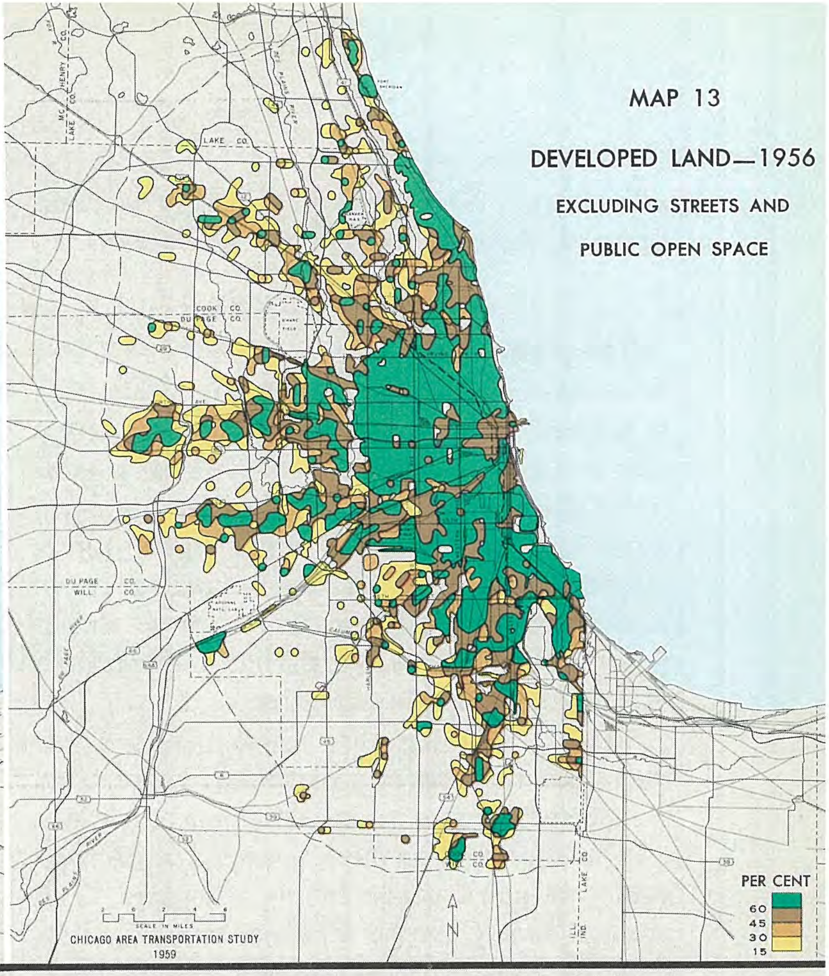
[10]For a comparison with urban land uses, by type, in other cities, see Table 43 in the Appendix.

TABLE 7
1980 LAND USE FORECAST COMPARED WITH 1956 LAND USE SURVEY

Land Use Type	Area In Square Miles		Percentage		Acres/1000 Population	
	1956	1980	1956	1980	1956	1980
Residential	180.6	443.5	32.1	40.9	22.3	36.3
Streets and Alleys	146.1	302.0	25.9	27.9	18.1	24.8
Public Open Space	114.9	151.1	20.4	13.9	14.2	12.4
Transportation	50.7	63.9	9.0	5.9	6.3	5.2
Manufacturing	24.7	43.9	4.4	4.1	3.1	3.6
Public Buildings	23.1	39.9	4.1	3.7	2.9	3.3
Commercial	22.7	39.0	4.1	3.6	2.8	3.2
Total	562.8	1,083.3	100.0	100.0	69.7	88.8
Vacant	655.3	134.8				
Unusable	18.4	18.4				
Grand Total	1,236.5	1,236.5				



Although 14.6 per cent of the Study Area is expected to be vacant in 1980, this land will be in scattered areas, mainly in the outer suburban regions.



Approximately 30 per cent of urban land is in streets, small parks and playgrounds; this is not included in the indicated percentage of land development.

the addition of areas expected to be occupied by expressways. In effect, a new transportation facility, the express highway, is being added to the group of existing transportation services which include rail, shipping, air and surface streets. The percentage of land used for transportation plus streets in 1980 (33.8 per cent) is hardly distinguishable from the 1956 percentage (34.9 per cent). This accents both the size and constancy of spatial needs for moving people and goods in urban areas.

Land estimated to be used for manufacturing, commerce and public buildings in 1980 has grown less rapidly than the land devoted to housing. Actually, each of these three activities gets a substantial increase in area, and an increase in acreage per thousand population. Manufacturing rises from 3.1 to 3.6 acres per thousand population, public buildings from 2.9 to 3.3, and commercial areas from 2.8 to 3.2. These all reflect a more generous use of land through the more open planning of buildings on sites and the provision of off-street parking.

By 1980 nearly twice as much land will be in urban use as in 1956—1,083 square miles compared with 563. This is the necessary consequence of a fifty-one per cent increase in Study Area population and a substantial preference for low density development. This land expansion nearly fills the 1,236 square mile Study Area. This will be seen in the map of developed land for 1980 (Map 12). Land use outside the cordon line is not shown, although population and trips were estimated for these areas.[11]

The 1980 land development pattern is much more extensive and less sharply defined than that of 1956 (Map 13). This is a necessity; there is less chance of contrast between urban and rural because the rural is nearly eliminated. The major undeveloped areas are those places formally set aside as public open space. In addition, the pattern of developed land lacks the three-dimensional aspect of intensity of use which gives the distribution of future population its greater contrast.

These extensive additions to the supply of urbanized land are in line with other changes expected by 1980. Car ownership is estimated

[11] See Maps 9 and 10 preceding.

to rise by twenty-eight per cent per capita and personal income by forty-seven per cent. Growth in these respects produces increased ability to own land and to provide one's own transportation. The exercise of this ability is what produces the lower density development.

This review has found that the proportions and amounts of lands estimated to be devoted to the various types of urban capacity in 1980 are not radically different from those of 1956. Changes were found to be explicable in terms of commonly observable trends. The forecast is therefore deemed to be reliable as a base for estimating the generation of future traffic.

Much thought and study have gone into the making of these projections. But, as in any forecasting, the estimated results will not agree exactly with the actual development. This is true because all the information and all the understanding of the forces at work are not available to the forecaster. For this reason the agencies sponsoring the Study have established and financed a group to make periodic reviews of these forecasts. Continuing review will enable the responsible public officials to reappraise their plans and programs from time to time and thus will provide an additional margin of security.

CONCLUSION

Urban land, by reason of varying accessibility, is a limited resource. Accessibility has very important effects upon land values; the Central Area commands the highest land prices, suburban lots lower, while relatively inaccessible farm land at some distances from the city has the lowest value. Because urban land is scarce and valuable, urban activities tend to arrange themselves economically with relation to one another over the land. This arrangement provides the characteristic shape and density of urban development.

It is this very property of ordered arrangement on the land surface which makes possible a more reliable forecast of land use. And this, in turn, is a means for making more accurate estimates of future travel. Land use is thus a quantitative index of traffic generation, but it also indicates much about the nature of the trips which are generated.

It would be narrow sighted to imply that land use develops independently of the location and quality of transportation facilities—the very things which are being planned. Planning transportation facilities on the basis of previously forecast land use thus takes on the character of making a self-fulfilling prophecy, since transportation improvements would be planned to reinforce the land use forecast.

There is enough truth in this argument to deserve some reflection. First, one must consider the extent to which land development is determined by transportation facilities. If one considers land having no access (the summit of Mount Everest) then development is unlikely. However, it is very unreasonable to expect that sites in the Chicago region will not be supplied with transportation service. Actually, there are roads virtually everywhere already. Secondly, it is not reasonable political philosophy to improve public facilities in one portion of the region while another is allowed to deteriorate; it is more likely that some equality of service will be provided by government agencies. Finally, of course, land development requires more than transportation at the site. There are sewer, water, electricity and many other services that contribute to site values. Most of these, together with schools and community services, are most economically provided near present development so that new growth is very heavily influenced by what is already in place. This aspect of growth is treated carefully in making the forecast. This being so, the pattern of future land development is not subject to violent change by reason of alternate plans for transportation improvements.

One also may raise the question as to whether the forecast land use is a desirable pattern from the standpoint of general community welfare. A good share of the difficulty in answering this lies in defining what is desirable. In time, regional land use development goals will be expressed in a regional plan. Below the regional level, there are few communities larger than four square miles, which is the size of typical suburban zones used here for forecasting purposes. Plans for these communities will, therefore, be at a scale and level of detail unlikely to be in conflict with the more general estimates made in this forecast.

At the metropolitan scale, the forecast does take into account the apparent preferences or desires of individuals and businesses. Each one, in selecting a site for home or business, tries to find the best location for his objectives. Moreover, the region grows by the addition of successive, small increments. This means that the existing land development pattern very measurably affects successive, individual decisions so that completely new patterns of development are less likely to occur.

These desires of individuals and the existing great investment in land and structures will be obvious considerations in developing land use plans. This forecast will thus be of use to the land planning agencies as a point of departure. It specifies the size of the problem and the probable consequences of continuing growth according to present patterns and future personal desires. This must be one of the first steps in considering future problems and in devising land development policies and plans capable of dealing effectively with them.

The land use forecast is used in this report as an important means to distribute future urban activities into traffic zones and thereby provide a basis for estimation of the probable future travel patterns. To the extent that it reflects accurately the sources of community growth and the land development characteristics of the enlarged metropolis, it will provide a sound foundation for proceeding towards the design of the travel facilities the region will require.

Chapter IV

ESTIMATING FUTURE TRIP MAKING

Growing numbers of people and an expanding and more productive economy are the main, active forces leading to heightened travel demands in the Chicago area. In the land use forecast it has been shown how the pressures created by these active ingredients are expected to result in great extensions of urbanized area, mostly at low densities. The locations of urban activities provide a rational means of estimating the location of future trips. This is based on the assumption—which was carefully documented in Volume I—that there is a close relationship between the number of persons arriving at each site in an urban area and the kind and intensity of activity going on there.

In making estimates of 1980 trip origins at each zone, several factors are employed. Of obvious importance are the land use forecast and the trip generation rates observed from 1956 survey data. But there is also supplemental evidence which brings additional control both to the total estimate of future trips and to their distribution throughout the urban region. This evidence derives from the population by place of residence and from the anticipated increases in income and car ownership. All these factors are coordinated in the preparation of the estimate of 1980 person trips.[1]

The degree of detail within which the trip forecast can be made is set by the land use forecast. Geographically, trips can be allotted within the specified one or four-square-mile zones.[2] These were the units of area within which future land uses were estimated. The six categories of land use projected limit the detail trip classification possible within a zone. As a general rule, trips were estimated simply as originating on or going to residential, commercial, transportation, industrial, public buildings and public open space lands. More detail is often wanted—smaller zones or more detailed land use categories. Future research work may well show that improvements are possible in both respects, but the detail projected by the present study is sufficiently precise for making sound estimates of future demands for travel.

Future person trips are estimated without respect to whether the trips are made by automobile, bus, suburban railroad or elevated-subway train. This important question is taken up in Chapter V. This chapter does include, however, an estimate of truck trips by zone of origin, and an estimate of the growth of person trips in the areas beyond the defined limits of the cordon line.

CALCULATING 1980 TRIPS FROM LAND USE

The 1980 land use forecast already has provided information from which logical inferences can be made about future trip making. The extent of urban development will have expanded greatly in the period between 1956 and 1980. This can be seen on Maps 12 and 13 which appear in Chapter III and which show the urban uses in both years. The main story is told by these maps: the outward extension of urban uses means a comparable outward extension of traffic generation. Within this general pattern, variations will depend upon the particular intensity and kind of land use. The outlines of the pattern of future trip making, however, must be similar to the outlined 1980 pattern of developed land, even though it does not indicate the intensity of trip making in different parts of the region.

To obtain a measured estimate of future trip making, the 1956 trip generation rates[3] can be applied against the 1980 land use forecast, by type of land use, within each distance ring.[4] This is done as a first step assuming, for the

[1]Detailed procedures for estimating future trips are described in *Estimating Future Trips for the Study Area* (32,710) (Chicago: CATS, 1960).

[2]See Appendix, Map 29.

[3]1956 rates are shown in Tables 9 and 10, Volume I.

[4]The land use forecast by district, by type of use, is given in Table 41, Appendix.

time being, that the 1956 rates per acre of land use will hold constant until 1980. While this assumption is later shown to be inappropriate, it provides a useful first approximation of total future travel.

Applying the reported 1956 trip rates per acre to the 1980 measured land produces the preliminary estimate shown in Table 8. This estimate of 1980 trip making—nearly sixteen million person trips on the average weekday—is an increase of fifty-six per cent over 1956 totals. This is low. The population in the Study Area, it is presumed, will increase by fifty-one per cent and will be wealthier and living at lower densities. Also, the number of cars owned is expected to increase by ninety-four per cent. Low density and increased car ownership have been shown to be associated with higher numbers of trips per person and tend to raise trip making per capita. To have trip making per capita remain nearly constant seems too conservative.

TABLE 8

1980 PERSON TRIPS BY LAND USE TYPE CALCULATED FROM LAND USE FORECAST, USING 1956 TRIP GENERATION RATES

Land Use Type	Estimated 1980 Person Trips	Percentage
Residential	9,657,000	60.7
Manufacturing	1,037,000	6.5
Transportation	309,000	1.9
Commercial	3,553,000	22.3
Public Buildings	1,027,000	6.4
Public Open Space	349,000	2.2
Total	15,932,000	100.0

Note: This is a first approximation of future trip making, not a final estimate.

Not only is the total low but the change in distribution can be questioned. This projection shows 60.7 per cent of all 1980 trips bound to residential land. This is significantly higher than the 54.9 per cent found in 1956. Such a shift is fairly radical, because it will force all other land uses to attract lower percentages of all trips. This seems unlikely, because the requirements of people for work, shopping, school and recreation all make it impossible for them to accomplish these purposes at residential locations. This distributional shift is caused, in part, by the variable growth rates forecast for the several land use categories. If the estimate of land use areas is correct, then one may question the validity of keeping trip rates per acre constant. Before any final decision is reached, it would seem best to examine trip estimates based on the expected daily travel habits and needs of the future population.

ESTIMATING TRIPS FROM FUTURE POPULATION

An alternative method of computing the numbers and kinds of 1980 person trips is based upon residential population. This method is independent of land use measures since it is derived from the population estimate. However, the residential population distribution is, in fact, determined from the land use forecast. An advantage of this method is that it is directly related to people and their needs. Basically, the method consists of estimating what results would be obtained if a complete home interview survey were taken at the projected 1980 residences.

The number of trips made by the average family has been shown to be very sensitive to the level of car ownership and also to the density of the area of residence.[5] Generally, the higher the car ownership, the more trips made on the average weekday. Also, the lower the number of families per acre of residential land, the higher the trip making per family. Knowing both of these facts for 1980, trip estimates can be made which are more reliable than if only one of the facts were known.

Future net residential densities, by zone,[6] already have been estimated as part of the land use forecast, but car ownership has been estimated only for the entire area. Since zonal car ownership rates are crucial to the task of estimating person trips (as well as vehicle trips), the allocation of the 1980 resident passenger cars to zones is made next. When this is completed, future person trips can be estimated.

[5]See Volume I, Figures 37 and 38.

[6]Total residential land area in each zone, divided into the zone population, equals net residential density.

The Distribution of Future Car Ownership

The number of automobiles owned by Study Area residents has previously been estimated to increase by ninety-four per cent. This estimate, described in Chapter II, was based on per capita gains in real income for the enlarged population and was simply an area total. To be useful in evaluating future trips, more information is required. Where will these new automobiles be owned? Will there be increases in car ownership in the densely built up city of Chicago, or will all the increase take place in the suburban regions?

As seen on Map 9 in the preceding chapter, most new residential construction will be in the suburbs, simply because there is little additional room for housing in the central city. Living in the suburbs, it is reasonable for these new families to own automobiles at least as frequently as do the existing suburban families. This is not simply keeping up with the Joneses, but is a necessary adaptation to the suburban environment. Low density, dispersed living arrangements require the use and ownership of cars.

If the projected families of 1980 were to own cars at the same frequency as present residents of each zone, per capita car ownership for the whole region would rise by about eight per cent. This comes from increasing suburbanization but does not account for the full increase due to rising real income. Families everywhere are expected to be relatively wealthier in 1980 than in 1956—those in the city as well as those in the suburbs. Thus, car ownership, which is sensitive to income changes, should increase above current levels everywhere. In the city this may be reflected by having a smaller percentage of families with no cars, whereas in the outer suburban areas, a greater percentage of families will have two cars.

To test this expectation, the history of car ownership both in Chicago and in the suburban area was plotted. (Figure 12.) The evidence shows that per capita car ownership has been rising in both areas over the last thirty years, and actually faster in the city than in the suburbs. It seems quite obvious that rising income affects car ownership in all parts of the region.

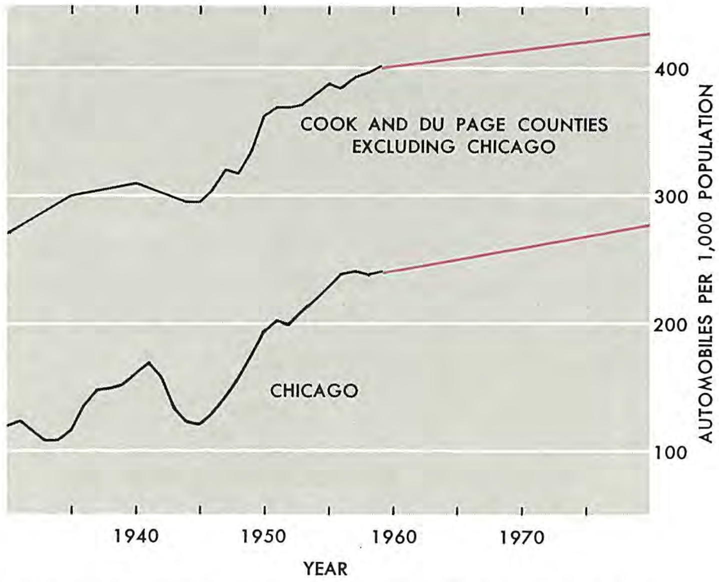


FIGURE 12—AUTOMOBILE REGISTRATION FOR MAJOR POLITICAL UNITS, HISTORICAL AND ESTIMATED TO 1980

See Table 40 in Appendix.

In the period from 1940 to 1956, real family income is estimated to have increased by fifty-seven per cent (see Figure 3, page 9), while automobile registrations rose from 190 to 280 passenger cars per thousand persons or by forty-seven per cent. For the period from 1956 to 1980, slower car ownership growth rates are forecast in relationship to further gains in income. Incomes are projected to increase by forty-six per cent, but car ownership only by twenty-eight per cent. Slowing rates of increase in car ownership are expected, because continually rising incomes have progressively less effect on this item of consumption.

Since incomes in Chicago currently are lower, on the average, than incomes in the suburbs, it is expected that income gains for Chicago population will have a stronger effect on increasing car ownership than will be the case in the suburbs. This has been true in the past as shown on Figure 12. Because the levels of ownership in the city were lower in 1940, the percentage of increase from 1940 to 1956 was greater than in suburban areas. City car ownership increased by forty-seven per cent during this period in contrast to a twenty-two per cent increase in suburban areas.

Following these trends, the projections shown on Figure 12 indicate a gain between 1956 and 1980 of about eighteen per cent in cars per thousand persons in the city and a thirteen per cent gain in the suburbs. These will, in combination, result in an average car ownership rate for the area twenty-eight per cent greater. The larger area increase results from the greatly increased proportion of the 1980 population that will be living in the suburbs.

TABLE 9
RESIDENT[a] AUTOMOBILE OWNERSHIP PER THOUSAND POPULATION BY RING, 1956 AND ESTIMATED FOR 1980

Ring	Approximate Distance From Loop in Miles	Resident Automobile Ownership Per Thousand Population		Percentage Increase
		1956	1980	
0 . . .	0.0	262	325	24.0
1 . . .	1.5	154	180	16.9
2 . . .	3.5	182	214	17.6
3 . . .	5.5	224	265	18.3
4 . . .	8.5	275	324	17.8
5 . . .	11.5	304	362	19.1
6 . . .	16.0	321	376	17.1
7 . . .	24.0	330	396	20.0
Study Area . .	. . .	260	334	28.4[b]

[a]Does not include approximately 120,000 automobiles owned by businesses and governments. With these included, the 1956 and 1980 Study Area rates rise to 283 and 362 registrations per thousand population, respectively.

[b]The Study Area percentage increase in per capita registrations is higher than any of its constituent parts because it is a combination of per capita increases and population growth in high-car owning areas such as Rings 6 and 7.

From these projections it is possible to establish expected 1980 levels of car ownership at individual zones. That is, given a 1956 rate of car ownership, an estimated 1980 rate can be established for each zone by increasing the 1956 base rate by the expected income growth. The results of this process are summarized for each ring in Table 9. This indicates similar average gains in car ownership in each ring. This seeming uniformity comes about, because in outer areas, where income effects are less, more of the new residential growth will occur in zones presently having higher than average car ownership rates.

Estimating Future Person Trips

With separate estimates of automobile ownership and of net residential density, two of the most important variables affecting future trip making are in hand. Using these, household trip making can be estimated. The reasonableness of such an estimate hinges on the assumption that the effect of these two variables on trip making frequency would be of the same magnitude in 1980 as in 1956. This assumption must, therefore, be examined.

What do car ownership and residential density measure? Car ownership is an indirect measurement of income and a more direct measure of potential mobility. Families with cars can make more trips within a given time span,[7] whereas families without cars must walk or ride on public transportation and thus can make fewer trips in the same time period.

Density is associated closely with car ownership, but it is also an independent index of trip making frequency. For example, in dense areas school children may walk to school, and other needs, such as shopping, going to the doctor or visiting, can be accomplished on foot. Since walking trips are not counted as origin-destination trips, dense regions reduce the need to make defined trips. Linked as they are to travel needs and abilities, it is reasonable to expect, then, that car ownership and density will influence the probable number of daily trips made by families in much the same way in 1980 as at present.

Car ownership and density measures can be related to trips made per household, by formula. With both items known, the average trips per household in zones are very reasonably described. The fitted formula[8] can be examined for reasonableness by comparing the estimate made by formula to actual sample data of 1956.

[7]When all trips made in the Study Area are arranged by their airline trip lengths and compared by mode of travel, automobiles show the highest average journey speed for all trip lengths. See Table 46 in the Appendix.

[8]Equation for estimating trips per dwelling unit by zone, on the basis of car ownership and net residential density, was: $Yc = 682.84 + 3.8109\ X_2 - .1939\ \text{Log}\ X_3$, where Yc = Computed trips per Dwelling Unit; X_2 = Cars per 100 Dwelling Units; X_3 = Dwelling Units per ten acres. District trip rates were calculated by aggregating zonal trip estimates.

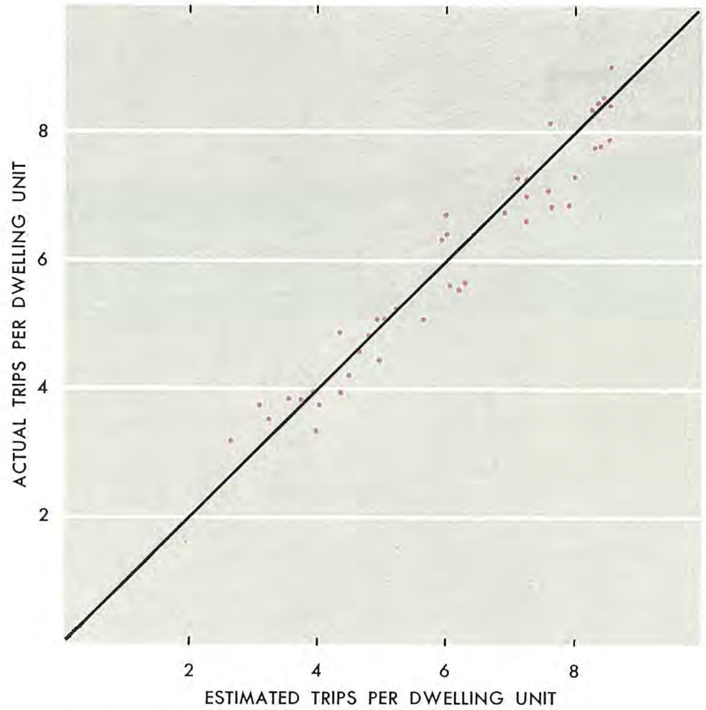


FIGURE 13—TRIPS REPORTED BY HOUSEHOLDS IN DISTRICTS, COMPARED WITH TRIPS ESTIMATED ON BASIS OF CAR OWNERSHIP AND NET RESIDENTIAL DENSITY

If all dots fell on the diagonal line, the estimate would be perfect. As it is, district estimates are all within ± 15 per cent of reported values. Central Area districts were estimated separately.

This comparison is made in Figure 13. If the two variables, car ownership and density, had accounted for every variation, and if all the measures had been exact, the predicted and actual would be the same and all dots would fall on one line. This, of course, cannot be expected to occur, partly because of the variability of sample data. The degree of correspondence by statistical measures is high. It is of some value to know that the sum of person trips for all zones, as estimated by formula, is almost exactly the same as the total of person trips represented by survey data.

Applying the formula to all 1980 zones yielded a total estimate of 18,081,000 person trips per average weekday for the 1980 population. This is an increase in trip making seventeen per cent greater than the increase in population. In other words, the typical resident in 1980 is expected to average about 2.3 trips per weekday, in contrast with 2.0 trips in 1956. Table 10 illustrates average family trip making rates, by distance ring, for 1956 and 1980.

TABLE 10
WEEKDAY PERSON TRIPS PER FAMILY,*
BY RING—1956 AND ESTIMATED FOR 1980

Ring of Residence	Trips Per Family	
	1956	1980
0 and 1	3.13	3.47
2	4.22	4.62
3	4.99	5.44
4	6.07	6.62
5	7.82	8.57
6	8.98	9.43
7	9.22	9.75
Study Area	6.13	7.53

*The occupants of a defined dwelling place constitute a family.

FINAL 1980 PERSON TRIP ESTIMATE

Two independent calculations of 1980 person trips now have been presented. The first, based on the acreage of forecast land use multiplied by 1956 land use trip generation rates, yielded 15.9 million person trips. The second, based on the estimated numbers and locations of future population, gave 18.1 million person trips. Both methods have been carried out to illustrate the processes of establishing total estimates. Obviously, it is necessary, using available evidence, to fix the most probable number of person trips expected by 1980.

There are several reasons for preferring the population based forecast. Being based on people, this estimate reflects the needs of people to travel in order to satisfy basic human requirements for work, for goods, for education and for socializing. The connection to person trips is direct in this estimate, but quite indirect in the case of land use.

The population based calculation also permits modifying family trip generation rates to account for the changes which inevitably come about with time. There is ample evidence to indicate that changes are taking place: car ownership is increasing and new residences are going in at lower densities. Both car ownership and lower densities are positively and measurably associated with greater trip making. In the population based estimate, changes in both factors were measured separately and used to compute trips. By contrast, the rates of land use trip generation could not be readily modified. Any modification would have had to work back through population as the prime mover, and, of course, this already had been done in the population based forecast.

Evidence is easily presented that the land use based forecast of 15.9 million person trips is low. If the 1980 population in each zone made trips at the same rates as their 1956 counterparts, the total number of person trips would be 16.9 million. But even this is low, because evidence has already been presented in Volume I that increased car ownership and lower densities will result in higher trip making per capita.

For these reasons, the total estimate of 18,081,000 average weekday person trips was taken as final. But these trips are computed only from household estimates. To allocate them to zones of origin and destination requires using the land use data. Before getting to zone detail, however, the total journeys must first be distributed according to the land use categories.

Allocating Forecast Trips to Major Land Uses

It has been shown (Vol. I, Figure 39) that as households report more trips, the mixture of trip purposes changes. As ever more trips are reported, trips made for social-recreation, shopping and personal business purposes increase most rapidly. Table 11 shows the extent of this shift expected from the changing volume of trips per household in 1980.

TABLE 11
TRIP PURPOSE DISTRIBUTION OF PERSON TRIPS FOR 1956 AND ESTIMATED FOR 1980

Trip Purpose	1956	1980
Home	43.5	42.9
Work	20.6	19.8
Shop	5.5	5.7
School	1.9	1.9
Social Recreation	12.8	13.3
Eat Meal	3.1	3.5
Personal Business	10.2	10.3
Serve Passenger	2.4	2.6
Total	100.0	100.0

These expected shifts in the purpose of trips will create changes in the distribution of trips to the several types of land use. Figure 14 shows the proportional distribution of trips by land use category as the number of trips reported by households increase. This illustrates a tendency for increased trip making to commercial land, to sites with recreational advantage, and to public buildings as trips per household increase. This is consistent with the shifting patterns of trip purposes observed in Table 11.

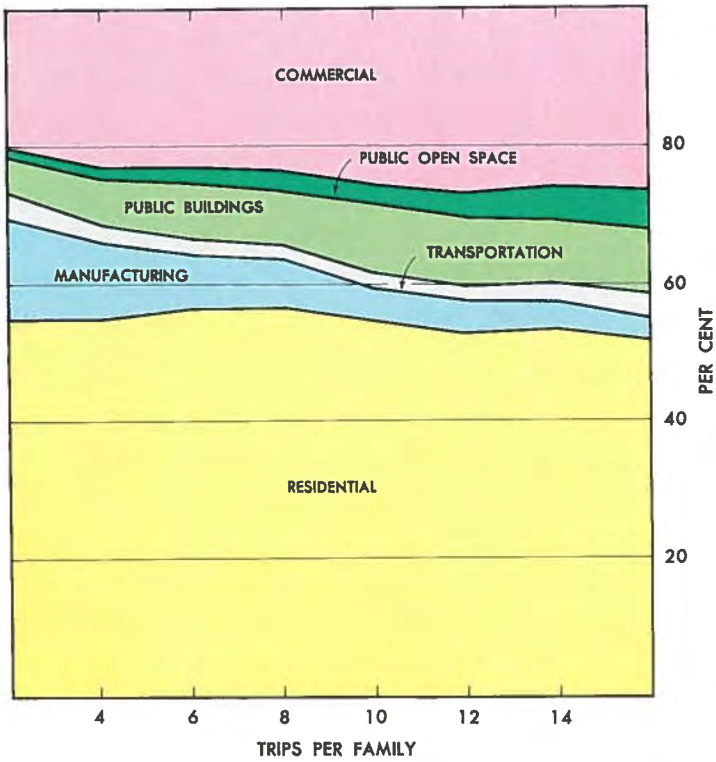


FIGURE 14—PERCENTAGE DISTRIBUTION OF WEEKDAY PERSON TRIPS BY LAND USE RELATED TO TRIP MAKING PER FAMILY

Using the evidence of Figure 14, and given the expected trips for the average household in each zone as computed on the basis of population, trips to each of the major categories of land use for 1980 were computed. Summing these zonal estimates, the distribution of 1980 trips by land use of trip destination is provided. The results are listed in Table 12.

This distribution of person trips by land use type, as estimated from population, is much closer to the 1956 distribution than the first estimate, based only on the land use forecast. Furthermore, the smaller differences are in the direction one would expect, judging from the expected changes in trip purpose.

A good check on these results was obtained by using the evidence of the economic forecast.

TABLE 12
PERCENTAGE DISTRIBUTION OF FUTURE PERSON TRIPS BY LAND USE, BY ALTERNATE METHODS

Land Use Category	1956 Actual	1980 Estimated From Land Use Forecast	1980 Estimated From Household Travel Patterns	1980 Estimated From Economic Forecast
Residential . . .	54.9	60.8	55.8	55.4
Manufacturing	7.6	6.5	5.7	5.7
Transportation	2.7	1.9	2.4	2.3
Commercial . .	24.0	22.2	25.0	25.3
Personal Business . . .	7.7	6.4	7.7	7.7
Public Open Space	3.1	2.2	3.4	3.6
Total . . .	100.0	100.0	100.0	100.0

This was done by taking the 1956 trips and grouping them by more detailed types (66 categories) of land use. Work trips were kept separate and expanded according to projected in- increases in employment within the same detailed classes. The non-work trips in each detailed group were expanded according to the projected shifts in dollar output for matching economic classification. These individual projections were then re-grouped into the six major land use classes to provide a separate estimate.[9] Table 12 also lists these results, showing that there is a very high correspondence between the estimate made from population and that made from the economic forecast. This final check provides assurance as to the distribution of person trips by land use of destination. This accomplished, it is possible now to turn to the task of allocating future trips to zones.

DISTRIBUTING TRIPS TO ZONES

The preceding section has fixed the total number of person trips expected to be generated in 1980. These are in the form that would be obtained if a home interview were taken twenty years from now—that is, the number of trips made by the households in each zone, with detail by the type of land use at the destination of each trip.

The next problem is to determine the destination zones of these trips. This can be accomplished with the aid of the land use forecast. Figures 15 through 18, page 42 illustrate how the location and intensity of land use dictate the patterns of trip making. The process of making distributions of trips to zones is described in the following sections. Trips are taken up by their categories of land use beginning with trips to residential land. A variety of evidence is brought forward to make the allocations to zones.

Residential Land Trips

In the land use forecast, population in each zone, as well as acres of land in residential use, was estimated. Knowing population and residential density, and also having car ownership estimates, the production of trips by the residents of a zone was established. This was the means just described for estimating the total number of 1980 person trips.

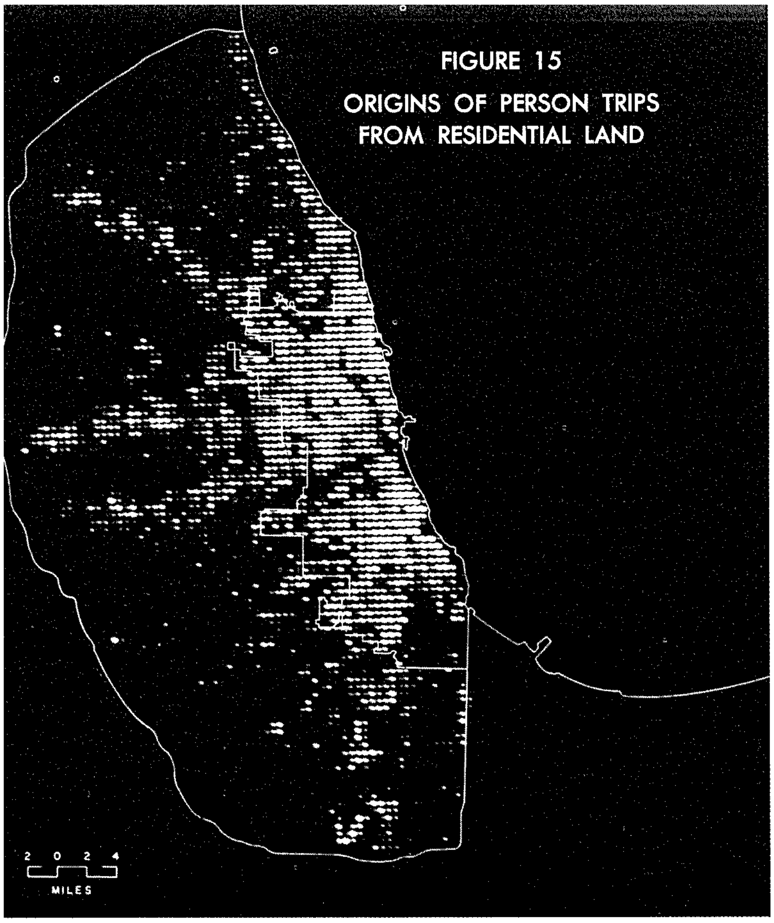
The remaining problem, then, was to determine how many of these trips would actually *begin* at residences in each zone—i.e., have their origins there.[10] This could be accomplished easily, because the combination of trips starting from homes, by residents, plus the additional trips made by persons visiting or carrying out business at these homes, is a known and quite stable portion of total trips by household members. The average number of trips per household in each zone was used with the relationships shown in Figure 14 to estimate the number of person trips beginning on residential land in that zone. The sum of these estimates averaged 55.8 per cent of all trips going to residential land.

Industrial Trips

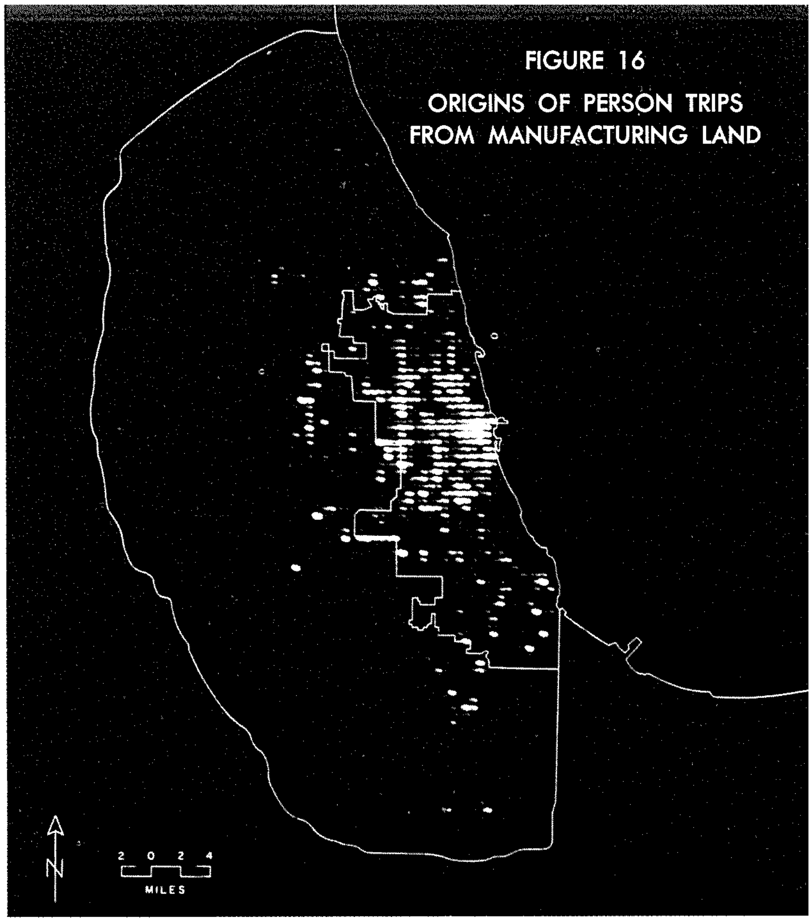
The land use forecast estimated the utilization of industrial land on the basis of the number of manufacturing workers expected in the Chicago area in 1980. Manufacturing workers make 91.5 per cent of all trips to manufacturing land. Since the number of future workers on each site already had been estimated, the 1980 trips to manufacturing land were easily fixed.

[9]Details are given in the reports, *1980 Trip Origins by Type of Land Use from Economic Forecast* by I. Hoch, February 9 and 27, 1959 (Chicago: CATS unpublished).

[10]Since origins must equal destinations at any land use or site, it is immaterial which is predicted or discussed.

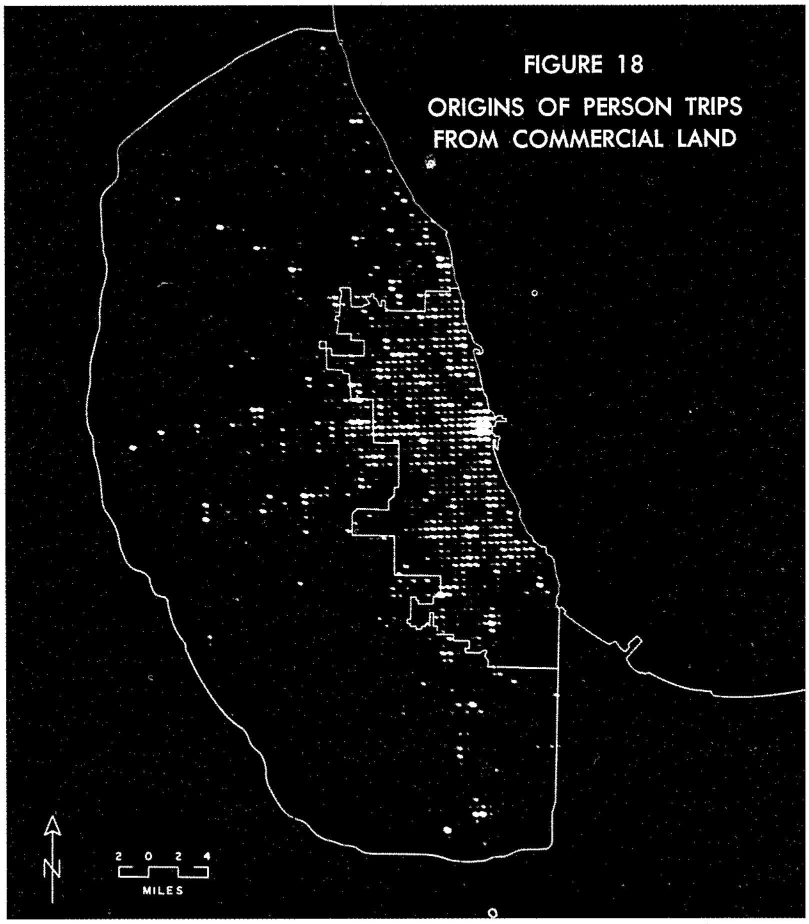


About 56 per cent of all person trips begin on residential land, and are, therefore, distributed with population.



Manufacturing attracts 7.6 per cent of person trips. These dots outline concentrations of manufacturing activity in the Chicago area. See Map 10, Volume 1.

These trips are made from local parks, golf courses and race tracks as well as forest preserves. This 3.1 per cent of person trips is scattered throughout the region.



One quarter of person trips begin on commercial land, mainly near where people live. The Loop and a few regional centers stand out.

Public Open Space Trips

Acreage in public open space was not added in amounts comparable to the increase in projected trips to this type of land. The largest increase in public open space lands was in the outer, suburban parts of the region Rings 5, 6 and 7. This included substantial increases in forest preserves and regional parks. These new lands, plus the very extensive existing forest preserve areas and other existing public open spaces, provide a substantial supply of this type of land use, yet less per capita than in 1956. In 1980, therefore, these lands probably will be used more intensively than in the past.

This view is reinforced by the fact that residential growth is greatest in these outer areas and this nearby population can be expected to use these lands at greater frequency than the one to six trips per acre per day observed in 1956. Accordingly, trip rates were increased enough in Rings 5, 6 and 7 to absorb most of the additional public open space trips.

Some lesser increases in rates to public open space in the presently built up part of the Study Area (Rings 0-4) were allowed, because of slightly greater trip making by nearby residents. Trip allocations in each zone were made using the revised trip generation rates. These resultant trips then were balanced with the expected number to be made by the population.

Trips to Transportation Lands

There are expected to be 130,000 more trips to transportation land in 1980 than in 1956, whereas transportation lands increase very slowly. Air transportation is the most rapidly expanding segment of the transportation industry and it is expected that nearly half of the net gain— 62,000 trips—will be going to airports. These additional airport trips (which include not only passengers but workers and visitors) were assigned to the expanding facilities at O'Hare Field and to a third major airport located in the southeastern part of the Study Area. The remaining gains in transportation trips were expected to be made to such places as trucking terminals, warehouses, freight depots, and public utilities, including water and sewer plants, telephone, gas and electric company activities. Growth in most of these activities fell into specialized locations. These included harbor areas like Lake Calumet and Navy Pier as well as sites along the new circumferential toll road and near new interstate highways. The remaining 68,000 new trips were placed in zones where these land uses were projected.

Commercial Land Trips

Trip rates to commercial land are the highest of any class. Within this classification there also are wide variations in trip generation rates. At the center of the city, the rates are so high that the analyst must use floor area rather than land area as the basic measure. In some suburban places, activities like wholesale houses, used car lots and lumber yards have very extensive land requirements and low rates of person trip attraction per acre. As a general rule, a slight increase in commercial acreage would result in a substantial increase in trips to any zone. Because of these high rates, it is particularly difficult to estimate commercial trips from land measures alone.

Fortunately, this difficulty could be overcome because of the way in which commercial land was projected. Future commercial land was considered as being either dependent or independent of the local population.

At each zone, sufficient commercial lands were provided to serve the requirements of the zonal residents for local commercial trips. These included such things as grocery stores, drug stores, beauty parlors, barber shops, eating and drinking establishments, dentists and doctors. This process was quite straightforward, because the 1956 land use inventory showed a stable relationship between the amount of such local commercial land and the amount of residential land in most zones.

There also were substantial amounts of non-local commercial land. Included were such things as major shopping centers, central business district functions, lumber yards, wholesaling and many other activities of a non-local, commercial nature. These were forecast independently of the local commercial land. New regional shopping centers were located; growth of wholesale commercial activities was anticipated in such locations as the Lake Calumet port area and near O'Hare Field; and space was provided in other suitable locations for additional, non-local commercial activities.

Based on this more precise land use identification, it was possible to allocate trips to particular zones. Seventy per cent of all commercial trips are local in nature, so seventy per cent of the commercial trips by zone residents were allocated to local commercial land in that zone. (Note that while all local residents might not shop in their own zone, but rather in neighboring zones, it was assumed that a like, reverse movement would be expected, so that the number of trips to this land would be the same.)

Trip generation rates could be applied to all new, non-local uses and thereby most of the new, non-local trips were accounted for. For example, thirty-three shopping centers had been built, planned or discussed publicly since the completion of the 1956 land use survey. These varied from the 147 acre Old Orchard center to one of but six acres. In addition, some twenty-eight more centers were considered feasible, based on 1980 population, and were located in suitable places. Both proposed and added suburban shopping centers are displayed on Map 11, page 30. Trip generation rates are quite high for these places—generally approaching twenty-two person trips per thousand square feet of floor area or as high as three hundred person trips per acre.

Using this additional information for commercial land, it was possible to allocate all future commercial trips to zones. This allocation produced slightly higher trip generation rates because of the increased rates of per capita travel.

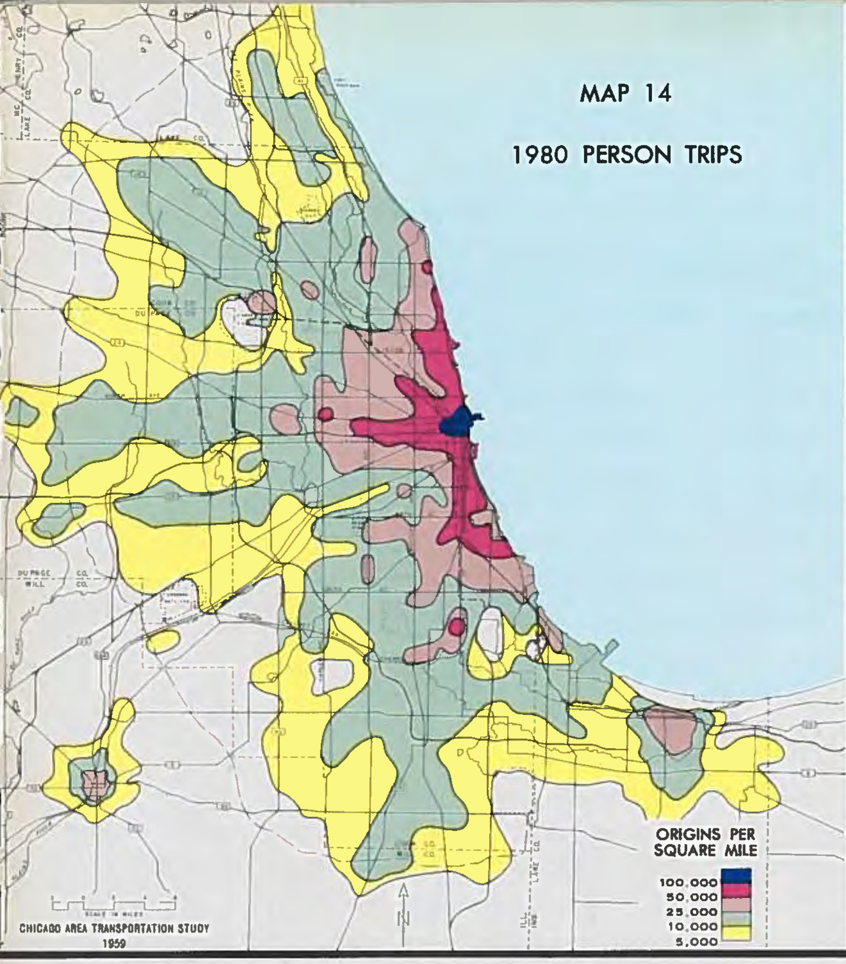
Public Building Trips

Trips to public buildings were estimated in a fashion similar to that of commercial trips. About eighty per cent of all trips to public buildings are local. These trips were assigned to the same zone as that of the residents producing them. These included trips to schools, post offices, churches, local government headquarters, and the like.

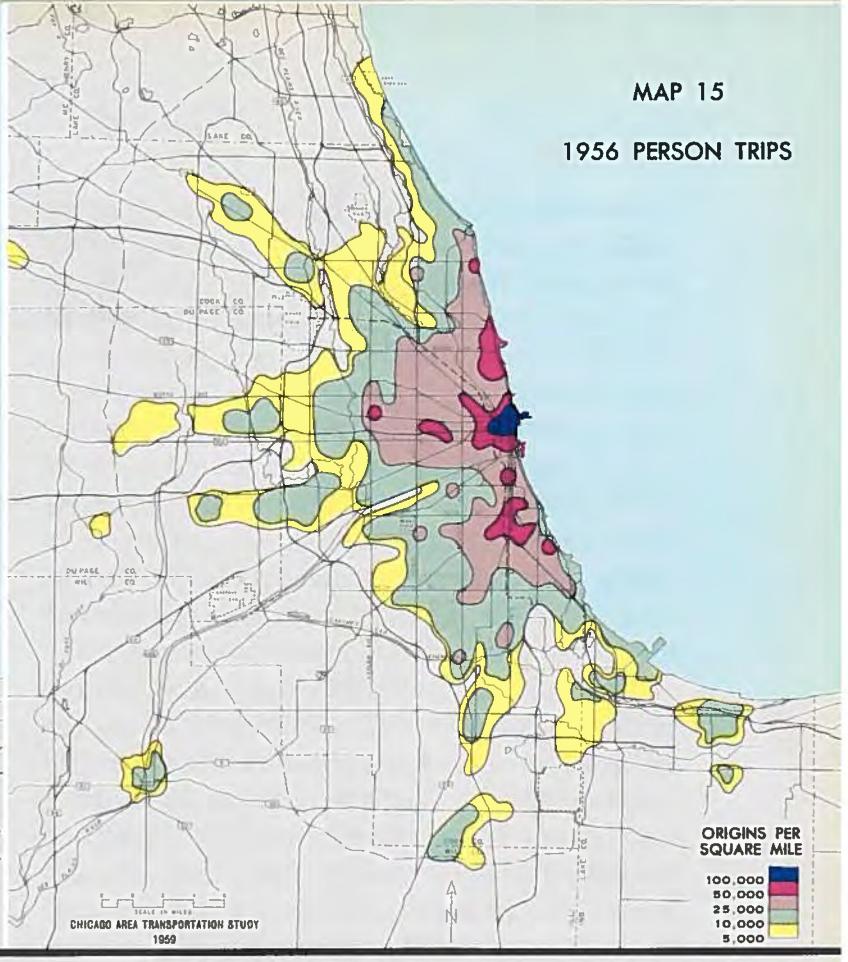
Longer trips to public buildings were assigned to the major institutions which are

TABLE 13
PERSON TRIP GENERATION RATES BY LAND USE TYPE AND DISTANCE RING: 1956 AND ESTIMATED FOR 1980
(In Person Trip Destinations Per Acre)

	Residential		Manufacturing		Transportation		Commercial		Public Buildings		Public Open Space	
Ring	1956	1980	1956	1980	1956	1980	1956	1980	1956	1980	1956	1980
0	2,151	2,431	3,692	3,692	273	273	2,126	2,209	1,976	2,429	98	98
1	224	252	243	243	37	42	189	218	255	342	29	30
2	127	141	80	80	16	18	122	140	123	174	26	30
3	106	117	87	84	11	13	143	163	101	120	28	32
4	67	75	51	48	13	15	212	238	78	91	14	15
5	43	45	27	27	6	8	179	193	58	69	6	10
6	31	30	16	18	3	9	133	177	47	50	3	6
7	21	22	18	17	6	4	132	193	14	28	1	4
Study Area	49	36	49	37	12	11	181	203	53	54	4	6



Although trip densities will rise in built up regions, most growth in trip making is expected in the suburbs. Over 18,000,000 person trips are forecast for 1980.



This distribution of trips bears close resemblance to that of population. This map shows the origins of 10,212,000 weekday person trips.

known to attract this kind of travel. Both existing and new colleges, medical centers and armed forces installations were considered in allocating these trips to zones. In some cases existing land uses were assumed to attract more trips than at present. This was particularly true for colleges and universities even though new sites, such as a campus for the University of Illinois, were provided. Similar allowance was made for increases at the medical center district, and new hospital sites were allowed in growing suburban areas. Continuing review of changes in these institutional land uses can be made to insure that any significant changes in trip generation will be taken into account.

REVIEW

The above steps completed the allocation of all person trips for 1980 to zones, according to land use. It is possible now to review the results. One method of review is to compare the land use trip generation rates of 1956 with those computed for 1980. These future rates are computed by dividing the number of person trips destined to each land use group by the projected acreage in each land use. Zones are grouped within rings for convenience.

Table 13 shows that, generally, the computed 1980 rates are similar to those of 1956. Most are slightly higher, and only a few are lower. The greatest stability is in the residential and manufacturing classes. Residential land shows higher 1980 rates in Rings 1 through 4. This must be so, because rising family income requires that the same household, on the same site, will make somewhat more trips in 1980 than at present. In the outer rings, residential rates remain nearly the same, because increased family trip making is offset by increased residential lot area per family. Manufacturing land has future rates very close to those of 1956, because the number of workers determines the number of trips and worker densities were kept near present densities.

The extent of changes in commercial, public buildings, transportation and public open space trip rates is reasonable. Obviously, land has some elasticity to absorb trips, with intensity of development being a major explanation. Commercial land in the inner rings is a good example of another cause. Here the reorganization of the means of distributing goods can change rates: the supermarket is replacing the corner store, and supermarkets draw automobile trips, whereas corner stores attract walking trips which are not counted. The projections of commercial trips in the outer region show substantial gains, but to rates which remain below those presently experienced in Ring 4. Transportation, public buildings and public open space show similar rate increases in outer rings, but remain near or below the rates currently observed in the completely developed inner suburbs.

These trip estimates were constructed within strict accounting controls. The numbers of trips projected for individual zones must add up to a predetermined total. The number of trips in each zone cannot exceed the limit set by the land development capacity of that zone. In each zone, also, there generally are mixtures of land use which lessen the chance of having unusual zonal trip generation rates. Such control totals make it unlikely that any zone is variant or that the sum of all estimates is affected by individual zone estimates. Continuing review certainly will serve to sharpen the trip making estimates as time goes on, but it is believed that the processes described insure a reasonably tight control on the total and the detailed forecast.

Of special interest is the changed geographic distribution of person trips resulting from the distribution to zones. Map 14 is a generalized illustration of trip origin densities for 1980. For comparison, Map 15 shows the 1956 pattern. While there have been slight increases in trip density at the center, the greatest growth has come in the outer suburban areas. The old, marked ridges of suburban development with higher rates of trip generation are preserved, but the valleys of formerly vacant land have been filled in with urban uses and as a result generate up to 10,000 trips per square mile.

These changes in trip making may be compared with the changes in population between 1956 and 1980 (Maps 9 and 10) and with the changes in developed land (Maps 12 and 13). There is a high level of correspondence, greater in the case of the population map, which portrays the element of intensity of use. Growth and extension of trip making of this magnitude can be expected when fifty-one per cent more people and their associated activities are settled in the urban region.

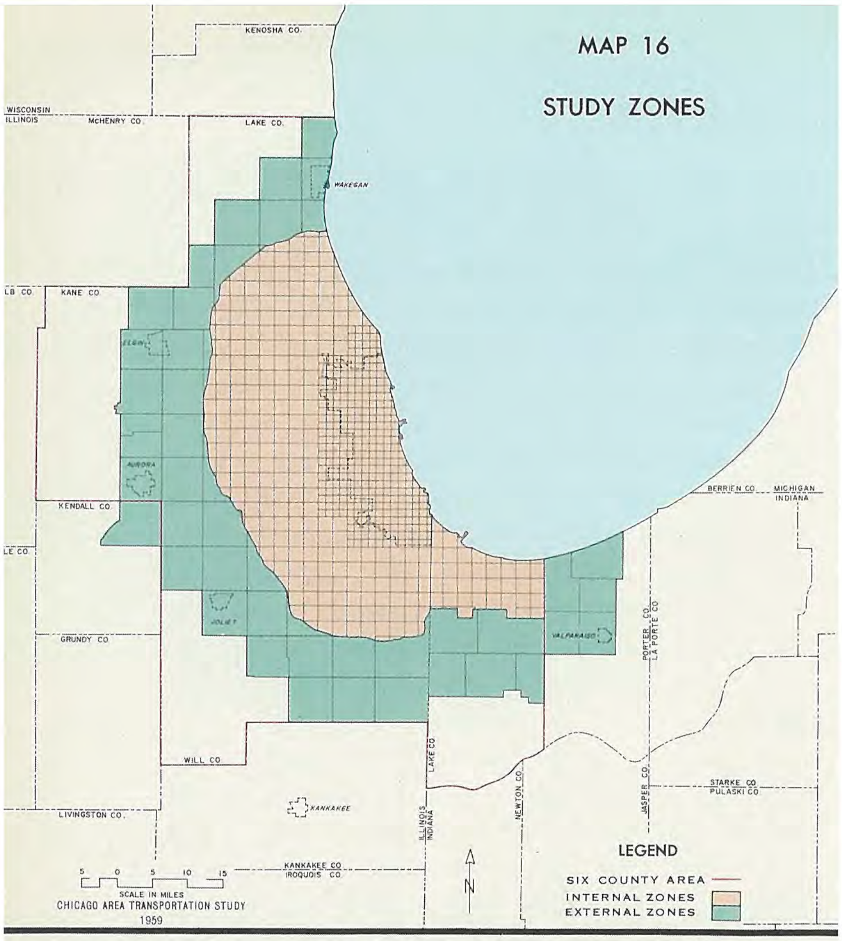
These projected internal person trips are not the only trips affecting transportation systems within the Study Area. Some persons living within the Study Area will make journeys beyond the cordon line, and some who live beyond the line will travel inside the area. It is necessary, therefore, to estimate the number of these external trips and this is taken up next.

ESTIMATING EXTERNAL TRIPS

By 1980, the wave of suburban expansion will be reaching and, in some places, extending beyond the defined cordon line. This growth will have a measurable effect on the new travel patterns to be expected by 1980. As of 1956, some 560,000 persons crossed the cordon line each day in automobiles and nearly 34,000 on commuting railroads. While these are less than six per cent of the current daily journeys, they are longer than the average internal trip and thus have a greater effect in establishing travel demands.

Presently, seventy per cent of the trips leaving the Study Area have destinations within fifteen miles of the cordon line. Selective growth in this territory will have considerable effect on both the volume and the origin-destination patterns of travel across the line. Hence, estimates had to be prepared of urban growth in both presently rural areas and around small cities near the Study Area. For these reasons, external zones of somewhat larger size were established in the area extending about fifteen miles beyond the cordon line and identified as Ring 8. This area and its zones are shown in Map 16.

The first step in estimating future trip generation volumes for these zones was to estimate their 1980 population. Estimates already had been made of the population for the Standard Metropolitan Area — five counties in Illinois plus Lake County in Indiana. The projection for the Study Area left a known remainder to be distributed to the rest of the six-county region. This outer population had to be divided further between zones of Ring 8 and the remainder of



Forecasts were made of 1980 population and trips in sixty-two external zones. Trips were made regularly in 1956 into the Study Area from these zones.

the six counties. Each zone was examined as to its past growth and, based on these studies, tentative population figures were set for these external zones.

These individual estimates then were checked against the previously determined totals. The individual zonal populations were then readjusted, as necessary, to conform to the over-all regional totals.

With a few exceptions—notably East Chicago and Whiting—population growth was an adequate index of growth in person trips, because population represented the total local activities and land uses of the zone. For most zones, then, 1980 population was converted directly to 1980 person trips. For East Chicago, Whiting and parts of Gary, account had to be taken of specialized industrial growth beyond that expected for the local population and appropriate trip adjustments were made at these zones. These estimates are summarized in Table 14 and were included in Map 14, which shows the 1980 distribution of person trips.

There are and will continue to be additional trip origins and destinations beyond these zones. About thirty per cent of person trips crossing the cordon line continued beyond Ring 8 to destinations in other parts of Illinois, Indiana and to the remaining states, or to Mexico and Canada. These trips were simply grouped at ten 'entry points' beyond Ring 8 and corresponding to defined sectors.[11] The 1956 trips, accumulated at these ten points were given growth factors drawn from estimated population growth in the United States by 1980.

In sum, the trips made by persons in surrounding areas and at more distant entry points were estimated principally as a function of population growth. These estimates then were combined with the forecasts of person trips within the Study Area, so that the total pattern of future person trip origins and destinations

[11]See Map 28 in Appendix for ten sectors. Note that for actual computation of future zonal interchanges, artificial populations at some distance from Ring 8 were created to represent a trip attraction level equated to the balance of the country included in that sector beyond Ring 8.

TABLE 14
POPULATION AND PERSON TRIPS INCLUDING EXTERNAL ZONES
1956 AND ESTIMATED FOR 1980
(In Thousands)

Area[a]	Population			Person Trips		
	1956	1980	Percentage of Increase	1956	1980	Percentage of Increase
Metropolitan Area	6,200.0	9,500.0	53.2	.....	.....	...
Study Area	5,169.7	7,802.2	50.9	10,212	18,081	77.1
Remainder	1,030.3	1,697.8	64.8	.....	.....	...
External Zones in Illinois	510.9	893.0	74.8	1,104[b]	2,234	102.4
External Zones in Indiana	498.0	842.0	69.1	1,000[b]	1,981	98.1
All External Zones	1,008.9	1,735.0	72.0	2,104[b]	4,215	100.3

[a]See Map 27 for definition of areas.
[b]Estimated.

was established for a very large region extending forty to fifty miles from Chicago's Loop. In the next chapter these trip estimates will be split between individual and mass transportation modes of travel. There remains to be fashioned, however, one piece of the trip generation forecast—namely, the forecast of truck trips.[12]

THE TRUCK TRIP FORECAST

In 1956 there were 854,000 truck trips made daily within the Study Area. Measured in units equivalent to automobiles, this converts to 1,476,000 automobile equivalent trips. Weighted in this fashion, trucks accounted for 21.9 per cent of all weighted vehicle trips made on the average weekday. By 1980 it is likely that this proportion will decline somewhat, since truck registrations are expected to grow more slowly than those of automobiles. Nevertheless, the volume of truck trips will remain a significant proportion of all trips, and their future numbers and locations must be estimated with care.

As indicated in Chapter II, truck registrations have been estimated to increase by sixty-two per cent by the year 1980. If truck trips grow as fast as truck registrations, then 2,391,000 weighted truck trips is the appropriate estimate for 1980.

[12]In addition to trucks, there is a very small group of vehicles —taxis—which was estimated independently. Comprising less than three per cent of vehicle trips, taxi trips are highly localized in the Central Area, with some trips made to airports and in the dense residential areas. These few trips were held essentially constant in number and location in the forecast of vehicle trips.

It is quite possible, however, to have a small change in the number of daily trips per truck. Economic studies showed increasing productivity in the trucking industry as in other parts of the economy. This may well double the average output per trucking worker by 1980. Most of this productivity probably will be in management and terminal operations (since it is hard to get less than one driver per truck!), but some undoubtedly will be in more efficient routings and larger trucks.[13] Since the larger trucks represent more automobile equivalents, this has the effect of increasing the number of equivalent trips per vehicle, per day. So the above forecast must be regarded as a lower limit.

In searching for an alternate method for estimating truck trips—and also for fixing the location of these trips at zones—it was found that truck trips were related closely to person trips at each land use type. It has been demonstrated that person trips are a measure of activities taking place at particular sites. So it is not surprising to find that truck trips can be related to those activities through the medium of person trips. As shown in Table 15, truck trips are related to the number of person trips in each land use category in a stable way. Residences, public buildings and public open space require fairly small amounts of goods (or truck borne services) compared to people. Manufacturing and commercial activities must have more truck trips as goods are fabricated and sold. Transportation and wholesale land uses reach

[13]One example of increased productivity is the 'piggy-back' movement of truck trailers on trains.

TABLE 15
1956 WEIGHTED TRUCK TRIPS PER 1,000 PERSON TRIPS BY LAND USE AND RING

Ring	Residential	Manufacturing	Transportation	Commercial: Retail	Commercial: Service	Commercial: Wholesale	Commercial: Total	Public Buildings	Public Open Space	Total
0	27	106	112	115	68	168	87	26	215	83
1	51	282	902	535	267	1,119	506	121	473	287
2	46	301	1,429	510	151	1,159	430	50	445	198
3	52	241	799	496	96	1,364	380	62	233	153
4	59	245	361	257	75	1,134	226	58	299	121
5	60	210	530	185	80	1,094	220	53	261	121
6	63	221	321	149	57	1,165	197	50	209	108
7	59	199	236	143	58	1,158	193	36	143	99
Study Area	57	245	575	266	92	1,072	254	58	255	139

high peaks, because they are primarily goods handling activities.

It may be queried why a simpler relationship, such as land use, was not employed to forecast truck trips. Actually, land use is a less direct measure of human activities than person trips, which are part and parcel of the energy source creating the transportation problem. Furthermore, on the basis of the described experience of estimating person trips, it is clear that land use trip generation rates are not constant. Actually, tests of 1956 data showed a more consistent and predictable relationship between truck trips and person trips than between truck trips and acreage measures of land use.

It seemed reasonable to assume that as more person trips are made to any area in the future, comparably more truck trips will be made. If more people go to industrial, transportation and commercial land, it is probable that more goods will be produced, transferred and sold. Proportionately greater truck movements can be expected. This holds, also, for the other land uses: more person trips to home, to school and to parks will require more deliveries and maintenance vehicles. This reasoning is reinforced by the current stability of rates in different parts of the Study Area. Therefore, it was assumed that existing rates of truck trips per hundred person trips would be the same in 1980 as at present.

Truck trips were estimated on the basis of the number of person trips projected for each zone in the Study Area in 1980. The principle used in fixing future truck trips was to hold those rates constant which exhibited little variation between distance rings in 1956 and, where there was more variation, to change the rates in the outer rings to approximate those in the middle rings. These were presumed to reflect conditions likely to obtain in the outer rings in twenty years. The only exception to these rules was industrial land. Here increased rates were estimated to take into account the expected greater output per worker.

By applying ring rates to the estimate of person trips in individual zones and then summing the results, it was estimated that 2,469,000 truck trips would be made on the average weekday in the Study Area in 1980. These trips also were summed by land use type and the average number of truck trips per thousand person trips for 1980 was calculated. As shown in Table 16, these relationships are substantially like those of 1956.

The increase in truck trips projected from the base of person trips is sixty-seven per cent over the 1956 total, three per cent greater than the growth rate of truck registrations. This is an excellent check. Having slightly greater increases in truck trips than in trucks is reasonable because of the anticipated greater productivity in the trucking industry and a greater portion of combination truck units. Because the detailed estimate checked out so well, and was already distributed by detailed location, this forecast of 2,469,000 truck trips was accepted as final.

CONCLUSION

Looking backward in time, trip making and travel are seen as one of the best gauges of the productivity of a community or nation. Trade, manufacturing, specialization and knowledge:

TABLE 16
WEIGHTED TRUCK TRIPS PER THOUSAND PERSON TRIPS—1956 AND ESTIMATED FOR 1980

Land Use Type	1980 Person Trips (In Thousands)	1980 Weighted Truck Trips (In Thousands)	Weighted Truck Trips Per 1,000 Person Trips	
			1980	1956
Residential	10,085	595	59	57
Industrial	1,037	288	278	245
Transportation	436	265	607	575
Commercial	4,522	1,086	240	254
Public Buildings	1,388	79	57	58
Public Open Space	613	156	255	255
Total	18,081	2,469	136	139

these are dependent upon rapid means of transportation and communication. In the past century, speed of travel has become progressively faster and people have been making more journeys. In 1916, the average person in the Chicago Area reported only 1.3 vehicular trips per day.[11] Forty years later he made 2.0 trips per day. In the future, the average person is expected to make 2.3 trips daily. This will come because greater productivity and higher levels of income are anticipated for the Chicago area and these, with technological improvements, will give the average person a greater command of energy for his personal use. This heightened amount of personal movement is natural, and it will come about provided facilities are available and friction losses do not erode other gains.

In this chapter, it has been shown that per capita trip making is expected to rise by seventeen per cent. This rise was calculated on the basis of changes in residential density and an estimated twenty-eight per cent increase in family automobile ownership. Combined with population growth, these factors are expected to raise trip making in the Study Area from 10.2 to 18.1 million person trips per day. Gains of this magnitude are already anticipated by the substantially greater trip making of present suburban residents.

With increased personal trip making, resulting from generally higher levels of wealth, present land use trip generation rates are expected to change. This change cannot be too great, because trip making is, in effect, a user of space. Cars must be parked or garaged. Even people walking into stores must be accommodated by more aisles, counters and sales persons — all requiring space. Thus, while existing land uses undoubtedly can absorb some additional trips, there are bound to be limits. As pressures from additional trips reach a certain point, they undoubtedly will be relieved by the acquisition of additional lands.

Using the trips estimated from the base of population, distribution was made to zones within the Study Area on the basis of the land uses projected there. In this distribution, attention was paid to projected residential location, the distribution of trips by purpose, land use and trip length, the location of manufacturing employment, and other facts. Examination of the rates of trip generation computed for 1980 showed that, generally, there were few significant changes from existing rates, and that changes were in directions which could be explained readily. Thus, the land use forecast furnished one of the important controls necessary for sound allocation of future trips to zones of origin and destination.

Emerging from all detailed forecasts is the dominant fact of an expanding metropolis. This is the most crucial problem to be faced in planning the needed transportation improvements. Growth and change of this magnitude create stresses and strains and bring continuous pressures to bear on parts of the transportation network. Growth in travel demands is moving outward progressively from the center. This is obvious to the most casual observer. The magnitude of this expansion of travel is not so obvious. Glacierlike, it will spread out with accumulating weight over the next twenty years. The essential task of advance planning is to scale this future problem and give it dimensions. Then the community can see the problem clearly and come to grips with it.

[11]Estimated on basis of data in the 'Report of the Chicago Traction and Subway Commission,' 1916.

Chapter V

ESTIMATING FUTURE MODE OF TRAVEL

In any large metropolitan area there are a number of kinds of transportation available. There may be automobiles, buses, subways, elevated trains, railroads, taxis, helicopters and even moving sidewalks. Generally, the larger the city, the more types of facilities are found. Each type of service is specialized and serves its particular clientele, but each contributes to the capacity of a system of metropolitan transportation.

Most of today's city travel, however, is made by automobile and by public transportation — buses, elevated-subway trains and suburban railroads. The other types are, so far, carrying only minute proportions of daily travel. Helicopters, for example, perform a very specialized service. There is always the possibility that more novel types of aircraft or other radically new means of transportation may begin to carry more people. But timing and the investment in present facilities inhibit rapid change. It is safe to assume that by 1980 the bulk of travel will continue to be made over the two major kinds of rights-of-way now in use — roads and rails.

The physical planning task must be to propose the number, location and capacities of both road and rail facilities. As a first step toward this objective, the growing demand for urban travel has been estimated — nearly eighty per cent more person trips in 1980 than in 1956. Now it is necessary to estimate how this demand will fall on the different types of transportation facilities. A sound appraisal, based upon people's requirements, is needed to plan an appropriate mixture of transportation services.

The future person trips projected are first of all divided into those traveling by mass transit and then those going in private cars. In estimating this division, all mass transportation trips — paying no heed for the moment to the question of allotment among bus, elevated-subway or suburban railroad routes — are divided into two groups: those trips connected with the Central Area, and the remainder, which are called local. Automobile trips are then estimated by allocating the remaining travelers at each zone to driver or rider status. Vehicle trips are forecast by adding in truck and external vehicle trip estimates from Chapter IV.

The extent to which projected mass transportation riders will use rail facilities — one of the very objects of planning — is dealt with in Chapter VI, because such usage estimates can only be made by assuming something about the facilities available. Only when these assumptions have been made can these travelers be allocated to rail and bus.

Before proceeding, it must be questioned whether such estimates are a sound basis for planning. It is conceivable, for example, that changes in public policy might substantially alter the proportions of persons using mass transportation. Also, since there are ranges about any "best" estimate, it may be questioned whether a range, or even a high estimate, would not be preferable. These problems must be thought through to establish a basis that will best serve the purpose of planning new facilities.

FACTORS AFFECTING ESTIMATES OF MASS TRANSPORTATION USAGE

There is a widely held belief that people will shift from the use of the private automobile to some form of public transportation if service is improved. Holders of this view argue that the actual usage of mass transportation facilities depends upon increasing the frequency of service, providing more comfortable seats or extending bus routes or rail lines. This view is very attractive from a number of viewpoints. To the public administrator, it promises some relief from seemingly endless demands for expensive highway construction projects. To the automobile driver — which is most of us — it holds the possibility of getting the other fellow off the street so that we can drive under less congested conditions. These persuasive reasons for accepting this view, plus the idea that it is cheaper to use mass transportation, have led some to proceed on this assumption without question. Implicit in this assumption is the belief that either system can meet the market demands and that they are competing for the traveler. Yet evidence in Volume I has shown that automobiles and mass transportation serve separate and distinct segments of the travel market. There is a valid question, therefore, as to the extent to which improved mass transit services would be able better to meet the market requirements of travelers presently using automobiles.

Most people will agree that the proper target for transportation planning is to provide for swift, safe movement of people and goods. And they will agree that this must be done within limited money resources and with respect for the requirements of the activities which use urban land. There are different ranges of conditions for which transportation facilities must be planned, and they indicate that more than one type of transportation service is needed. Such different types of service must be planned to supplement one another so that in total they provide an integrated system. The different types must be planned so that each serves its appropriate market and service area. Specialized facilities are most suitable where conditions of land use and personal travel needs are more likely to be in harmony with the kind of service each type of transportation can provide. In short, services must be sensitive to the demands of the market place.

This, then, is the central philosophy: the appropriate location and probable use of each mode of transportation is determined by certain functional requirements. Among these requirements are land use, density of development and such consumer characteristics as automobile availability, ability to drive, plus the age, sex and type of work of the traveler. Planning contrary to these requirements is to invite waste.

Consider first the requirements imposed by land use and density. It has been shown in Volume I that at densities of less than 25,000 persons per net residential square mile (about twelve families to the net acre), buses operate in very limited numbers.[1] Suggesting that buses should serve lower densities immediately implies the chance of financial loss. Similarly, an outer belt commuter railroad line connecting such low density points as Wheaton, Downers Grove and Park Forest would influence more people to make trips between these places, but hardly enough to warrant risking the investment. A less extreme proposal, such as new radial commuter service along the Sanitary Canal to the Loop, undoubtedly would gain some travelers. However, such a facility would help to supply a fairly constant number of daily travelers to the Loop, so that its gains might be at the expense of other rail lines. In effect, land use and density strongly condition the level and character of travel demand, and demand strongly influences the kind of service which can be provided.[2]

People also have individual requirements which, in the aggregate, affect demand for mass transportation. For many users, transit suits their needs exactly, but others, because of personal or family situations, represent more of a "captive" portion of the transit market. Husbands have to go to work but wives need the car. Children must go to school and in many places walking is not feasible. Many persons have to make journeys but being unable to drive, they are dependent on transit. Of course, many households do not or can not own cars, yet they still have to make trips. All these personal conditions do affect the transit market.

Figure 19 shows how families without cars use mass transportation for most of their journeys, while families with one or two cars use mass transportation at low and nearly constant rates regardless of location in the metropolitan area. This fixed or constant frequency of transit usage in car owning families seems clearly related to the likelihood of having select family members who are constrained to use transit for particular reasons. These include the members who, because of age or lack of

[1]Those which do operate at lower densities are more often school buses, not available for general travel. For example, in Rings 6 and 7 of the Study Area, forty per cent of bus passengers are on school buses.

[2]See Vol. I, p. 69 ff.

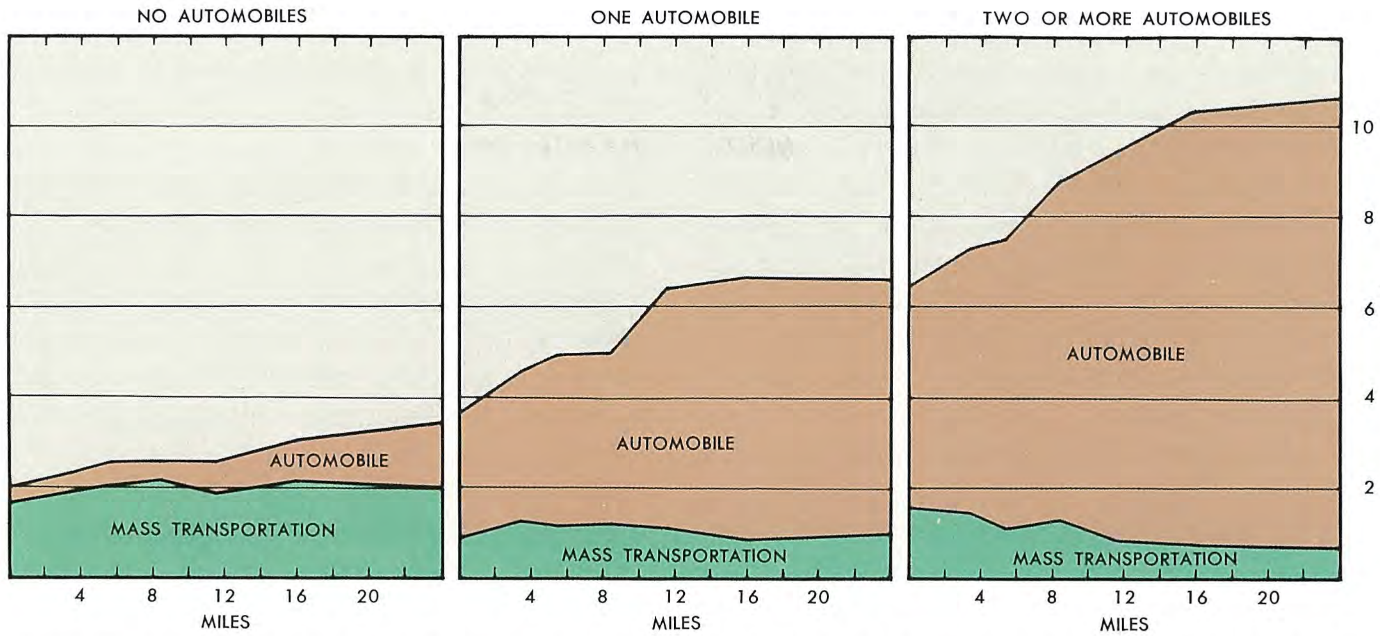


FIGURE 19—TRIPS PER FAMILY, BY MODE, FOR FAMILIES WITH NONE, ONE, AND TWO OR MORE AUTOMOBILES, BY DISTANCE FROM THE LOOP

See Table 55 in Appendix.

training, are not capable of driving, those others who must travel but find the family car unavailable and those who, because of their destination (i.e., the Loop), are better off using transit. Even when more trips are made per family, there is no reflection of this fact in increased mass transportation usage.

The conditions of land use and density, plus the measurable requirements of people, are major determinants of the travel market. If demand is constrained by these factors, it is unlikely that changes in supply will have any great effect on the number of users. Since the objective of this chapter is to estimate future transit demand, account must be taken of these market influences. For purposes of estimating, therefore, the future land use and density patterns and the estimates of future car ownership are assumed to influence the level of transit demand in the future in much the same way as they do now.

The Possibility of Changing Land Use

It may be argued that the preceding attitude, while logical, is excessively deterministic. Indeed, why not control land use and density so as to control the level of mass transportation usage? (This, incidentally, is easier than legislating automobile ownership!) If denser living and working conditions can be obtained, more travelers would use mass transportation services. This resultant additional transit usage, it is reasoned, can result in significant community benefits — among which are better and less expensive transportation.

These are important considerations and deserve careful review. If such changes are possible, then the whole land use forecast presented in Chapter III becomes merely an extension of current practices which might be changed substantially by government action. To determine whether a different pattern is desirable and even possible, several questions must be answered. What are the economic advantages to the mass transportation rider? What are the consumer benefits in more dense living arrangements? Can sweeping changes in density and mass transportation be carried into being?

One way to appraise the economies of mass transportation is to consider the actual choices of people. For the long journey — especially into the densely developed Central Area — most travelers choose rail facilities, if available. Economic factors, including parking fees, form part of their appraisal of the situation. For shorter trips, however, people who can drive generally use automobiles. The fixed transit fare, plus less personal convenience because of waiting, begin to favor automobile usage for very short journeys. Considering all factors, under current conditions, it is quite likely that the aggregate of all consumer reactions accumulate to produce the present day proportions of automobile and mass transportation usage. Finally, it is reasoned that this resultant usage from many individual choices is basically an economic decision in which time and comfort play their parts.

Whether it would be financially advantageous for more travelers to use mass transportation in the future will depend on significant changes. Today, the average CTA rider pays 4.3 cents per mile, but spends an average of thirty-eight minutes in traveling from door to door. The automobile traveler pays from 4.5 to 6.4 cents per mile over a similar distance, but it takes him only twenty-two minutes.[3] As people's time, comfort and convenience become more valuable to them (by reason of increased productivity), they will select the travel means which emphasize these qualities. The problems of increasing comfort, speed and convenience of transit service, without substantially raising fares, is a particularly difficult problem to the transit operator. The extension of transit services into less dense living and working developments will likewise strain the earning power of the rest of the transit system. There appears to be a point where customer demand is evenly balanced against the cost of providing more services.

Whether the final balance sheet of community values would show a gain by having urban areas built at high rather than at low densities is really unknown. Urban studies are almost a blank in this respect. One might ask what returns can be accrued from having people living or working closer together. Generally, low density living would appear to be preferred by the bulk of families with children. It would be regarded as safer and more pleasant than crowded conditions. Many industrial wholesaling and some commercial activities are more efficient at low densities, but dense working places are desirable where high accessibility to other people is needed. All these are speculations, not facts, so it can only be said that there is no clear proof of greater values to be obtained by high density arrangement.

If measurable and demonstrable savings could be achieved by guiding future urban development toward high densities and greater usage of mass transportation, current trends would have to be reversed and this probably would require a reversal of current practices and policies in all or nearly all of the political jurisdictions in the Chicago area. Zoning regulations, road and parking programs, health and building codes, and assessment procedures might have to be changed. In addition, changes in lending policies, both by private institutions and government, would be required and private builders would have to be subject to additional controls. If such policies should run counter to the preference of people, it would be hard to expect elected officials to persist in them. Current popular demand, as expressed in thousands of daily decisions, has been predominantly towards low density use of the land. The momentum of these many individual decisions is very great and would make a major directional shift hard to accomplish.

It must be concluded that substantial increases in density, with attendant increases in potential mass transportation usage, are not a reasonable expectation until people know for certain that the establishment of high density development would be advantageous to their individual and collective interests. Present knowledge of urban affairs does not permit clearcut conclusions to be reached on the advantages of higher density, mass transportation cities. A more reasonable position is that people, acting in their own interests in a relatively free society, are gradually evolving their desired

[3]In 1956, Chicago Transit Authority receipts from bus and elevated-subway fares averaged about $380,000 per weekday. For this, and on a typical weekday, an estimated 10,600,000 miles of person travel were reported on CTA facilities for an average cost of about 3.6 cents per mile. In 1957, fares were raised from twenty to twenty-five cents, and so mileage costs would presently be about 4.3 cents per mile. Private automobile costs range between seven and ten cents per mile. Since average car loading is 1.56 persons per car, this means that average costs per person lie between 4.5 and 6.4 cents per mile, including fixed costs of car purchase. For speeds of travel, see Tables 46 and 47 in the Appendix.

environment and, lacking further evidence, this must be presumed to be efficient and satisfying. This, of course, was the premise underlying the land use forecast.

Quantitative Estimating Policy

If conditions of land use and personal requirements dictate demand for mass transportation, and if these conditions cannot be changed radically, what is the outlook for future transit demand likely to be? The population of the Study Area, it is estimated, will increase by half, and the Central Area is expected to attract even more travelers in 1980 than at present. These new people and the growth in the Central Area are factors tending to increase potential transit riding. In opposition are the trends towards low density, high car ownership living patterns.

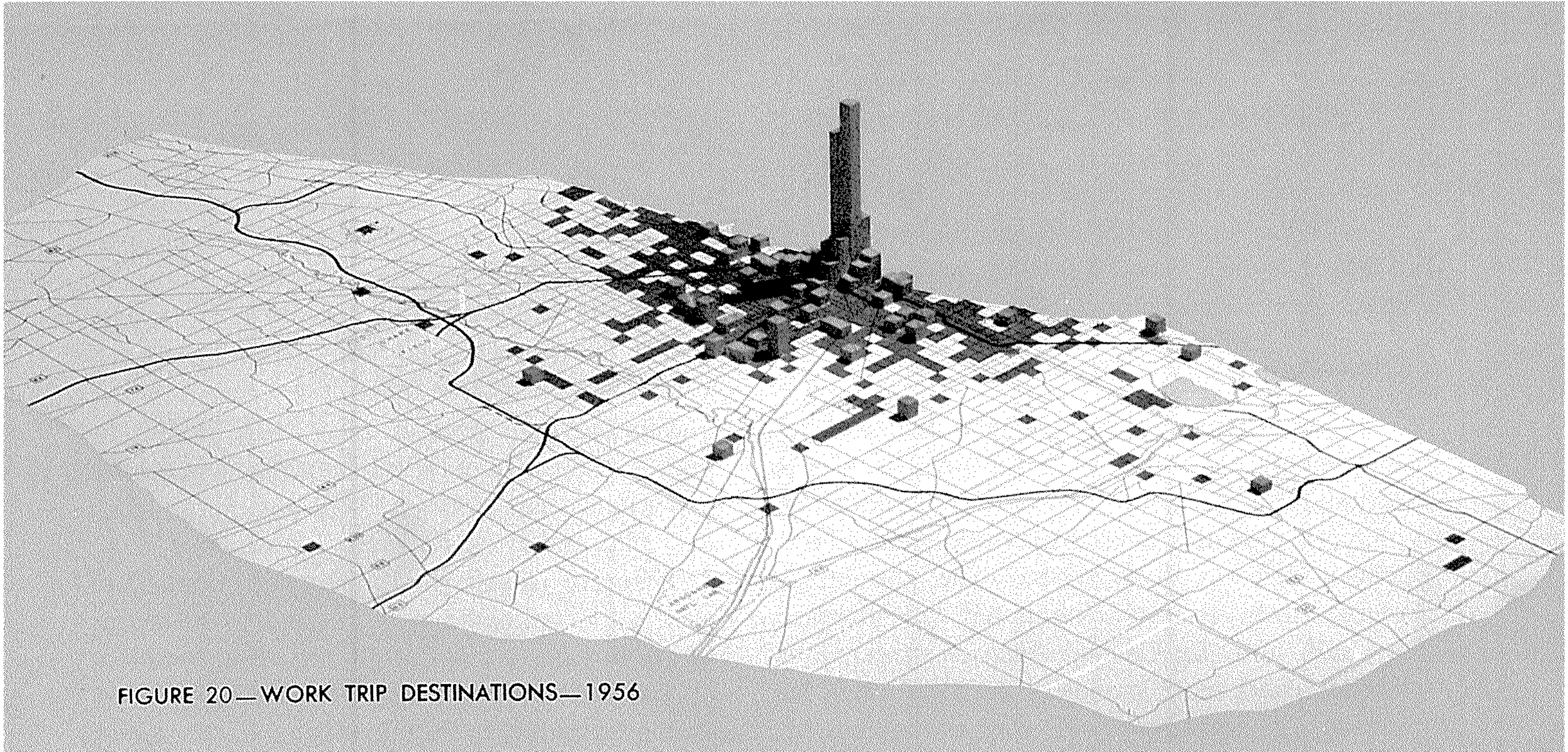
Given the future land use, population growth and shifting car ownership patterns, it is possible to fit all three elements together in a measured way to estimate future transit riders. But any estimate is based on a number of unknowns and upon certain assumptions. Many estimators provide a range of values rather than a single, most probable one. Heretofore, the attempt has been made to select the single, most probable answer rather than to provide a range of possible answers. In anticipating future transit riders, however, this approach was changed to establish a somewhat higher estimate than the most probable. The reason is simple. The situation may be likened to making estimates for a water system where costs associated with not having enough water are significantly greater than costs for having a little extra.

Clearly, the transit systems are a very important factor in the daily movement of people. They are crucial suppliers of people to the highly developed business center of Chicago. These services are required for a substantial segment of the population — they are, in fact, a public utility. Therefore, it would seem preferable to be on the high or safe side in making estimates rather than to be sorry for having been too conservative. When trip estimates were computed from land use, density and car ownership data, these estimates were checked against extensions of trends and a reasonable but high figure was established. The estimates thereby represent potentially attainable levels of transit usage, given the projected population and land development patterns.

Suppose that these estimates turn out to be high — i.e., that mass transportation will have less riders than forecast. Will any harm come to a plan prepared on such an estimate?

If future transit riders are overestimated or even underestimated with respect to proposed future bus lines, this should not affect the planning scale. If the number of bus riders is overestimated, buses probably will leave the streets and be replaced by private automobiles. Using current patterns of bus travel and assuming an overestimate by as much as one-fifth, it could mean that road usage would be increased by one million passenger car miles daily. However, some buses would leave the streets and, since buses are larger, slower and less maneuverable than automobiles, the equivalent of 230,000 vehicle miles of travel would be taken off the streets. The net increase in street usage (770,000 vehicle miles) would amount to about one per cent of the total estimated 1980 vehicular travel. Any error resulting from overestimating (and, by the same token, underestimating) bus usage is unlikely, therefore, to have a sufficient impact on highway requirements to cause plan changes. Seen from the effect on planning of bus service, adjustments are constantly being made to market variations by changes of routing and scheduling of service, and this will continue to be accomplished as necessary and will certainly take advantage of street and highway improvements.

In the case of rail rapid transit users, estimates are more crucial in their effect on plans, but these estimates are made within fairly tight limitations. Of current rail and rapid transit trips, eighty-one per cent are connected with the Central Area, and the number of trips generated by this area has held steady over the past twenty-five years. The record of riders on elevated-subway trains and on suburban railroads also has been steady. With such a stable



The Central Area is represented by the tallest blocks and those immediately adjacent; thirty per cent of the Study Area's labor force works here.

history, there is much less likelihood that future estimates will be wide of the mark.

In sum, the policy to be used in estimating trips by mode is that mass transportation trips are relatively firmly fixed by household and car ownership characteristics, and by the pattern of land development. Short of governmental regulation (as in World War II) or radical technological change, the view held is that the mass transit demand is determined heavily by conditions which would be extremely difficult to alter. However, because of the importance of this service to a very substantial segment of the population, estimates of transit riding were, wherever possible, stretched towards the highest realistically attainable number.

CENTRAL AND LOCAL MASS TRANSPORTATION

For the purpose of estimating future mass transportation trips, it has been found most useful to divide all of these trips into two groups — central and local. Central trips are defined as those mass transportation trips which have one end, but not both, within the Central Area.[4] All of the remaining mass transportation trips are considered local.

This division of trips has a functional basis which justifies its employment in the mechanics

[4]Chicago's Central Area, as defined by the Chicago Department of Planning, is bounded by North Avenue and 26th Street to the north and south and by Lake Michigan and Ashland Avenue to the east and west (see Figure 9, page 24).

TABLE 17
CHARACTERISTICS OF CENTRAL AND LOCAL MASS TRANSPORTATION TRIPS

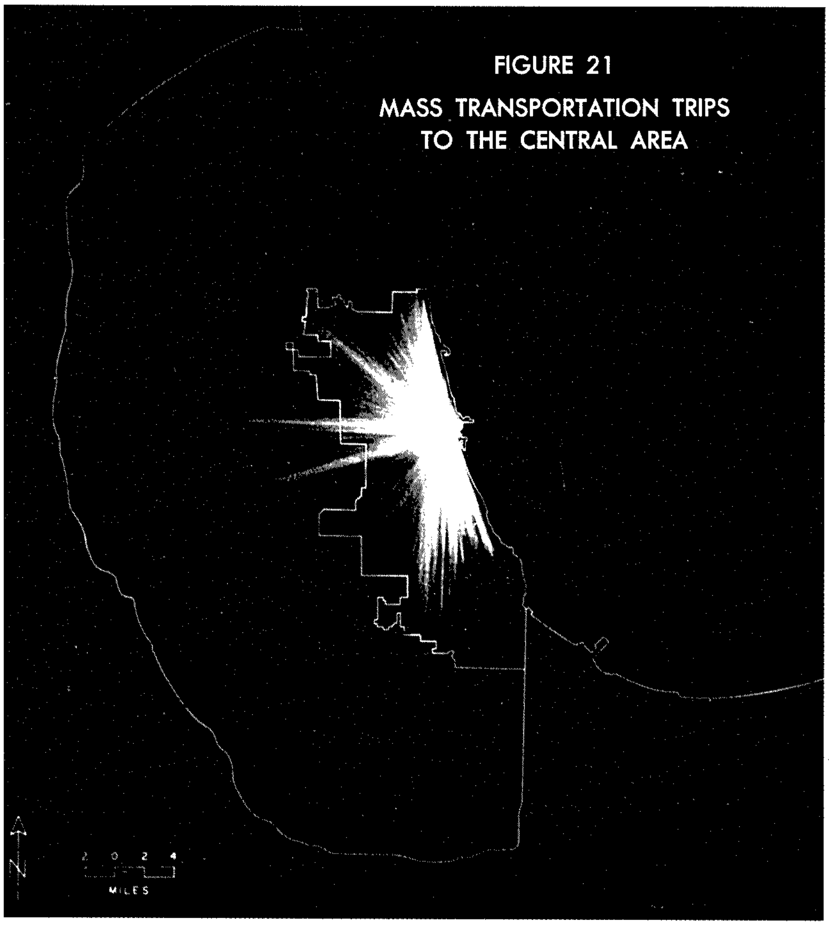
Characteristic	Loop District 01	District 11	Central Districts	Local
Mode of Travel				
Bus	31%	58%	43%	89%
Elevated-Subway	45	28	35	8
Suburban R.R.	24	14	22	3
Total	100%	100%	100%	100%
Mean Airline Trip Length (In Miles)				
Bus	5.9	4.8	5.3	3.1
Elevated-Subway	7.3	6.9	7.2	7.0
Suburban R.R.	14.0	14.1	14.0	10.5
All Mass Transportation Trips	9.1	7.2	8.3	3.6
Travel During Morning Peak, 7:00 A.M. to 9:00 A.M. Percentage by Mode				
Transit	87%	58%	72%	26%
Automobile	13	42	28	74
Total	100%	100%	100%	100%
Percentage of 24 Hour Total Arriving 7:00 A.M. to 9:00 A.M.	20%	17.8%	18.6%	13.8%
Percentage Between Home and Work	66%	72%	68%	44%
Percentage of all Transit Users Having Driver's Licenses	49%	39%	45%	25%

of estimation. The central trips bring persons over longer distances from residential places to the Central Area, which is the most concentrated and most specialized work place in the Study Area (See Figure 20). Local mass transportation trips, on the other hand, have the function of carrying persons shorter distances between fairly dispersed locations, principally within the higher density, inner rings of the Study Area.

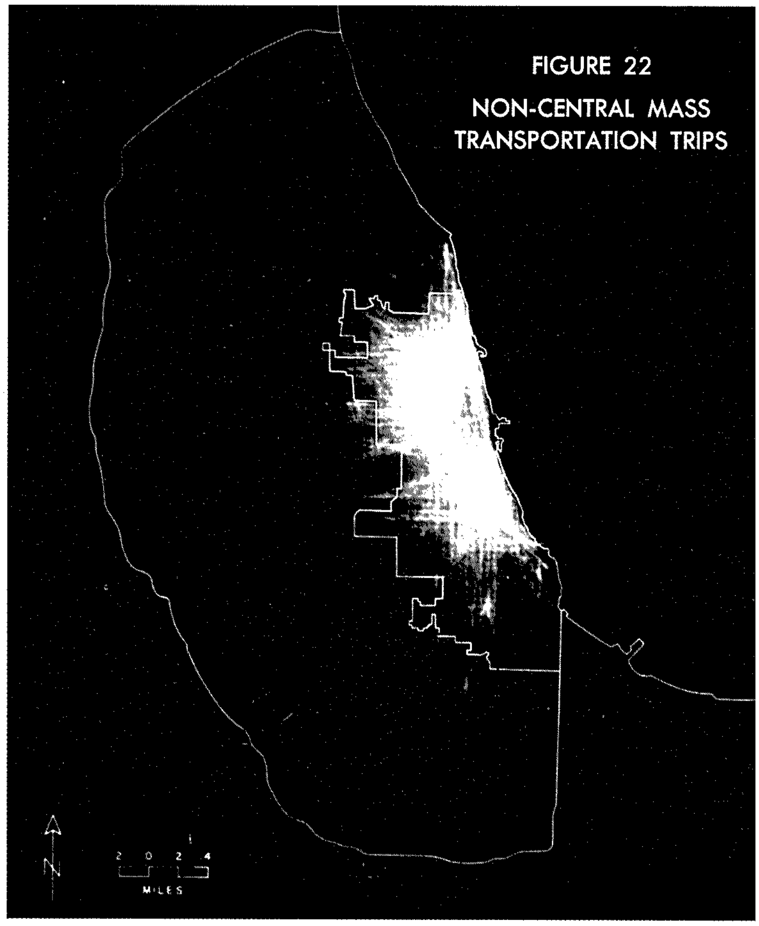
Central and local mass transportation trips are made by riders with substantially different characteristics. Passengers to the Central Area are predominantly in the work age groups, are more frequently going between home and work, and are more likely to be licensed drivers. Local mass transportation passengers more frequently include the young and the old, are going from home to work less frequently and are less likely to have driver's licenses (see Table 17).

Associated with these functional differences are differences in trip characteristics. Central mass transportation trips are much longer, averaging 8.3 miles in length, while local trips are only 3.6 miles on the average. More than half of all central mass transportation trips (fifty-seven per cent) are made by rail transit, whereas most local mass transportation trips (eighty-nine per cent) are made by bus. Also, the central trips are more heavily concentrated in the morning and evening rush hours.

Demonstration of these facts exists in the desire line displays of central and local trips, shown respectively in Figures 21 and 22. There is no mistaking the concentration of central trips. By contrast, the local trips are dispersed in direction, but are predominantly in the high density, inner rings of the Study Area—especially within Chicago. The central trips appear to ride over the pattern of local trips, and this, in fact, is the case, because these trips move to a large extent on rights-of-way which are over or under the surface mass transportation facilities.



Over 1,035,000 mass transportation trips focus on the Central Area. More than half are made on suburban railroad and elevated-subway trains.



Eighty-nine per cent of 1,417,000 non-central mass transportation trips are made by bus. These trips are spread evenly, mostly within densely settled Chicago.

THE LESS DENSE PORTIONS OF SUBURBAN MASS TRANSIT TRIPS DO NOT REPRODUCE; FOR THEIR LOCATION SEE FIGURES 32 AND 33.

Central trips are those which, in the future, will be most likely to use rail facilities, whereas local trips will be more amenable to surface transit. Since a prime concern of planning will be to establish estimated requirements for grade separated, high speed transit services, the division of the transit forecast into these two groups has both reason and utility. The central transit user estimates are reviewed first.

ESTIMATING 1980 CENTRAL MASS TRANSPORTATION TRIPS

About forty-three per cent of all trips made by mass transportation in 1956 were connected with the Central Area, or approximately 1,035,000 daily person trips. Half of these trips—517,000—were inbound and the other half outbound. Not included in these figures are 126,000 mass transportation trips which had both origin and destination in the Central Area and which were, for this reason, considered to be local in character.

The problem at hand is to estimate how many centrally oriented mass transportation trips there will be in 1980. To solve this problem, attention must be focussed on that spot whose requirements, in large measure, determine the answer—namely, the Central Area itself. The needs of the Central Area for residents, workers and shoppers are fixed largely by the floor area of establishments; more people will not come there than can be accommodated at the prevailing standard of floor area utilization. The buildings have a capacity and this is a major determinant of the expected daily intake of travelers. Given total travelers, those expected to arrive by transit must be determined. In this fashion, estimates of future Central Area mass transportation trips are constructed.

Future Mass Transportation Trips to the Central Area

The number of person trips with destinations in the Central Area and the proportions arriving there by mass transportation are both heavily influenced by the future development of this core area. Reference has been made in Chapter III to the Central Area Plan, prepared by the City of Chicago Department of Planning. This plan is an official statement of the intensity, kind and location of development expected for the Central Area. As such, it provides an excellent basis for estimating future trip making to this 15.6 square mile area.

The Central Area plan indicates that the predominant new building activity is expected in the places lying close to, rather than within, the Loop (See Figure 9, page 24). The Exposition Center, the University of Illinois campus, a transportation center, and a substantial amount of new residential construction ring the Loop. Most of the gain in floor area expected (about five per cent) is in residential floor space, although gains in office space are expected as these uses displace older warehousing and other commercial activities. Generally, the plan emphasizes high rise residential structures on ample sites, with parking, and it seems reasonable that the areas selected for growth are those areas now without buildings, or with older structures.

The expected increase in floor space would indicate a proportionate gain in trip making, but other factors may change the present rate of trips per unit of floor space. Rising personal income will tend to increase the rates of per capita trip making, and this should bring about some increase in the number of trips made to each unit of floor space. But rising income also may increase floor space usage per capita. Wealthier families will have larger quarters and office workers require more accounting machines, air conditioning and other space users. Shifts in the kinds of activities housed in the area also may change the average number of trips per unit of floor area. In the past there probably has been an increase in office floor area, with compensating declines in manufacturing and wholesaling space. There is evidence that the number of shoppers coming to the Loop has been declining, so that the type of activities housed has been changing. All of these factors—shifts in per capita space usage, trip frequency and changes in the make-up of Central Area activities could operate to change rates of trip generation, yet the combined effect is hard to predict.

Fortunately, there is good evidence which permits an independent, historical appraisal of the number of daily person trips going to the Central Business District, which is roughly equivalent to the Loop. While this is only a part of the larger Central Area, it generates forty per cent of the Central Area's person trips and fifty-two per cent of all its mass transportation trips. It is, therefore, a substantial indicator of trends in the number of daily person trips and also of the proportionate usage of mass transit facilities.

The trend data are based on one-day counts of persons entering and leaving the Central Business District. These have been taken nearly every year since 1926, usually in May. The number of persons entering, classified by mode of travel, is shown in Figure 23. Persons crossing the cordon line do not always stop in the Loop, so many through trips are included. It appears that about forty-five per cent of the entering trips go through without stopping. Of the fifty-five per cent who stop in the Loop, only a portion is there at any one time—some leave before others arrive. At about 1:00 P.M., the number of people accumulated reaches a maximum (Figure 24). For example, in 1956 about 840,000 persons entered the Central Business District and 466,000 reported stopping there. The accumulation at 1:00 P.M. was 317,000 persons.

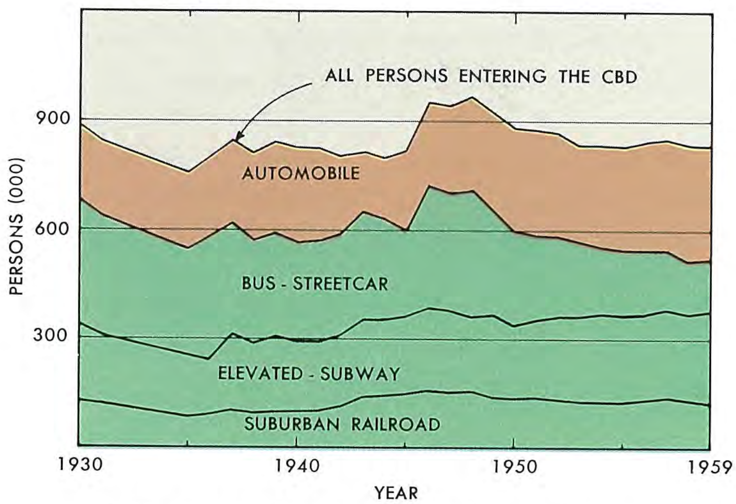


FIGURE 23—PERSONS ENTERING THE CENTRAL BUSINESS DISTRICT FROM 7:00 A.M. TO 7:00 P.M., BY MODE, FOR SELECTED YEARS 1930-1959

See Table 44 in Appendix.

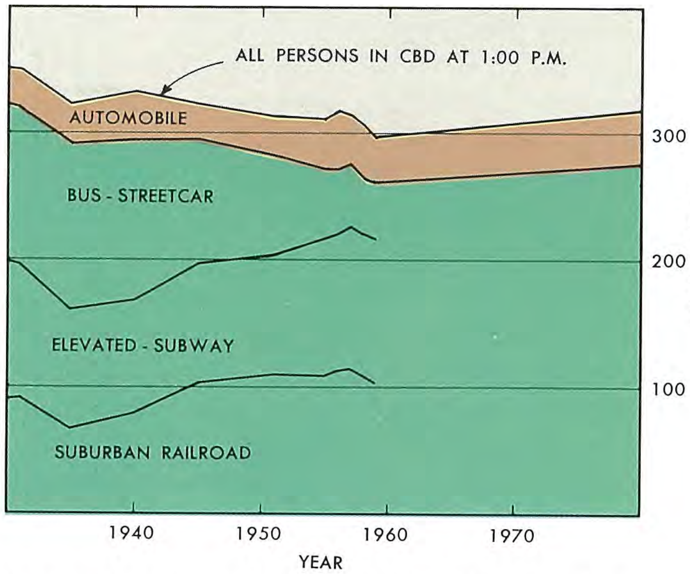


FIGURE 24—PERSONS ACCUMULATED IN THE CENTRAL BUSINESS DISTRICT AT 1:00 P.M., BY MODE, FOR SELECTED YEARS 1930-1959 AND ESTIMATED TO 1980

See Table 50 in Appendix.

From the two graphs, (Figures 23 and 24) something can be inferred of the nature of what has been happening in the Loop. The number of persons crossing the Loop cordon has been holding steady, or declining slightly, for over thirty years. The only exception was during the Second World War when the number rose sharply—probably because gasoline rationing forced many people to route themselves through the Loop on mass transportation. Even during the war, however, the peak accumulation of people did not rise, and this almost certainly is due to the controlling influence of building floor area on the maximum number of persons which can reasonably be served at the same time.

The slow and steady decline in the accumulation of persons in the Loop probably is due to the increasing specialization of the Loop as a work place. In 1956, about 250,000 of the peak accumulation of 317,000 persons were workers, leaving only twenty-one per cent of the peak daytime population in the categories of users of services, shoppers, visitors, lunchers and convention goers. These persons use floor space at intensive rates. Although no reliable long term evidence is available on floor space by type, it is almost certain that the total floor space in the Loop has increased between 1930 and 1956. It is likely that the greatest increase has come in offices, whereas retail, amusement and similar activities have declined. It is apparent, therefore—perhaps because of work specialization—that the effective rate of floor area trip generation in the Loop has been declining.

Within these over-all trends it is clear that the number of persons coming to the Central Business District by mass transportation also has been declining. Surface transit has shown the greatest loss in patronage. The suburban railroads and elevated-subway lines, however, have registered gains, almost certainly at the expense of buses. These gains reflect increased emphasis on work and increasingly longer journeys. More people seem to be coming and going by automobile, but, contrary to popular impressions, the number who remain for long periods of time has not gained substantially.[5] The share of persons accumulated in the Loop and who come by automobile, has increased only very slowly since 1930—from eight to twelve per cent of the total and this while the total was dropping.

This evidence tempers the prior expectation that the increased floor area represented in the Central Area Plan would increase daily journeys. Any trip making forecast must fall within fairly tight limits since neither the plan nor the trend data suggest substantial changes. In fact, the plan could not be expected to indicate a substantial increase, because the mass of floor area already on the site is so great—actually totalling 362 million square feet and containing almost thirty per cent of all nonresidential floor space in the Study Area.

What, then, is the best estimate to make with respect to the number of trips coming to the Central Area? Following the floor area gains indicated by the plan for this area suggests gains in the order of five per cent. Following the trends of the last twenty years suggests further decline. But these are not wholly irreconcilable.

The Central Area may be considered as two parts—the Loop, and the remaining area. In the Loop, because of its extremely intensive use, changes in floor area cannot be great and, in fact, the Central Area plan does not anticipate much change in the quantity of nonresidential floor area. The plan does propose, however, some 10,000 apartments on railroad air rights east of Michigan Avenue. These proposed apartment hotels add five per cent to the total floor space in the Loop.

Considering trends, an increase in floor space of this kind would suggest something approaching stability in the daily intake of persons. Besides, it is probable that the effect of additional residential space would be likely to increase automobile and taxi usage more significantly than it would transit. These places are within walking distance of the Loop, and if these residents go elsewhere in the city, they would be more likely to travel by passenger car. The daily person trips to and from the Loop might increase slightly as a consequence of this increased floor area, but the effect on transit usage would probably not be expected to change current trends. Weighing all of these factors and recognizing that transit services must continue in a healthy fashion to supply the buildings of the Central Area, it has been assumed that there would be no further reductions in the persons arriving by transit and that there would be slight increases in person trips to the Loop.

Turning to the areas adjacent to the Loop, proposed changes in floor area have a more significant effect on projected trip generation. The floor area changes emphasize a shift toward more residential usage, particularly for families of higher average income. This tends to increase journeys, but likewise to increase dependence on passenger cars for trips away from the Loop and on walking or the use of buses for trips to the Loop.

The nonresidential changes are in the direction of converting more extensive manufacturing and warehousing areas toward more person-serving uses. The University of Illinois, the Transportation Center and the Exposition Center are examples. These, plus increased floor space for offices, represent a gain of five

[5]This is evidenced by increasing volumes on the Outer Drive which is the by-pass route for north-south traffic.

per cent in floor space in Ring 1. In this adjacent area the conversion of commercial land and the expanded residential areas—particularly assuming higher income households—should tend slightly to increase over-all rates of trip generation. An estimated thirteen per cent increase in person trips was projected for this part of the Central Area.

While there is an increase of thirteen per cent in daily person trips projected for this part of the Central Area, these travelers are not so highly oriented to transit as those going to the Loop. Subways are not so conveniently placed nor are suburban rail stations convenient to this part of the Central Area. Moreover, land development is not so dense. This means that increased travel by passenger car is much more likely here than in the Loop. As can be seen by comparing present modes of travel to these two parts of the center (Table 22 in the Appendix of Volume I) the adjacent area (District 11) is much more heavily served by cars and buses than by rail facilities. Parking provisions are easier and more likely to be made in this part of the region. Weighing these factors, the planning assumption made was that the number of transit trips to this part of the Central Area would not decline, but would remain at the 1956 level. Some growth was expected here in passenger car trips.

This planning figure for transit journeys in 1980 assumes a healthy, regenerated frame for the Loop and a continuing and vital assembly of activities within the Loop. The projections are illustrated in Figure 24 and reflect an optimistic yet attainable goal for transit service. It is obviously a present goal of city authorities and of community leaders to conserve the great capital investment in Central Area buildings. These currently are estimated to be worth over five billion dollars.[6] It also assumes substantial efforts to maintain and further improve the rail facilities whose current replacement cost might be one-half billion dollars. To supply the people needed to support the Central Area investment, transit facilities are vital. During the present peak hours of travel, eighty-seven of one hundred Loop travelers come by transit, and three-quarters of these on rail facilities. The forecasts, while somewhat optimistic in the light of past trends, do represent a reasonable planning target. The projected central transit trips—1,035,000—will be attainable, but only with substantial effort to reverse the past trends.

Predicting the Origins of Mass Transportation Trips to the Central Area

The object of this chapter is to fix the number of person trips at each zone in the area, according to the mode of travel. Given the total Central Area transit trips, these must be fixed according to their noncentral origin or destination zone as a step in achieving final zonal estimates. Establishing the sources of travel to the center is of significance to the operators of transit service. If more riders go to the Loop from areas nearby, then more bus usage is indicated. If these travelers come from greater distances, elevated-subway trains and suburban railroads will receive more patronage. This has bearing on the frequency of service, on the extension of elevated lines and subways, and on parking and loading problems at suburban stations.

The distribution of the origins of central mass transportation trips is determined partly by the sheer magnitude of the central concentration of nonresidential floor space. Thirty per cent of the working population of the Study Area is employed there—fourteen per cent in the Loop and the remainder in the surrounding Ring 1. Containing by far the largest single concentration of jobs, the Central Area is bound to attract workers from almost every zone in the region and the Central Area worker is a prime transit customer.

The specialized character of the activities in the Central Area is also a major determinant of the travelers who are attracted. Here are department stores, women's specialty shops, headquarters of corporations, lawyers' offices, ticket agents, wholesale houses, theaters and

[6]Floor area multiplied by $15.00 per square foot for estimated value.

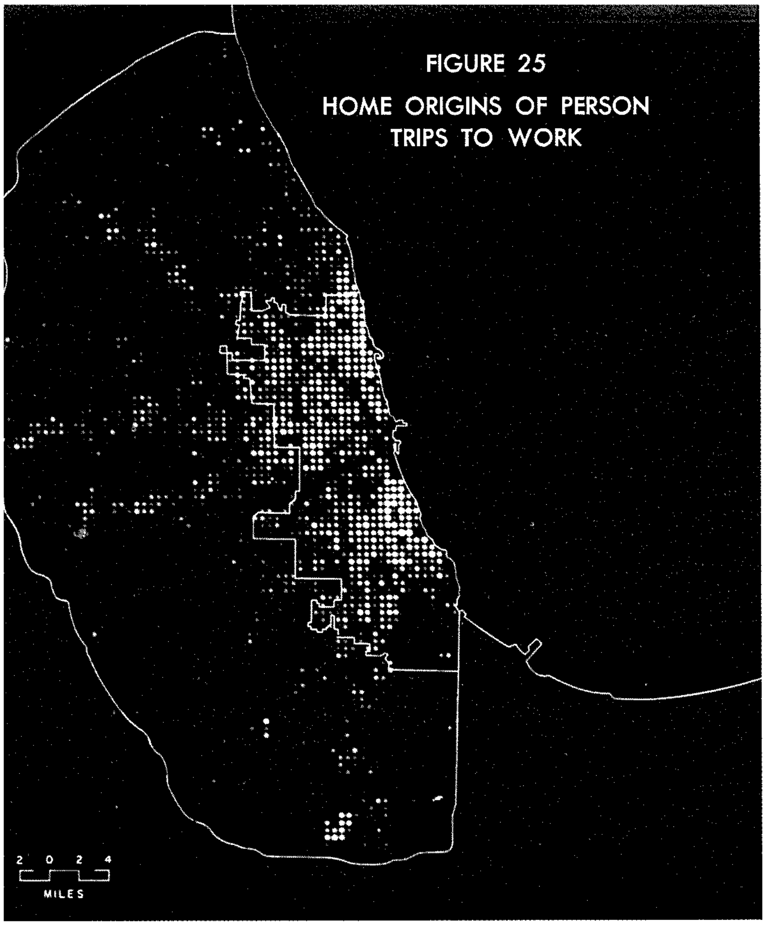


FIGURE 25
HOME ORIGINS OF PERSON TRIPS TO WORK

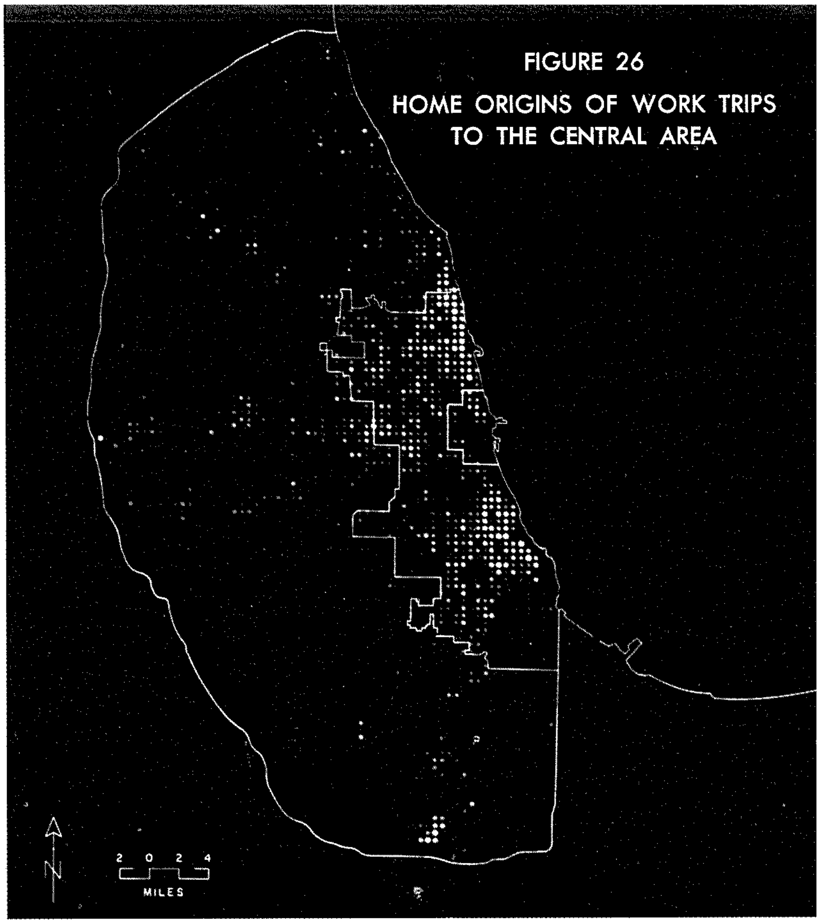


FIGURE 26
HOME ORIGINS OF WORK TRIPS TO THE CENTRAL AREA

The residential origins of all work trips approximate the distribution of population. Home origins of work trips to the Central Area are distributed nearly evenly with population. The availability of suburban railroads and elevated-subway trains is a powerful factor in permitting the daily assembly of 551,000 workers within this concentrated, highly specialized area.

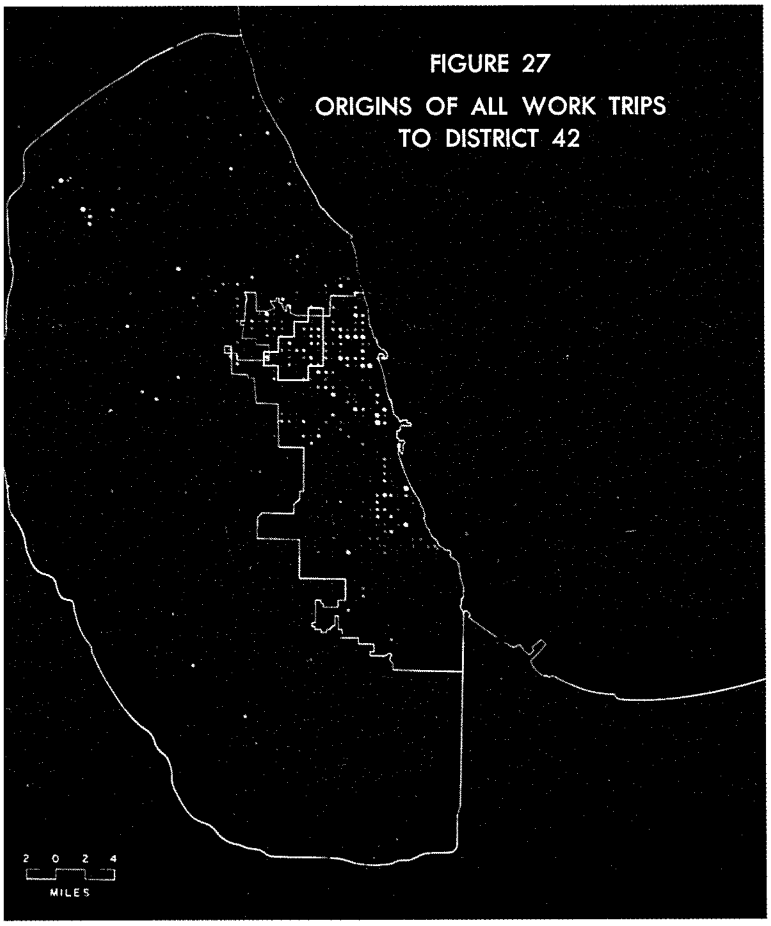


FIGURE 27
ORIGINS OF ALL WORK TRIPS TO DISTRICT 42

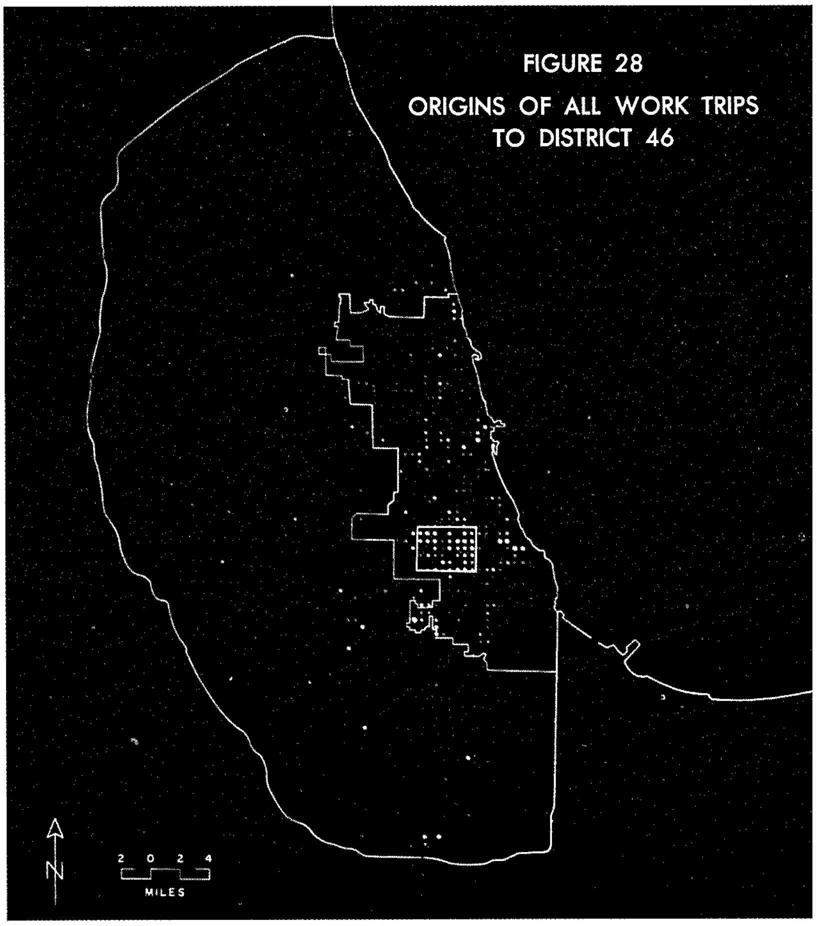


FIGURE 28
ORIGINS OF ALL WORK TRIPS TO DISTRICT 46

The sources of trips to work in Districts 42 and 46 are highly localized. There are many trips originating within each district and progressively fewer as distance between home and work increases. These are less specialized work centers. There is a tendency to minimize journey length and fewer, more dispersed jobs keep the home to work journey on a more individualized basis.

other services which are not obtainable elsewhere. Sooner or later almost everyone in the Chicago region must make a trip to the Central Area for one or another of these services. In the aggregate, this specialized and highly concentrated group of activities produces a steady daily flow of trips to the Central Area, drawn more or less proportionately from the population in all parts of the Chicago region.

With these kinds of attractive power, the Central Area has a more universal draw than does any other place in the Study Area. This can be demonstrated in several ways. First, a dot map of the residential origins of all work trips is shown in Figure 25; this is a reasonable approximation of population. Figure 26 shows the origins of all work trips destined to the Central Area, and it can be seen how closely this distribution approximates that of Figure 25. By contrast, Figures 27 and 28 show the origins of workers to two work places which are non-centrally located. Figure 27, which covers all workers employed in District 42 (the vicinity of Irving Park and Cicero), shows a very local attraction. The same localization appears when the work place is shifted to District 46 (the vicinity of 69th and Ashland) where nearly all employees live south (Figure 28). In fact, examination of every non-central work center showed a similar effect in being selective as to the source of workers. It is quite clear that the Central Area work places draw their workers much more evenly from all parts of the region than is the case for any other employment location.

A second demonstration is given by Figure 29, which shows the comparative distribution of population and Loop employees for two different time periods. In 1916, more than half of the population of Chicago lived within five miles of the Loop, and more than half of the people employed in the Loop resided within the same distance. The similarity between the two lines of population and employment is quite remarkable, indicating that the proportion of the population employed in the Loop was nearly constant, whatever the distance from the Loop. In 1956 the same situation obtained, except that the center of gravity of population, and of Loop employment, had moved outward and had become less peaked, which is to say that population was becoming more widely distributed. These two sets of data indicate the pervasive attraction of the Loop.

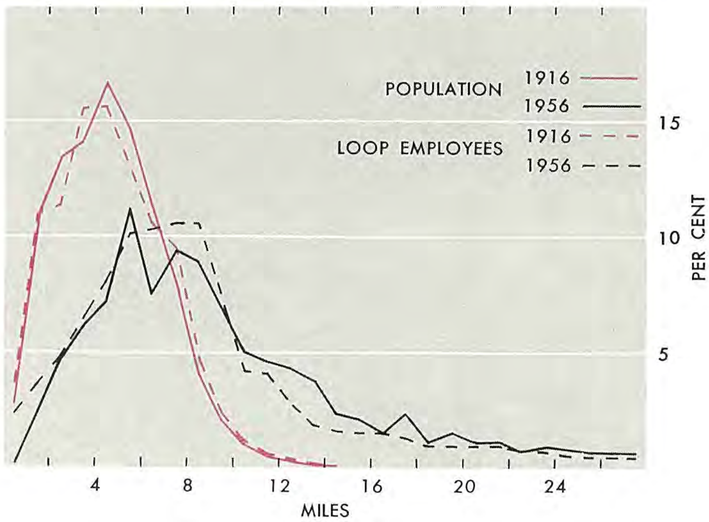


FIGURE 29—PERCENTAGES OF STUDY AREA POPULATION AND LOOP EMPLOYEES FOR 1916 AND 1956, BY DISTANCE FROM THE LOOP

See Table 35 in Appendix.

In the future, the Central Area should continue to attract trips from all parts of the survey area. Its degree of specialization probably will increase. While its share of total Study Area employment, it is estimated, will decline from 30.5 to about 21 per cent in 1980, it still will be the largest single magnet for workers. Since future population will be living at greater distances, the average employee will live farther out and, of course, the average length of the Central Area work trips will increase.

Employment in the Central Area is very closely related to the number of mass transportation trips ending there. One would expect this, since sixty-eight per cent of Central Area and eighty-three per cent of Loop employees use mass transportation. Figure 30 shows that beyond eight miles from the Loop, a high proportion of those who use mass transportation to the Central Area are traveling to work. In the area closer to the Loop, many more people take mass transportation to, than work in, the

Central Area. This is to be expected since, in this short distance range, many will use mass transportation for shopping, personal business and recreation.

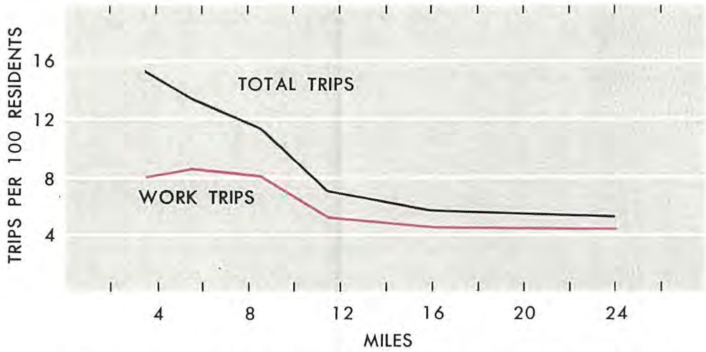


FIGURE 30—1956 MASS TRANSPORTATION TRIPS TO THE CENTRAL AREA PER 100 RESIDENTS, INDICATING THOSE GOING FROM HOME TO WORK, BY DISTANCE FROM THE LOOP

See Table 32 in Appendix.

In the future, fewer mass transportation trips per hundred population will be made to the Central Area. This is because mass transportation arrivals in the Central Area are projected to remain constant, while the population in the Study Area will increase by half. It was reasoned that the drop in rates would be similar for all parts of the Study Area because, as has been indicated, the Central Area exerts an attraction which is affected only slightly by distance.

Actual zonal estimates were made in a fashion calculated to meet two requirements. The first was that the total origins must equal 517,000 (the total transit destinations in the Central Area) and the second that the rate of central transit trips per hundred residents, for 1980, would keep each zone's rate at the same relative position to its neighbor's as at present. This last condition has the virtue of retaining high rates at zones conveniently located with respect to transit service, yet accounting, too, for the increased and substantially rearranged grouping of homes. If anything, this is conservative with respect to the outer suburban zones, since it is likely that Central Area jobs and services will be relatively more specialized in the future. More specialization tends to minimize the effect of distance and to make attraction rates more nearly uniform. The final average 1980 rates, by distance ring, together with those for 1956, are shown in Figure 31.

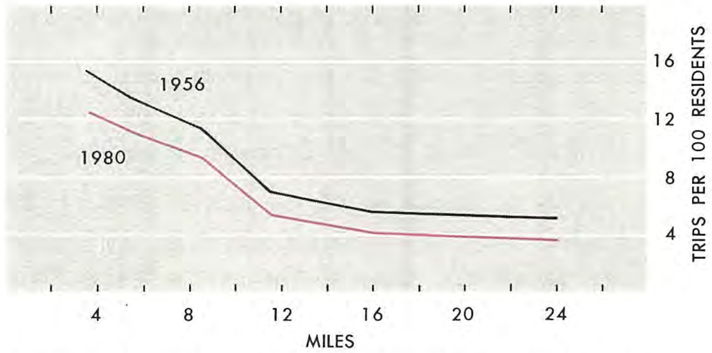


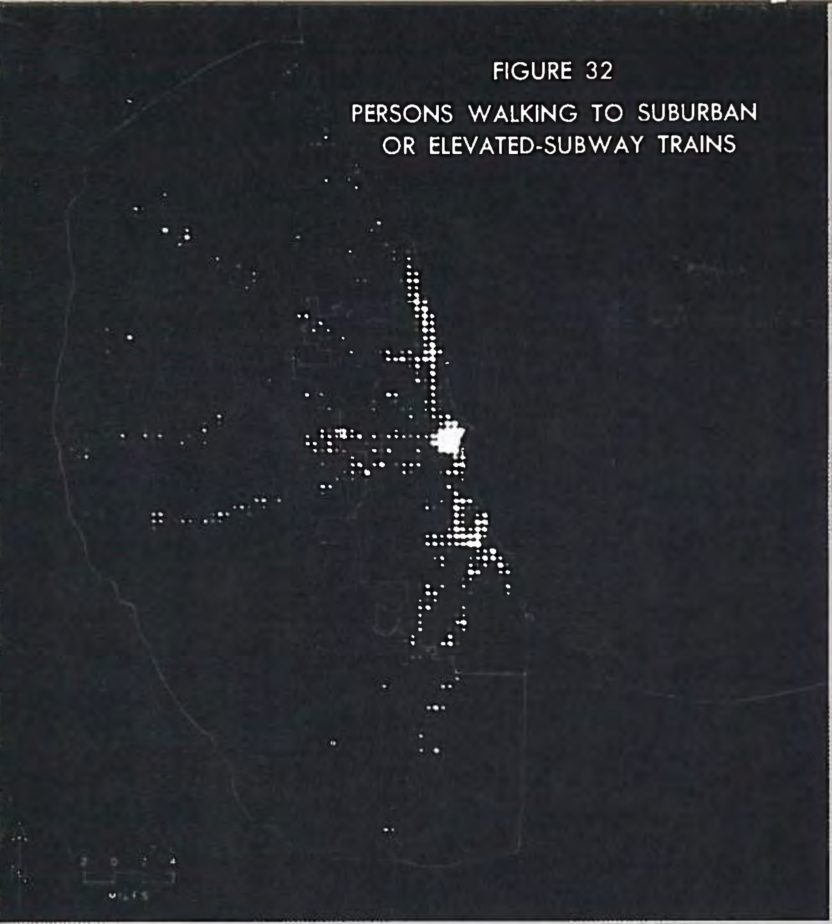
FIGURE 31—MASS TRANSPORTATION TRIPS TO THE CENTRAL AREA PER 100 RESIDENTS, 1956 AND ESTIMATED TO 1980, BY DISTANCE FROM THE LOOP

See Table 32 in Appendix.

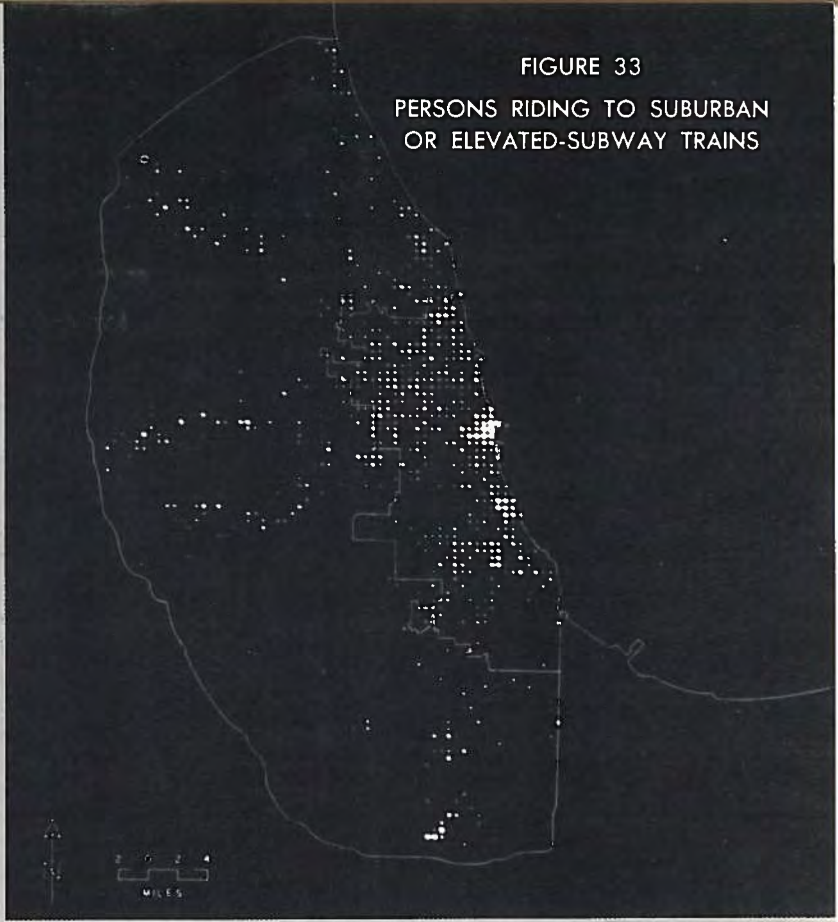
The outward extension of travelers will still preserve the higher attraction values associated with parts of the region having good commuter service. At present, many people walk to suburban railroad or elevated-subway stations. For railroad commuters this is true for sixty per cent of the travelers—the other forty per cent driving or being driven to the suburban station. For elevated-subway users, about half walk and the other half use a feeder bus or occasionally are driven. Under this condition, the closer a household to a rail service line, the greater the chance of finding a Central Area transit user. This is illustrated in Figures 32 and 33.

Figure 32 shows the location of residence for every recorded Central Area traveler of 1956 who walked to railroad or elevated-subway station to start his journey downtown. The number and intensity of dots represents the number of walkers. The sharpness with which these walking sources outline the suburban rail and the elevated-subway lines is quite convincing evidence of the importance of this easy access on travel frequency.

In contrast, Figure 33 shows the location of homes of every traveler who drove, or came as an automobile or bus passenger to the station. These dots also are close to the rail lines, but the dispersion is much greater.



Dots indicate places where persons start walking when making trips by suburban railroad or elevated-subway train. These, naturally, are grouped close to stations.



These dots indicate the trip origins of persons who use automobiles or buses to reach rail stations. About 55 per cent walk from home to rail facilities.

In the future, more people will drive or ride to rail stations. There will be fewer walkers because the population will be more widely spread and because new stations and new rail facilities cannot multiply fast enough to maintain today's close average relationship between homes and stations. While, in the future, railroads will draw commuters over greater distances to their stations, nearby residents should continue to furnish proportionately more travelers than those farther away.

TABLE 18
CENTRAL MASS TRANSPORTATION TRIP ORIGINS, BY RING, 1956 AND ESTIMATED FOR 1980

Ring	Average Distance From Loop	Trips to the Central Area	
		1956	1980
0 and 1........	...	517,000	517,000
2	3.5	115,000	92,000
3	5.5	130,000	104,000
4	8.0	147,000	118,000
5	11.0	52,000	50,000
6	16.0	37,000	51,000
7	24.0	23,000	78,000
8*	...	14,000	25,000
Total ...	...	1,035,000	1,035,000

*Outside Study Area.

The final estimates are summarized in Table 18. This tells a clear story: more trips to the Central Area will be coming from more distant points and fewer from nearby. At a distance of ten to twelve miles, which is to say, such places as Evanston, Oak Park and the South Shore, there will be little change in numbers of persons using mass transportation to the Central Area, whereas there will be substantial growth from the regions beyond these places. The bulk of this growth will lie in the zones adjacent to the suburban rail facilities, since it is presumed that these will continue to supply the most rapid service to the center.

Central Mass Transportation Trips: Conclusion

In the foregoing sections the reasoning has been described which led to estimates of the numbers of mass transportation trips going to the Central Area in 1980. An official plan indicating a moderate increase in total floor area set the main scale. This gain in buildings, together with the forecast rates of car ownership and pattern of residential development, was used in establishing the estimate that transit riders would remain as numerous in

1980 as they were in 1956. This is a reasonable basis for developing plans. Changes of some magnitude were expected in the origins of these trips. Travelers would come from greater distances and probably be more prone to use elevated-subway and suburban rail lines than the bus—a conclusion which is borne out by trend data.

This conclusion has important implications for public action in the Central Area. Rail service and high density core are linked like Siamese twins: one cannot exist without the other. If large numbers of people are to be delivered to this single, most specialized center in the same quantity, and with similar peak times of demand in the future, special attention must be given to the maintenance of the advantages of rail service.

At the residential end of each trip, low densities will force more and more people to drive or ride to a rail terminal. This will create an additional hurdle to the convenience of using rail facilities in lieu of one's car. Two things can be done to maintain the relative convenience of rail service to the traveler. At the suburban stations on railroads and the outer stations on elevated or subway lines, good transit feeder service, adequate parking and easy drive-in facilities will significantly reduce frictions at the suburban end of rail lines. Perhaps even more important, however, will be the improvement of travel from downtown station to the final central destination. Such things as moving sidewalks or continuous service systems have been talked about but these seem quite expensive. Yet, even grade separated and covered pedestrian walkways would be an improvement.

If rail advantages are not maintained, it is possible to conceive of a thinning of central densities as buildings give way to parking lots and peak hour congestion helps to induce a relocation of offices to less congested locations.

Observation of trends and current practice suggest that the actions expected to lead towards lesser central densities are in force. New buildings have parking garages built as integral parts of the structure. Existing and committed express highways will, by their effect on increased capacity and ease of access, increase the demand for central parking. Likewise, such expressways will increase, somewhat, the competitive value of non-central sites, because they lessen access advantages of the center.

The maintaining of a dense central area and, by the same token, the proposed number of future transit riders requires substantial effort to modify current trends. This will require a two-part program. One part is improving the convenience of transit for door-to-desk travel and the other is establishing a policy which will control the use of private cars to and within the Loop or core area. This public action is assumed in establishing the target figure of 1,035,000 daily person trips to and from the Central Area via mass transit facilities.

ESTIMATING LOCAL MASS TRANSPORTATION TRIPS

Historical data on usage of surface mass transportation—including buses and the now extinct streetcars—can be interpreted as trends in local mass transportation trips. One reason is that local mass transportation trips are made up almost entirely (eighty-nine per cent) of bus trips. This is virtually mandatory because the dispersed pattern of origins and destinations of local journeys make these difficult or impossible to service by rail facilities. Only three and eight per cent, respectively, are made by suburban railroad and elevated-subway train. Moreover, of all bus trips, seventy-four per cent are local and this proportion has been virtually constant over time. The Chicago Transit Authority carries about ninety-five per cent of all bus passengers in the Study Area, so its records may be considered as indicative of the trend in numbers of local transit trips.

The number of persons using the mass transportation facilities of the CTA and predecessor companies has been declining for many years. From 3.15 million revenue passengers each weekday in 1930,[7] records show a drop of

[7]This figure refers to prior companies absorbed in 1947 by the Chicago Transit Authority. This and subsequent daily figures are based on a mean of 316 weekday equivalents per year.

mass transportation passengers to 1.75 million daily in 1959. This is a decline which has occurred in a period when urban population in the area has been increasing.

The loss has been mainly in riders on surface mass transportation, as shown in Figure 34. Excluding the war years, when bus usage rose greatly due to gasoline rationing, the decline in patronage of buses and streetcars from 1930-1959 has averaged nearly two per cent per year.[8] The number of subway and elevated train passengers, however, has shown greater stability.

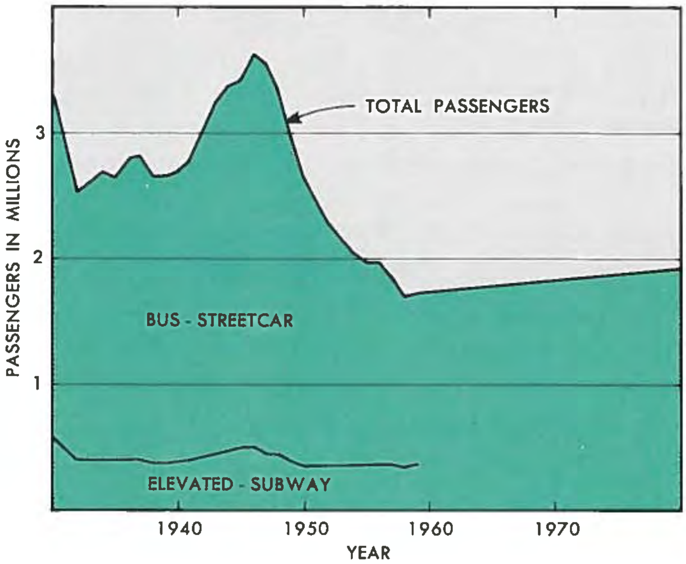


FIGURE 34—AVERAGE WEEKDAY REVENUE PASSENGERS OF THE CHICAGO TRANSIT AUTHORITY, BY MODE, FOR SELECTED YEARS 1930-1959 AND ESTIMATED TO 1980

See Table 48 in Appendix

If projections were based only on extension of trends, the present number of local transit trips might be halved or cut even more by 1980. But trend extension of such fluctuating data is neither a reliable nor a particularly helpful way of making forecasts. It is better to understand the reasons behind the decline in order to infer what may occur in the future.

There are a number of underlying reasons which explain declining bus usage. First, buses provide a slower journey for most travelers than all other forms of vehicular travel and, over the long term, this disadvantage is probably causing losses to the private car. Second, fare increases tend to magnify the advantage of the private automobile for short trips.[9] Third, with urban growth at low densities, destinations are becoming more scattered, whereas mass transportation (as the term "mass" implies) is designed to serve large and concentrated groups of people. A thinning of trade areas makes it difficult to provide frequent service for fewer riders. This causes headways to be increased, thus increasing the waiting time of riders and making transit service less convenient. Finally, automobile ownership is increasing with rising real incomes and more widely spread ownership is gradually eroding the local transit market. All of these reasons sum to one conclusion—that the private automobile has been gaining in advantage in serving the market for short, local trips.

Increases in automobile ownership will have more effect on bus use than on the use of elevated-subway trains or suburban railroads. People who use these latter two modes of travel will more often come from car owning households, but this will less often be true of bus riders. Sixty-six per cent of railroad and forty-eight per cent of elevated-subway passengers currently report knowing how to drive, whereas only twenty-seven per cent of bus riders can drive. Also, half of the bus riders come from households with no car, whereas for railroad users the figure is twenty per cent and for elevated-subway riders forty-three per cent. Use of rail facilities thus depends on considerations other than the rider's ability to use a car. But an increasing number of cars and drivers are expected to have a more marked effect on the use of buses for local trips.

The fact of increasing automobile ownership appears to be the most important factor correlated with the declining use of buses.[10]

[8]By comparison, car registrations have been increasing in the city of Chicago at an average annual rate of about five per cent since the war.

[9]For longer trips, the cost of the mass transportation journey is more competitive with that of automobile travel. And, by the same token, it costs the mass transportation company more to haul passengers for longer distances. The short trips are highly profitable, even though they do tend to slow down service somewhat.

[10]Study was made of other variables related to bus usage. Residential density over long periods of time has remained nearly constant, while bus use has changed markedly. The same holds true for distance from the Loop. Level of service appears to be a result, not a cause, of changing demand for mass transportation. Income data were not available.

It is a good index of what is probably the ultimate cause—rising income. With higher income, people are able to buy a more personalized type of transportation which is consistent with the increased value they ascribe to their personal time. Higher quality, as measured in speed and convenience, is provided by automobiles. Since there are limits to the money and time which can be spent for travel, the allocation of these two resources to the automobile means that less can be spent on other means of travel. In other words, because automobile ownership rises, bus usage will decline, and as a direct result.

Historically, it can be shown that bus use declines as car ownership increases. Figure 35 illustrates how, between 1946 and 1958, the number of daily CTA surface passenger rides declined from eighty-nine to thirty-nine per thousand population. During the same period, automobile registrations in the city of Chicago climbed from 131 to 242 per thousand persons. Up through 1955, both rates changed quickly, but in recent years much more slowly. As previously indicated, this is a reasoned connection: if people buy cars, they will use them; if more people have cars, buses will be used less.

Evidence on car ownership is clearly a crucial factor in estimating future local mass transportation trips. The means of using this evidence to make estimates is shown in Figure 36. This graph, based upon survey results of reported automobile ownership and bus use, indicates that a zone which increases its average car ownership towards the figure of one car per family will have sharp declines in local mass transportation trips. However, smaller effects on local transit usage may be expected as average car ownership rises above one car per family.

District estimates were prepared using the relationships shown in Figure 36. The 1956 automobile ownership rates were known for each district and the 1980 rates had been estimated as described in Chapter IV. The relationship shown in Figure 36 then was used to compute expected local mass transportation trips consistent with the changes in automobile ownership. These rates are expressed in local mass transportation trips per hundred person trips. When applied against the district estimates of person trips for 1980, they produced the estimated local mass transportation trips for that year. The working assumption used is that, for portions of the Study Area as large as a district, the car ownership properties of residents will reflect the proportionate usage of transit for local journeys.

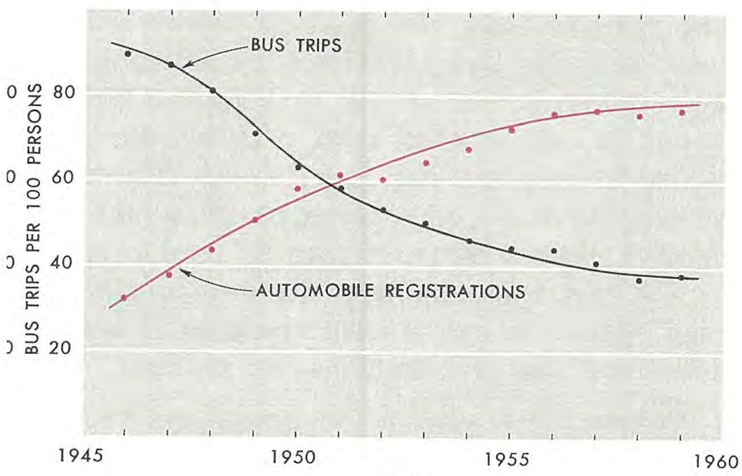


FIGURE 35—CITY OF CHICAGO AUTOMOBILE REGISTRATIONS AND AVERAGE WEEKDAY BUS TRIPS ON THE CHICAGO TRANSIT AUTHORITY SURFACE SYSTEM, AS RELATED TO POPULATION, 1946-1959

See Table 49 in Appendix.

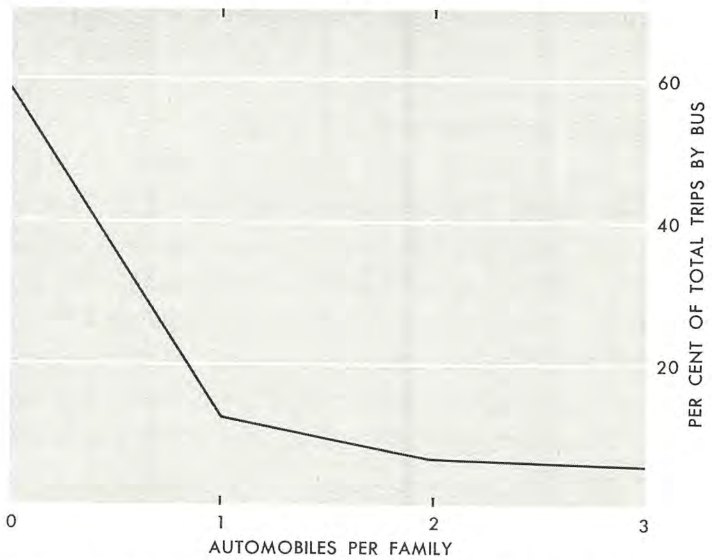


FIGURE 36—BUS TRIPS AS A PERCENTAGE OF ALL PERSON TRIPS RELATED TO AVERAGE FAMILY AUTOMOBILE OWNERSHIP

See Table 52 in Appendix.

TABLE 19
LOCAL MASS TRANSPORTATION TRIPS, BY RING, 1956 AND ESTIMATED FOR 1980

Ring	Local Mass Transportation	
	1956	1980
0 and 1	126,000	126,000
2	247,000	239,000
3	336,000	299,000
4	396,000	322,000
5	162,000	161,000
6	102,000	137,000
7	48,000	162,000
Total	1,417,000	1,446,000

Within districts, zones have individual characteristics of land use and density which affect their generation of local mass transportation trips. These properties are expected to remain much the same for most zones and, where variations occur, special account can be taken of them. Therefore, the percentages of all person trips using local mass transportation would be expected to remain in the same proportion from one zone to the next. A shopping center, for example, with a high percentage of bus trips, would be expected to continue at a higher level than a nearby low-density residential zone. However, since the district containing both shopping center and residential area would, in 1980, have more cars and fewer local mass transportation trips, both types of areas would be expected to lose local mass transportation trips, but in the same proportion. This is quite reasonable since bus trips are short and therefore the residential area is likely to produce those which go to the shopping center. In short, the sum of the zone forecasts in each district was factored to meet the previously estimated district total.

The results of these calculations are shown in Table 19. At the center, local transit trips are those serving a vital need and are required, in large measure, to link residential business activities. Because of the future daytime population expected here, local transit trips are kept constant. The greatest declines are found in Rings 3 and 4, which is not unexpected, since it is in these outer parts of Chicago where automobile ownership will rise, with only small changes in population. In suburban rings, however, the growth in population is so great that the effect of greater car ownership is overcome and local transit trips are projected to increase in number.

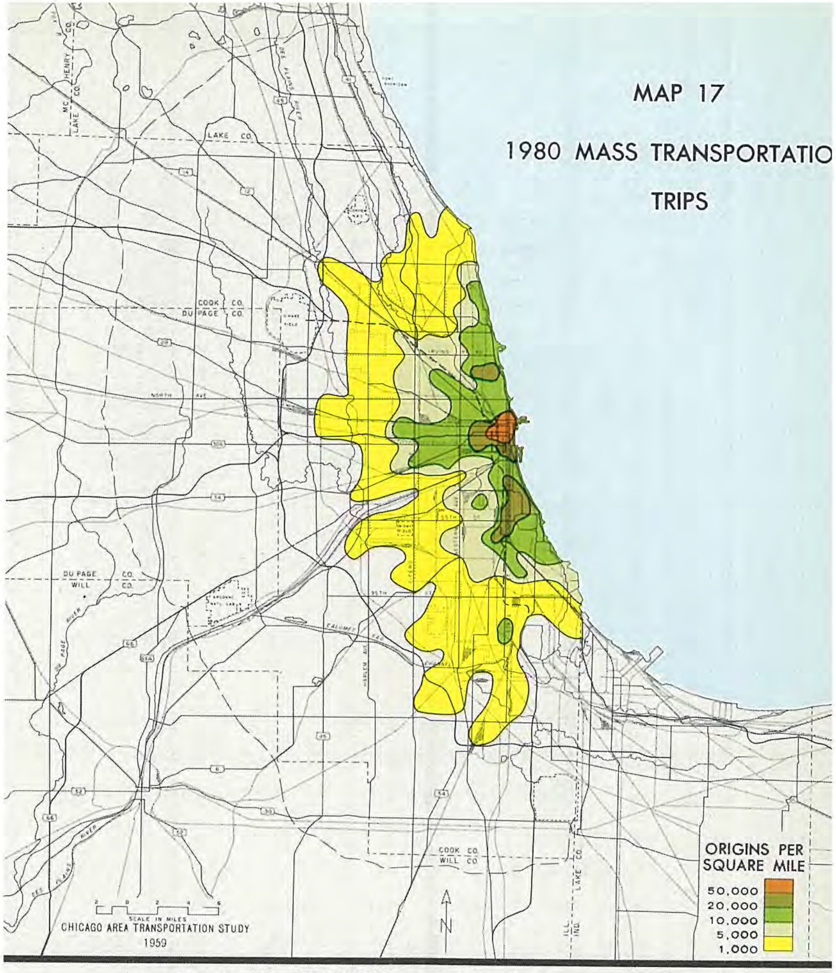
All told, the mass transportation trips which are essentially local in nature are set as being about two per cent greater in 1980 than in 1956. Once again this is an optimistic number. To provide service to a greatly dispersed market of transit riders whose typical density is declining will be quite difficult. There is now little or no bus service in most of Rings 6 and 7. If these projected future trips are to be served, extensions of service will have to be made and this would be, in many cases, into areas where densities are quite low. Such service extensions will tax the ingenuity of the supplier of local bus service and would appear to require something more than is presently being accomplished, excepting by school buses.

MASS TRANSPORTATION FORECASTS REVIEWED

Combining the separate forecasts of mass transportation trips which are centrally and locally oriented, there is only one per cent more mass transportation trips estimated for 1980 than existed in 1956. From 2,452,000 daily person trips in 1956, the mass transportation market for planning purposes is reasoned to consist of 2,481,000 trips in 1980. (Table 20.) This increase is much smaller than the rise in population, but it is more than recent trends would lead one to believe.

TABLE 20
ALL MASS TRANSPORTATION TRIPS BY RING OF ORIGIN, 1956 AND ESTIMATED FOR 1980

Ring	1956	1980
0 and 1	643,000	643,000
2	362,000	331,000
3	466,000	403,000
4	543,000	440,000
5	214,000	211,000
6	139,000	188,000
7	71,000	240,000
8	14,000	25,000
Total	2,452,000	2,481,000



An estimated 2,481,000 transit trips (one per cent more than in 1956) are displayed by origin location. The pattern shows a shift toward the suburbs with some declines in Chicago.

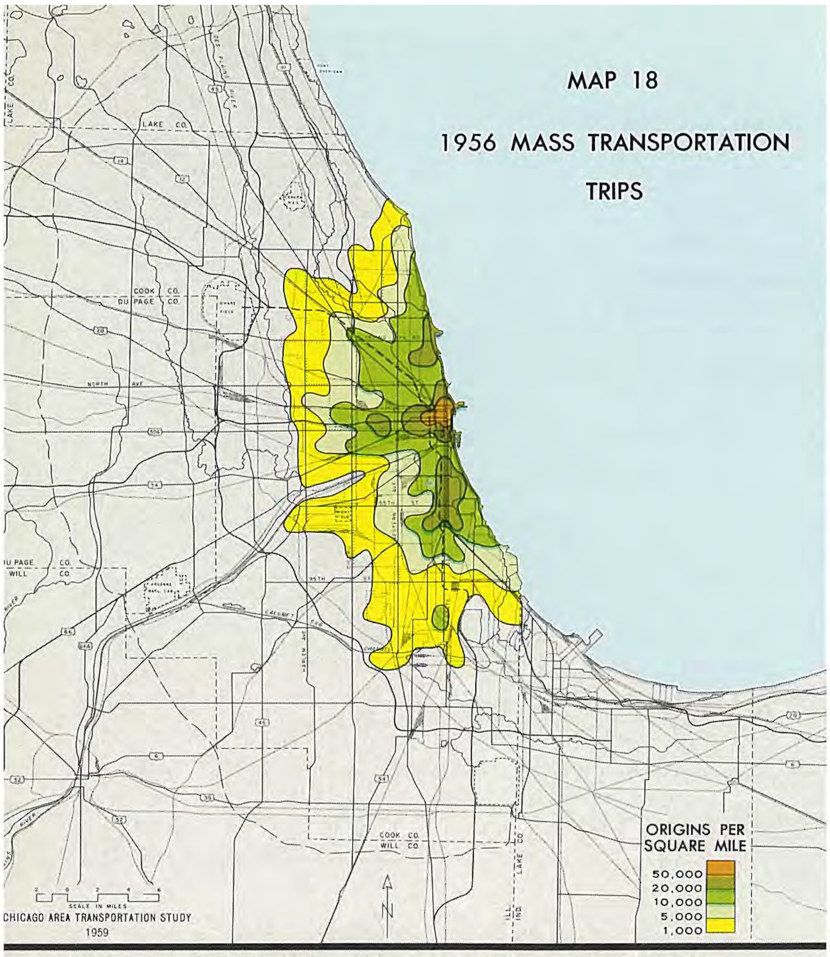
As a check, this total estimate is plotted on the figure showing Chicago Transit Authority daily revenue passengers since 1930 (Figure 34). To make this plot, the estimate was adjusted to exclude suburban railroad passengers and those bus riders in areas outside the CTA territory. (It was presumed that the CTA would continue to serve the same territory.) The result appears to be higher than either short or long term trends would indicate. Only the recent rise in revenue passengers in 1959—the first upturn in fourteen years—gives an indication that the prevailing rapid downward trend might be abated.

A second check was to estimate bus trips only as a function of the number of cars per family. The estimate of car ownership (Chapter II) had been detailed to the extent of giving the probable numbers of families owning zero, one, and two or more automobiles in 1980. The present percentage use of buses, related to car ownership, is known. For example, the average family without a car makes 1.4 bus trips per day, while one and two car families make 0.7 and 0.6 daily trips by bus. Using these figures, it was estimated that 1,729,000 bus trips would be made daily in 1980. When central trips are excluded, this drops to 1,460,000 trips, which differs only two per cent from the more detailed estimate reported in Table 19. While not an independent check—since both estimates were based on car ownership—it still is useful as a demonstration of consistency.

A third check was based on the economic forecast. This forecast indicated that household expenditures for "local and highway" transportation (that is, intra-urban mass transportation and inter-state buses) would be likely to decline from 195 to 177 million dollars between 1956 and 1980. This is a nine per cent decline and would imply an equal or greater decline in numbers of riders. This is, of course, not designed to be optimistic. Moreover, the economic forecast is not too precise on an individual industry basis. So this must only be regarded as a rough corroboration of the range of likely happenings for mass transportation.

In mapped form, the forecast of 1980 mass transportation trip origins by zone exhibits very little change from that of 1956 (Maps 17 and 18). Closer inspection reveals slight extensions of the territory where there are more than a thousand mass transportation trip origins per square mile. But there also are reductions in some of the areas with highest rates of mass transportation trip making. Generally, the colored areas are those in which there is little change or even slight reductions in mass transportation riding. The gains are estimated to take place in that wide region of less than one thousand transit trips per day which extends out to the cordon line. In this region more people will likely be originating their trips to the center. Here also, local bus riding potentials are estimated to be gaining (see Table 19).

This review indicates that the basic estimate of total mass transportation trips is in reasonable balance with the other projected changes



Most mass transportation trips are made in the densely settled central city, with concentrations along rapid transit lines. The remainder are scattered along suburban railroads.

in the region. Changes in living habits and in the wealth and land uses of the region indicate that mass transportation facilities will carry a smaller share of the region's travelers. This will be so even though some increase in total transit riders has been estimated. This is a beginning point from which to examine the changes in transit service which will be required to serve this shifting market of riders. These trip origins will be converted to trips in Chapter VI and this will establish the measurable demand for which service must be provided.

THE FORECAST OF 1980 VEHICLE TRIPS

Up to this point this chapter has been concerned with extracting mass transportation trips from the estimate of 1980 person trips. This was necessary in order that demands for bus and rail service—including both elevated-subway and suburban rail lines—could be established as a basis for planning. It was also the necessary means of determining how many automobile trips to expect.

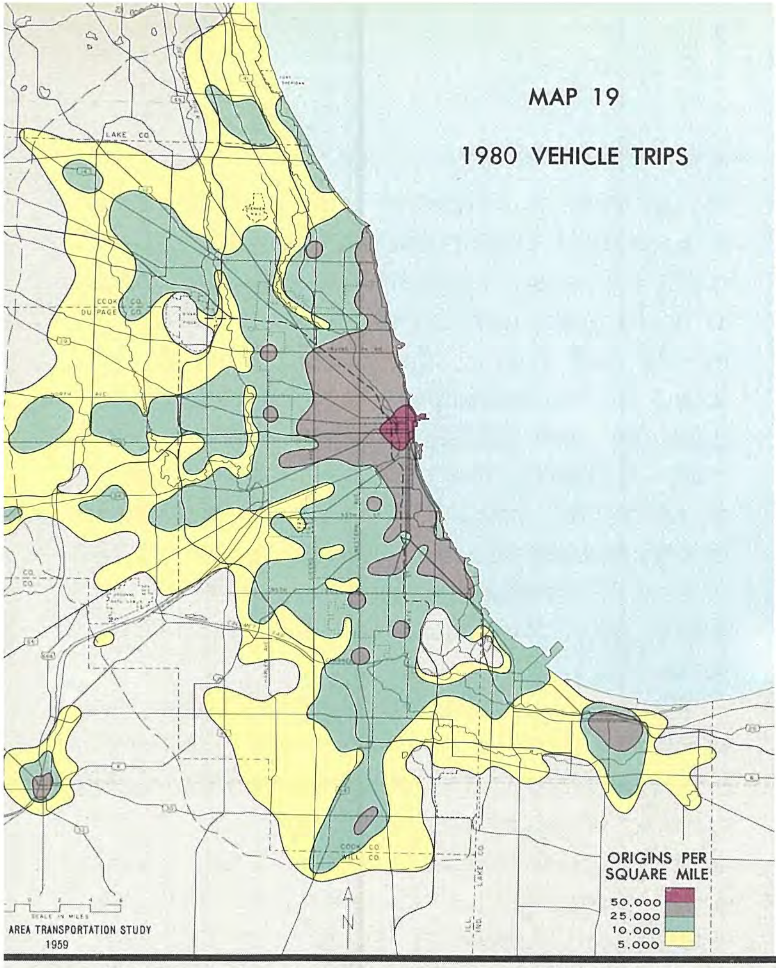
The growth in persons moving by private car is expected to be great—an estimated eighty-six per cent of all person trips in 1980. This is a residual proportion: all person trips not made by mass transportation are presumed to be by passenger car or, in some instances, by taxi. Of course, this assumes that newer forms of transportation—helicopters, moving sidewalks, and ducted fan or pressure-pad aircraft—will carry less than one or two per cent of all person trips. These novel forms seem highly specialized and unlikely to have any chance of serving a significant portion of the area's travel requirements in the next twenty years.

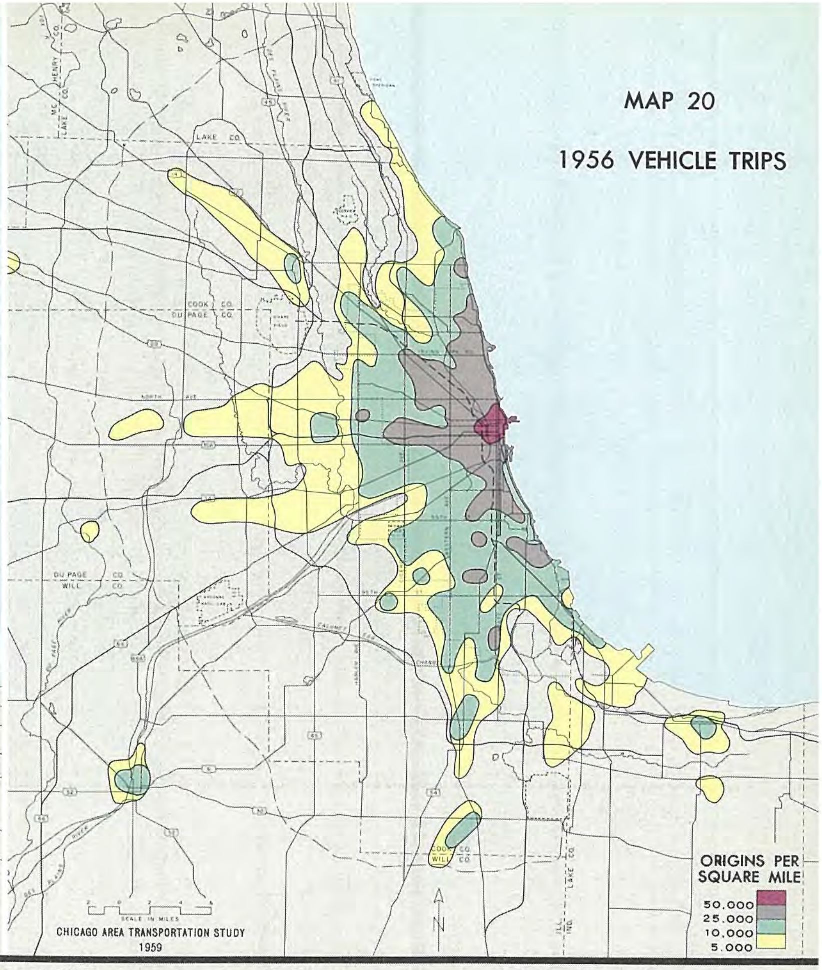
When future mass transportation trips are subtracted from future person trips, it is found that an estimated 15,600,000 person trips remain to be made over the road system of the area, in private vehicles or taxis, each weekday. Assuming, for the moment, that car loading will remain at the present 1.56 persons per car, this means that approximately ten million vehicular trips will be necessary to carry these people on an average weekday. However, car loadings may vary throughout the region, so this should be considered only as a total for checking purposes.

Automobile trips could also be forecast directly from the estimated future numbers of automobiles. In 1956, the 1,342,000 automobiles reported garaged at homes made 4,945,000 trips. This is an average of 3.7 trips per weekday. Applying this rate against the comparable 1980 estimate of 2,600,000 automobiles, would result in 9,600,000 automobile trips per day. Added to this would be trips made by nonresidents and taxis, which could bring the total again to about ten million daily vehicular trips. This figure must also be regarded as a check, since it does not give the locations of trip origins and destinations, but only the numbers which would be reported if interviews were taken in 1980.

The actual forecast of vehicle trips at each zone was based on more detailed considerations[11] and produced a total of 10,194,000 daily automobile trips. This figure is slightly greater

[11]See *Estimating Future Trips for the Study Area* (32,710) (Chicago: CATS, 1960).





Vehicles, it is estimated, will make 12,700,000 trips daily in 1980, an increase of 94 per cent over 1956. The miles of travel driven each day are expected to expand proportionally. The bulk of this new growth will fall on the suburbs and on regions which now are vacant or in agricultural use. District totals appear in Appendix Table 45.

than indicated in the two check totals described above. The more detailed calculation was based upon projected car ownership in each zone with modifications based upon expected variations in land use and density, which would have local effect on the number of persons per vehicle.

This forecast implies a slight decrease in car loading—from 1.56 to 1.53 persons per car. This is a very natural consequence of higher income and more widely held car ownership. Somewhat more cars will be available to the traveling public. However, this figure cannot drop too far. In recent years it appears that a lower limit is being approached. Work trips already average 1.2 persons per car—which means that only every fifth car has a passenger. This cannot be lowered much more. For other trip purposes, such as social recreation, shopping, school and serve passenger, the presence of passengers is almost a direct implication of the trip purpose, so that car loading should decline very little.

The forecast of automobile trips has been combined with the forecast of truck trips (see Chapter IV) and all 1980 vehicle trip origins, by zone, are presented in Map 19. This may be compared with a similar map of all 1956 vehicle trips (Map 20). Generally, the expansion of vehicle trips in the next twenty years follows the expansion of person trips: there are slight gains in the central part of the urbanized area, but by far the greatest growth takes place in the suburban regions. Here the fingers of suburban trip making have fattened perceptibly and most of the land now vacant will be generating trips at the level of five thousand automobile equivalent trips per square mile.

The more thinly developed suburban lands (Rings 6 and 7) still will account for eighty-one per cent of the increase in travel expected when the area reaches the projected size. This has very great significance in accelerated demands for road improvements in these places. However, these travelers will continue to be a part of the great metropolitan region. So, they will be drawn daily towards and into the dense, built up city. Since the streets and highways in the built up center currently are congested, improvements will likewise be needed here. This fixing of origin location of vehicle trips brings the forecasting chain one step closer to fixing the expected 1980 travel demands of the region.

CONCLUSION

This chapter has dealt with the difficult problem of the future usage of mass transportation. Seen from the standpoint of the traveler, both private automobile and public transit have advantages. He may be expected to use whichever means best suits his requirements. This is of significance for planning, because, in a democratic society, people must be allowed a freedom of choice.

Travel to the dense and specialized Central Area is principally on public transit because this is the most convenient way for the bulk of the travelers. Travel between most non-central locations is mostly by personal car. Those who do use mass transportation for non-central trips appear to use this mode of travel more by constraint than by choice. These travelers go mainly by bus and, for the most part, they either have no car available to them or they themselves cannot drive.

What will the future be like? It is clear that there must be a dense Central Area and that it is Chicago's policy to promote this. To continue to have such a center, it must be fed by rail transit services. Rail facilities alone have the capacity to deliver peak hour travelers in the quantity required in a dense center. In view of these considerations, the working estimate for future central mass transportation journeys has been held constant. This, in the light of past trends, may be slightly optimistic, but it represents a reasonable planning objective.

Non-central mass transportation travel, however, will be affected by rising incomes and more widespread car ownership. Therefore, while trips will grow with population, it seems inevitable that the average traveler will make less frequent use of local mass transportation services. Unless mass transportation can be tailored towards individual requirements, it must continue to serve a "captive" market. This market will be spread out more thinly than at present, which will complicate the problems of service. Faced with this view of the future population's requirments, the wisest planning policy is to estimate local bus usage, as determined by current behavior, with respect to car ownership. This gives about the same number of potential riders as at present.

This approach—setting planning figures on the basis of people's choices—is questioned by many writers. They argue that the suburban dweller should be prevented from stretching out into quarter acre lots because a high density, compact city would be much more efficient. This, they argue, would encourage greater mass transportation usage. Such an approach would require substantial governmental action to control building practices. Controlling building and subdivision practices towards this end does not seem a reasonable future expectation. A strong reason is that there is no evidence that high density living is more efficient or that it is preferred by most families.

The approach used in constructing these estimates is that people will continue to behave in the future much as their past behavior would indicate. The general rule has been to scale estimates to the most probable results deriving from the needs and demonstrated behavior patterns of people. This approach was modified somewhat, in making estimates of future transit riders, to be certain that the future task of transit service would not be underestimated.

Given the transit user estimates, the total projected person trips to be carried in passenger cars was established. From these estimates it is possible to develop future travel requirements for rail or rapid transit facilities on the one hand and for highways and expressways on the other. These will be the determinants of needed improvements in both types of facilities. By converting these journeys into measurable trips between particular zones, it will be possible to plan for those changes both in highway and in rail networks best suited to serve the changing travel demands.

Chapter VI
FUTURE TRAVEL DEMAND

In the preceding chapters the growing Chicago region has been advanced to 1980—first, in terms of expanding population and productivity—then, as a pattern of land development. The land development pattern was shown to fix the density of person and vehicular trip terminals. These trips were further distinguished according to the most likely mode of travel. These successive and related estimates are the building blocks for the principal objective of this volume—describing 1980 travel demand.

Travel demand arises from people and from the arrangement of land uses. Numbers of trips constitute a rough index of demand, but the true measure is in journey miles, not journeys. The longer the average trip, the greater the usage of facilities. One seat on a bus may be used several times in the course of an hour, or may be occupied by a single rider. Likewise, longer average vehicle trips will create greater demands for highway capacity.

It is the objective of this chapter to scale future travel demand in vehicle miles for highways and in passenger miles for transit facilities. This will be done first in regional totals, then the estimation of the smaller components or interzonal trips will be described and, finally, the results will be reviewed. This final stage of forecasting will provide the framework for proposing, testing and evaluating plans for major highway and transit improvements — the subject of Volume III.

ESTIMATING TOTAL TRAVEL DEMAND

In many urban area transportation studies, formulas have been devised to describe existing origin-destination patterns. These formulas then have been applied to future conditions, assuming that measured relationships will remain constant. However, when they are applied to an enlarged and changed distribution of trip origins, these formulas can produce unreasonable increases in the total miles of travel and can, therefore, raise serious questions as to the projection technique. This can come about because a systematic, but very small error in each calculation can be magnified greatly when accumulated for a whole region. For this reason, over-all estimates of travel mileage should be prepared independently of the operation of any predictive equation. The cumulative mileage then produced from any predictive formula must be shown to check closely with these control figures.

If there were no change in the length of the average trip by 1980, increasing vehicle mileage would be close to ninety-one per cent greater (the same as vehicle trips), and mass transit passenger miles would remain virtually constant. But the changes in the arrangements of land use and in income were shown to create shifts of origin-destination patterns, so evidence is needed to establish whether average journey length is likely to remain constant. In proceeding to make over-all estimates, vehicle miles are treated first and then estimates are made for total passenger miles of transit journeys.

Vehicle Travel Miles

A tentative first approximation of vehicular travel miles can be obtained from time series data reflecting vehicle usage. Table 21 shows estimates of annual average miles per registered motor vehicle for the United States and for Illinois. Between 1940 and 1958 there has been no noticeable trend suggesting significant changes. The obvious effects of the war years must, of course, be discounted. Since these estimates are dependent on estimates of average miles per gallon of gasoline, they must be taken as being only indicative. Nevertheless, a preliminary conclusion is that annual average mileage per vehicle registered in the Study Area will be about the same in 1980 as it is today.

Because growth in traffic has been so steady, it is difficult to believe that average annual mileage per vehicle remains virtually constant. However, when the growth in registrations is taken into consideration, this would account for most of the vehicular traffic increases of the last ten years.

TABLE 21
ANNUAL AVERAGE MILEAGE PER REGISTERED VEHICLE

Year	United States[a]	Illinois[b]
1940	9,347	9,464
1941	9,545	9,620
1942	8,157	8,755
1943	6,766	6,838
1944	7,006	7,075
1945	8,094	7,938
1946	9,974	10,075
1947	9,839	9,933
1948	9,716	10,270
1949	9,544	10,041
1950	9,369	10,318
1951	9,476	10,401
1952	9,690	10,410
1953	9,674	10,196
1954	9,608	9,815
1955	9,615	10,015
1956	9,623	9,693
1957	9,571	9,706
1958	9,658	9,781

[a]*Automobile Facts and Figures* (Detroit: Automobile Manufacturers Association, 1959-60), p. 43.

[b]State of Illinois, Division of Highways, Bureau of Research and Planning, Table MFC., Motor Fuel Tax Collected and Motor Fuel Consumed (1930-1958).

There are very real limits to the amount of travel being performed each day and each year. While there are people such as traveling salesmen who ring up large annual mileage, most car owners are unable to devote much time to travel, because they are at work, at school, or have other competing demands for their time. Travel is only occasionally rewarding in itself. This is particularly true in urban areas. So, journeys will be completed as quickly as possible to accomplish particular and limited objectives. The typical driver currently averages more than an hour a day in travel inside the Study Area. This time cannot be increased without taking time from other activities. Moreover, travel costs money. When time and cost restraints are recognized, it can be seen that increases in wealth and mobility are likely to be fully accounted for by increased levels of car ownership, and miles driven per vehicle may be expected to remain steady.

To check this tentative conclusion, two additional estimates can be made. One is based upon the privately owned passenger cars according to the location of the owner's residence. The other is based upon the location of vehicle trips and considers trips by all vehicles—commercial as well as private—and external as well as internal trips.

The first test is based on Table 22. This shows that suburban residents not only own more cars on the average, but that they drive them farther each day than do city residents. For each vehicle owned, the weekday mileage actually driven on streets inside the Study Area increases the farther out one lives. At the same time, evidence shows that mileage per vehicle per day seems to be about the same for multi-car families as for those with one car.

If the low density suburban population grows most rapidly, it may be reasoned that mileage per car owned would also grow. If it is assumed that the mileage per vehicle owned, taking into account shifts in multiple car ownership, will remain the same in each ring in 1980 as in 1956, the average trip length would increase. The effect of this assumption, because of the great growth in Ring 7, would be to increase vehicle miles fourteen per cent more than vehicle registrations — i.e., average weekday mileage per vehicle would increase from 11.83 to 13.56 airline miles.

But is the assumption of all things being the same in each ring reasonable? Ring 7 is now a sparsely settled portion of the urban area. Schools are, on the average, farther from homes, as are grocery stores and other conveniences. For this reason, vehicular trips now are longer than average. Likewise, Ring 7 is far from the central city and the bulk of potential places of work and other activities. Therefore, greater average travel distances are required to get to work, to visit friends, or to reach hospitals and department stores. Will these same conditions hold in 1980? As the outer suburban areas become more completely built up, industrial plants, shopping centers and other metropolitan activities will be in closer proximity to residences. This being the case, trips by residents in the outer suburban areas should tend to become shorter as those outer areas fill up.

By taking the more reasonable assumption that mileage per car, per day, of residents in

TABLE 22

AVERAGE AIRLINE DISTANCE OF INTERNAL* AUTOMOBILE TRIPS
BY RESIDENCE LOCATION OF OWNER AND BY NUMBER OF CARS OWNED

— On Average Weekday in 1956 —

Ring of Residence	1956 Percentage of Households With				Average Daily Mileage Per Vehicle		
	No Cars	1 Car	2 Or More Cars	Total	1 Car Households	2 Or More Cars In Household	All Vehicles
0 + 1	65	32	3	100	8.02	9.09	8.03
2	50	45	5	100	7.87	9.60	8.17
3	41	54	5	100	9.68	9.09	9.55
4	28	61	11	100	10.53	10.66	10.55
5	12	71	17	100	12.71	12.43	12.61
6	9	66	25	100	15.36	13.73	14.65
7	8	68	24	100	17.90	16.26	17.20
Area Average	31	58	11	100	11.60	12.38	11.83

*Data from a sub-sample of all interviews (3,892 car owning households owning 4,608 automobiles and reporting 13,761 automobile driver trip records). Covers only trips with both origin and destination inside the survey area.

Ring 7 will be the same, in 1980, as those of the present residents of the next closer ring (Ring 6), future travel mileage would increase only four per cent faster than registrations. This slight percentage increase in average automobile mileage seems to be more consistent with the historical information on mileage per vehicle, and with the limitations on personal time and expenditures for travel.

A different estimate can be made by analyzing the trip length of all vehicle trips by place of trip origin. In addition to resident passenger car trips, the trips of trucks, of taxis, and those made by nonresident vehicles are considered. For this approach, it may be assumed first that the average length of 1980 trips will be the same as those of 1956, according to the ring of trip origin. Table 23 shows the number and length of all vehicle equivalent trips in 1956 and, using this assumption, the computed mileage for 1980 trips. The effect would be to increase vehicle miles by ninety-nine per cent while the trips increased by ninety-three per cent.

The assumption of the same average 1980 trip length for trips originating in each ring is almost certainly not true. The direction of shifts, but not the magnitude, can be predicted.

TABLE 23

ALL VEHICLE EQUIVALENT TRIPS 1956 AND ESTIMATED FOR 1980 BY RING OF ORIGIN AND MILES OF TRAVEL INSIDE THE STUDY AREA

Ring of Origin	Vehicle Equivalent Trips (In Thousands)		Total Airline Miles of Travel 1956 (In Thousands)	Average Trip Distance 1956	Estimated Total Airline Miles For 1980* (In Thousands)
	1956	1980			
0	161	183	802	5.01	920
1	507	585	2,238	4.42	2,580
2	549	751	2,780	4.28	3,210
3	909	1,045	3,593	3.95	4,130
4	1,440	1,668	5,470	3.80	6,350
5	1,103	1,728	4,494	4.08	7,030
6	1,032	2,654	4,257	4.13	10,950
7	733	3,993	3,429	4.68	18,700
Total	6,534	12,604	27,067	4.14	53,870

*1980 Trips multiplied by 1956 average length.

The most probable changes are towards an increase in the length of journeys which start from Ring 0 and 1, and towards some reduction in length for trips which originate in Ring 7. Increases at the center would come about because of increased specialization of land uses serving a larger and more widely spread population. Since all area residents use Central Area services at some time, and since Central Area jobs draw workers quite evenly from all parts of the area, an outward extension of residences will surely lengthen the average journey to and from the center. The opposite tendency—reduction of journey lengths in peripheral areas—would, as pointed out above, be due to the greater development of land in that part of the region. These are self-cancelling changes, so, once again, there is evidence that vehicle miles of travel should roughly double by 1980. This evidence provides a control total to be achieved by the application of any predictive formula.

Transit Passenger Miles

For transit riders the length of journey is of significance in converting total journeys into measurable demands. The transit companies produce seat-miles of transportation. These are as perishable an item as any commodity produced; unused, they are gone immediately, never to be used again. It is, therefore, a major challenge to the transit industry to have its services provided at the right place and at the right time, and in the right quantity. The number of travelers, their location, their journey lengths, and the time occurrence are what provide the demand. The location of routes, size of vehicles and headways need to be adjusted to this demand.

The number of 1980 transit trips has been established in Chapter V as approximately the same as the number for 1956. However, the length of journey may change, thus changing the requirements for service. Since demand is measured in passenger miles, it is essential to ascertain whether trip length is changing.

Transit companies do not maintain records on journey length because they generally operate on a single fare system. No exact answer as to past trends is possible from direct measurement or official records. Some guess, however, can be made from other types of records which have been kept over time.

Of all transit riders, surface transit passengers have been declining most severely, rapid transit next, and suburban rail riders least of all. Table 24 gives evidence of these trends. If 1929 is read as one hundred, then there are only forty-five per cent as many surface riders, fifty-seven per cent as many rapid transit riders and ninety-four per cent as many suburban rail users in 1959 as there were thirty years earlier. Since length of trip is greatest on suburban railroads (14.1 miles, including external trips) and shortest on surface transit (3.6 miles), and with evidence of a proportionate shift of transit riding towards the rail facilities, there is a strong suggestion that the average transit journey is becoming longer.

TABLE 24
TRENDS IN USAGE OF TRANSIT FACILITIES
(Annual Revenue Rides in Millions)

Year	Surface[a]	Elevated-Subway[a]	Railroad[b]
1920	775	191	..
1926	932	229	76
1929	967	197	84
1935	708	127	54
1940	730	124	64
1945	923	157	94
1950	723	111	89
1955	511	113	84
1959	433	113	79

[a]From records of CTA and predecessor companies provided by CTA. The CTA accounts for about ninety-five per cent of all area public transit company fares.

[b]The annual CBD cordon count gives the number of rail riders entering the Loop stations on an average weekday. The number entering multiplied by 316 gives an estimate of annual inbound rail passengers. This number is then doubled to account for both inbound and outbound rail journeys per year.

Another means of estimating 1980 transit passenger mileage is to assume that average journey lengths will be the same for trips in each ring of trip origin. In carrying out this estimate, local trips can be treated separately from those going to and from the Central Area. The assumption of similar average distance is not questionable for trips to the center from any one zone or ring, since these distances obviously must remain the same. Local transit lengths are not likely to change significantly, for local

TABLE 25
TRANSIT AIRLINE TRIP LENGTH BY RING OF TRIP ORIGIN,
1956 AND ESTIMATED FOR 1980

Ring of Origin	1956 Average Airline Distance (Miles)		Per Cent 1956 Trips		Per Cent 1980 Trips	
	Local	Central	Local	Central	Local	Central
0 and 1	1.6	8.3	8.7	50.0	8.5	50.0
2	3.8	3.2	17.6	11.1	16.5	8.9
3	3.6	5.4	23.6	12.5	20.6	10.1
4	3.6	7.9	27.8	14.2	22.3	11.4
5	3.7	11.1	11.5	5.1	11.1	4.8
6	3.7	15.1	7.0	3.6	9.5	4.9
7	5.7	22.8	3.4	2.2	11.2	7.5
8	5.9	28.4	.4	1.3	.4	2.4
Total Average Airline Distance	3.55	8.28	3.55	8.28	3.72	10.8

stores, schools, or work places will be about the same distance from residences in the future as at present.

Table 25 shows the trip lengths computed on the basis of this reasoning. The average local journey increases by only five per cent, due to the greater number of trips estimated for the suburbs where these transit trips tend to be slightly longer. On the other hand, transit journeys to and from the Central Area become thirty per cent longer. In combination, the total mileage of the projected 1980 transit trips is calculated to increase by twenty-two per cent, from 13,683,000 airline miles in 1956 to 16,500,000.

Preliminary Gross Estimates Reviewed

These preliminary estimates of 1980 travel have indicated that automobile and truck travel is expected nearly to double, whereas passenger miles of travel on public transportation facilities would gain by twenty-two per cent. The vehicle miles of travel would increase in roughly the same ratio as registrations and vehicle trips. Transit passenger miles, on the other hand, are expected to grow faster than trips.

The total estimates of future highway and transit usage are important in establishing the expected degree of travel increase as a control total. What must be accomplished to make these gross estimates usable in determining planned improvements for the highway and transit systems is to anticipate how this travel demand will be distributed throughout the region. Only with this information can highway and transit services be adjusted properly to meet the changing needs. The next step, therefore, will be to detail this future travel mileage by location. This involves estimating future zone-to-zone travel movements.

ESTIMATING 1980 INTERZONAL TRAVEL

Connecting origins with destinations to create future journeys is a crucial problem for sound transportation planning. Predicting what one person might do would be difficult, and trying to predict what he would do on a particular day, impossible. Fortunately, the problem does not have to be drawn so finely. The real question is, rather, what will a large number of people most probably do on an average weekday. By grouping journeys at zones of origin and destination, the individual journey becomes a part of a large cluster of journeys, and the characteristics of travel of a large number is more stable and predictable.

The detailing of the future trips is the last step in the forecasting procedure. As before, in the interests of accuracy, all essential ingredients in making these estimates are described. Vehicle trips are estimated first, followed by an estimate of transit journeys.

The task to be completed for both groups of trips can be stated simply. As a "given," there are 582 internal zones, each of which has a previously determined number of 1980 trips.

These trip volumes represent all trip origins. Since they are average twenty-four hour origins, and, therefore, equal to the destinations, they also represent destinations. There is an additional outside universe of trip ends in some sixty-eight zones lying just beyond the Study Area which may or may not exchange trips with the internal zones. The task of prediction is to describe the most probable pattern of trip exchange between each internal zone and all other zones both inside and outside the Study Area. These zone-to-zone estimates then are used as the detailed travel demand which must be served by improved future major highway and transit systems.

ESTIMATING VEHICULAR TRAVEL

To predict future vehicle travel reliably requires that the fundamental properties of travel in an urban environment be understood. This has been, and continues to be, a complex problem. Travel reflects the needs of people and institutions, and the ways in which they function within a highly complex urban system. For estimates to be sound, these needs must be understood and must be described accurately.

In addition to people's needs, the physical array of urban activities over the landscape is an obvious determinant of travel. Here again, the correct measurement, description and exact relationship of travel to the urban landscape is only slowly yielding to hard exploratory investigation.

To build understanding, attention is given first to a description of the existing trips according to their length. The existing information shows a very orderly pattern of number of trips according to journey length. Next, a tentative theory is advanced to explain why these patterns occur. This theory is stated in mathematical terms. With appropriate operational measurements, this allows a test of the theory by "predicting" current behavior. By this procedure a suitable means for estimating detailed future travel patterns can be achieved.

Existing Trip Length Distributions

Trips by cars and trucks are short. Travel in urban areas consists of a very large number of short trips, with progressively fewer trips reported as distances of travel increase. This pattern is described in Figure 37 which shows the number of auto driver journeys in three different urban areas by length of trip.

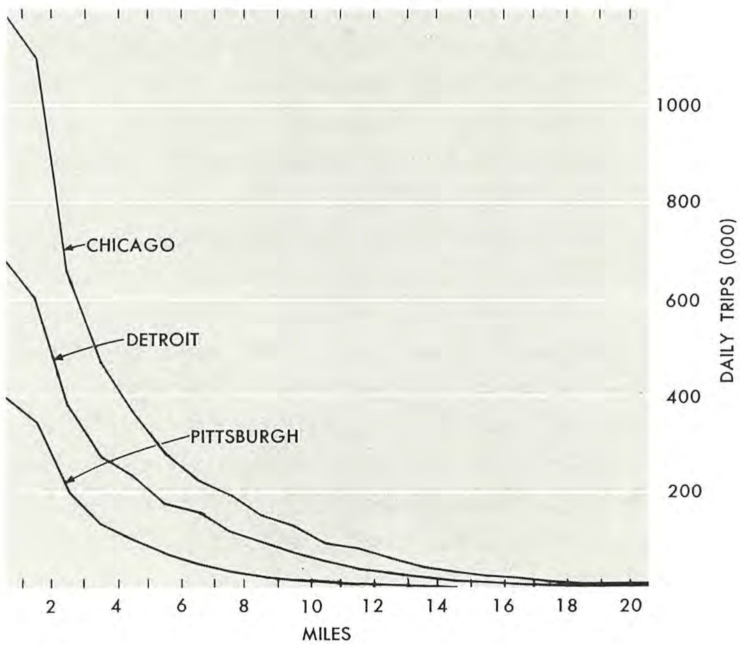


FIGURE 37—COMPARISON OF INTERNAL AUTO DRIVER TRIP LENGTH FREQUENCY DISTRIBUTION FOR THREE URBAN AREAS BY AIRLINE DISTANCE OF JOURNEY

See Table 51 in Appendix.

This figure displays a regular and steady decline in number of trips recorded with each increase in travel distance. In the Chicago area more than half the trips were under three miles in length and the same is true in every other urban study for which data were reported. This repeated and regular pattern probably is the result of common forces at work in all urban areas. If the reasons can be established, they will provide a basis for explaining future travel.

The basic reason for this pattern is that travel has costs. The longer a journey, the more it costs. The term "cost" does not mean simply dollar and cents. There are costs in energy, in work, and, of course, in requiring the use of resources that might be employed otherwise. These costs occur because there is a "friction" component of space which can be overcome only by expending energy for travel—i.e., doing work. If there were no friction and no costs of travel, distance would be of no consequence and one would shop in California or New York as readily as at the corner grocery.

These costs not only affect journey length directly, because of the limited resources of the traveler, but indirectly through their influence on the arrangement of land uses or urban activities. The spacing and mixture of land uses is affected—or even, in large measure, determined—by these travel costs. The repeated, common requirements of people are represented by numerous establishments distributed throughout the urban area. The common goods in grocery, hardware and drug stores are standardized, and these establishments are found in any neighborhood, because each serves a relatively small trade area. The same pattern is true of beauty parlors and barbershops—even doctors' offices and banks. These relatively standard services, like standardized goods, must be distributed in the same way as people, because this is the most economical arrangement for keeping the travel costs down. As goods and services become increasingly uniform and are required as an everyday need of people, the tendency to disperse in the same fashion as the resident population will persist, subject to a balance between economies of scale (i.e., size of store) on the one hand, and the cost of aggregate travel on the other.

The less common goods and services and the constantly emerging new activities such as airports, research centers and computation laboratories are less likely to be reproducible—partly because of their newness and partly because of the limited probability of their use by the average person. These places still will seek locations which keep aggregate travel to them down. The most specialized activities tend to seek out central locations. If they are moderately common—i.e., department stores, high schools or hospitals—they will be distributed like the population, but at greater intervals than the more common stores.

The costs of travel are not solely responsible for all location choices. Some services are designed to serve businesses and some businesses are more concerned with water, land or other requirements than with the costs of trucking or convenience to labor supply. Yet, each activity is dependent on and related to others, and so all are located in an urban region, with an awareness of the real costs of travel.

This spacing of activities, combined with the tendency of people to economize in travel, is what causes the pattern of automobile driver trip length distribution observed in Figure 37. The reason for this is the balancing of the costs of travel against the requirements and rewards for performing travel. The many common needs are close by, and there is little to be gained in driving farther for such establishments as schools or groceries. But when a hospital, a baseball game or a particular friend is wanted, longer trips are made. These longer trips are always in the minority, not only because they cost more, but also because they are less frequently required by the average person.

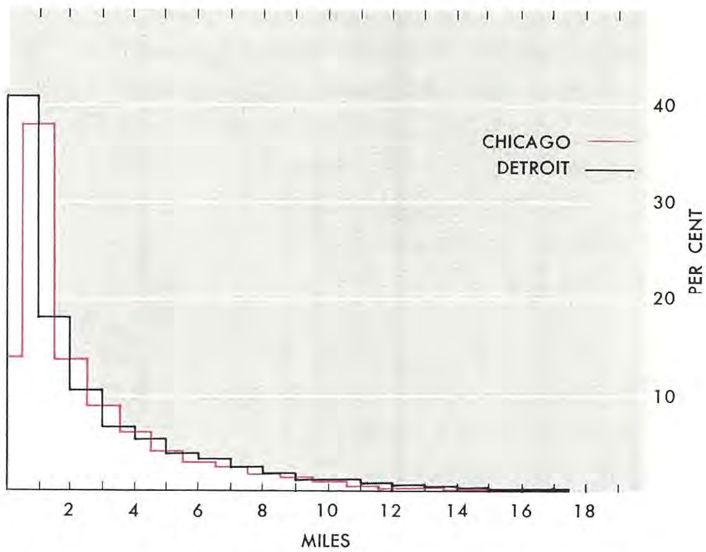


FIGURE 38—COMPARISON OF INTERNAL TRUCK TRIP LENGTH FREQUENCY DISTRIBUTION FOR TWO URBAN AREAS BY AIRLINE DISTANCE OF JOURNEY

See Table 51 in Appendix.

Trucks have a travel pattern similar to that of automobiles. Figure 38 shows the distribution of truck trips by length of trip, as reported in both the Chicago and Detroit areas. The same two factors will explain this pattern—costs of travel and a diversity of trip requirements. The truck driver or dispatcher will seek to minimize travel distance, thus keeping trips as short as possible. However, because of specialization of load or destination, the distances between stops may have to be fairly great. Milk trucks simply go from house to house along a route. Local repairmen and dry cleaners work and deliver in their own communities or trade areas. But other trucks—especially the large combination units—have much more specialized loads and destinations. At the extreme of this group is the interstate trucker. So, again, specialization of journey tends to increase journey length, even though all truckers will try to keep travel time and distance between stops as short as possible.

A Descriptive Theory of Urban Travel

For both automobile and truck movements, the number of trips plotted against trip length provides an extremely orderly pattern. This cannot come about by accident. It has been argued that one cause is travel cost. But travel also has rewards. The observed patterns have been attributed to the natural and universal tendency to economize, pitted against the attraction of particular and special rewards. One force shortens journeys—the other lengthens them. The actual distributions represent a particular balance or equilibrium between the two forces at a point in time, and over a particular arrangement of urban activities or land uses.

That actual travel patterns represent the resolution of two competing tendencies is only a verbal description. To use such an explanation for describing future travel, a more precise statement is required. The following paragraphs will develop a mathematical description of this idea. This will be followed by tests of the accuracy of the formulation and lastly by an operational system for estimating future travel.

Despite the fact that individual journeys defy prediction, the proposed descriptive formula can best be illustrated by considering an individual trip. It is assumed that in making this trip, the traveler will seek to keep it as short as possible. However, the trip has a reason for being made that is peculiar to the particular traveler. This may be stated as a requirement of the traveler for which a satisfaction is sought. The more selective this requirement, the longer the journey is likely to be.

For purposes of illustration, suppose that a particular traveler is going to buy a simple commodity such as a carton of milk. He does not have to be very selective, because milk is common and is sold at almost any food store. It can be established by measurement how many destinations in the entire region are at places which sell milk. Assume that it is one of every 100 or 1/100. In addition, this traveler wants a particular brand sold at only half of the stores; so that the chance of any milk store having the desired brand is only one in two. This means that his chance of finding a randomly chosen destination to be satisfactory is 1/100 x ½ or 1/200. Since this traveler is economical, i.e., he wishes to travel no farther than necessary, he will choose the nearest suitable destination. There is, then, a 1/200 chance that the nearest one will do—i.e., will be at a place that sells the brand he desires. If this destination isn't a store or one that sells the desired brand, then the next is considered and so on until the closest satisfactory point is found. This kind of elimination process can be described mathematically. The closest possible destination, or first point considered, has 1/200 probability of satisfying this traveler. The chance that he would stop at this first point, therefore, would be 1/200, and, of course, the chance he would not is $1-1/200$ or 199/200. The chances of finding the next closest destination point suitable would again be 1/200, but, of course, there is the possibility that the first point would have been chosen and that he would not even get to the second. So his chance of stopping at the second point is somewhat less than 1/200. Precisely stated, the chance of choosing the second point is the chance of getting there $(1-1/200)$ multiplied by the chance of stopping, 1/200. The chance of the third point being selected is the chance of passing the first $(1-1/200)$ multiplied by the chance of passing the second $(1-1/200)$ and, finally, multiplied by the chance of stopping (1/200) or $(1-1/200)^2 \times 1/200$. The chance he would stop at the 100th closest destination point would depend on the chances of getting past the first 99 points $(1-1/200)^{99}$, multiplied by the chance of stopping, 1/200.

To generalize, the probability of a specified trip origin stopping at any randomly chosen destination point may be designated as l. This value is a reflection of the degree of special purpose of a trip. (It is comparable to the 1/200 value in the preceding example.) The probability of that trip stopping at a particular destination point will depend not only on the extent of trip specialization or l value, but also upon how many other points V, lie closer to the trip's origin point. So that the chance of stopping at a particular destination point is equal to the probability of getting to it, $(1-l)^V$ multiplied by l, the probability of stopping.

This provides a simple description of the hypothesis of urban travel patterns advanced. Given any trip origin with a probability l of stopping at a randomly selected destination point, the chance it will stop at a particular destination is:

$$\text{Probability of stopping} = l(1-l)^V \qquad [1]$$

The formula can be further modified to consider zones or clusters of destinations rather than individual ones by assuming that all destinations at any zone are at a specific point—the zone center. Once again there is the chance that the trip will get to the zone at all—i.e., $(1-l)^V$, where V represents the volume of zonal trip destinations lying closer to the point of origin than the potential destination zone, j. Moreover, there is the chance that the trip will still not have found a satisfactory destination even after having considered zone j; i.e., $(1-l)^{(V+V_j)}$. Now clearly, the difference between these two values is the chance that the trip will have stopped at the zone of interest (zone j) so that: the probability of stopping at zone j is

$$(1-l)^V - (1-l)^{(V+V_j)}. \qquad [2]$$

And, from this, it is clear that the larger the number of destinations contained in zone j (i.e., the larger V_j), the greater the chance that a trip will stop in j.

This formulation is not yet satisfactory, since the objective of this work is to predict how many journeys will probably be made from one zone to another. The most simple assumption would be that all trips starting from a zone are alike with respect to their l values. If this were so, it would be possible to describe the expected trips originating in any zone, i and destined to any zone j, (V_{ij}). This would involve, simply, multiplying the entire expression [2] above by V_i (i.e., the total trips originating at zone i) so that:

$$V_{ij} = V_i \left[(1-l)^V - (1-l)^{(V+V_j)} \right]. \qquad [3]$$

But this assumption is not warranted. The term l is a measure of the extent of selectivity of a particular journey. Most frequent journeys are for common, relatively uniform requirements and, this being so, there is little to be gained by traveling farther. For such trips, there is naturally a comparatively high value of l. But there are other journeys with lower values of l, because these travelers have more reason to be selective. Trips to work, for example, are bound to reflect this property, because simply any job will not do, and a slightly higher pay check makes it rewarding for most people to be selective and, therefore, willing to travel some distance. The journeys starting from any zone will certainly have a variety of l values, and any final formulation must take this into account. This leads to a final equation,

$$V_{ij} = \sum_{l\,\min}^{l\,\max} \Delta V_{i_{(l)}} \left[(1-l)^V - (1-l)^{V+V_j} \right], \qquad [4]$$

where $\Delta V_{i_{(l)}}$ represents the portion of all trip origins from zone i having a particular l value.[1]

Testing the Theory

The above is a reasoned hypothesis, but it requires proof. To make a test, these general statements must be translated into an operational form. To accomplish this, two preliminary problems must be solved. First, a method must be established to describe the order of search any traveler would use in deciding on his destination. This is crucial in describing V. Secondly, some method must be found for describing the l values for the trips at any zone.

Three measures have been suggested to establish the nearness of points in an urban region: distance, time and travel cost. If all roads were alike and all carried the same vol-

[1]See Appendix, page 111 for a more formal mathematical statement.

umes, the three measures would be the same. There are differences, however. Distance by itself cannot take into account varying travel speeds, natural barriers or regions of substantial congestion. In this respect, it probably is not a true measure of the weighting an individual driver uses in evaluating alternate possible destinations. Measures of time overcome much of this difficulty, but these cannot account for such things as toll roads. Travel costs, therefore, would be the preferred measure—particularly since it is some balancing of travel costs, in the most general sense of the term "costs," against probable rewards that establishes the theoretical *l* value of any trip. The trouble with travel costs, however, is that at the present state of knowledge they are very difficult to establish and measure. For this reason, it was decided that travel time would provide the most useful index, even though it is more difficult to measure and describe than distance.

Travel time for vehicles must be measured over the street system. To make this possible, each link in the major road system of the area was inventoried as described in Volume I of this report. The length, speed and other characteristics of each link were coded, and the link was identified by geographic position and by its connection with other links. The coded system then was entered into a large computer. The computer, by searching outward from any zone of origin, could find the travel path with the shortest elapsed time from that zone to every other zone.[2]

This information allows the ordering of zones of possible destination with respect to nearness to the selected zone of origin. This provides an operational definition of the term *V* in the proposed formula, i.e., all trip destinations at zones whose travel time from a zone of origin is less than the elapsed time required to reach a considered destination zone, *j*. This describes the surrounding field of destination opportunities which the driver is presumed to scan in making his choice.[3]

[2]A full description of the process and the coded network is contained in the Appendix, page 104 ff.

[3]Now it is clear that each driver does not wake up in the morning, have coffee and then start searching for a place of work. Nevertheless, at some time alternate possibilities are considered for any journey, and in many cases the decision whether to go at all will have been weighed, so that the end result is an ordered pattern of observed behavior. All travelers are constrained to be economical as to their expenditures on travel—yet all will also have particular needs which must be satisfied. The formulation describes this more real and more elaborate form of selection.

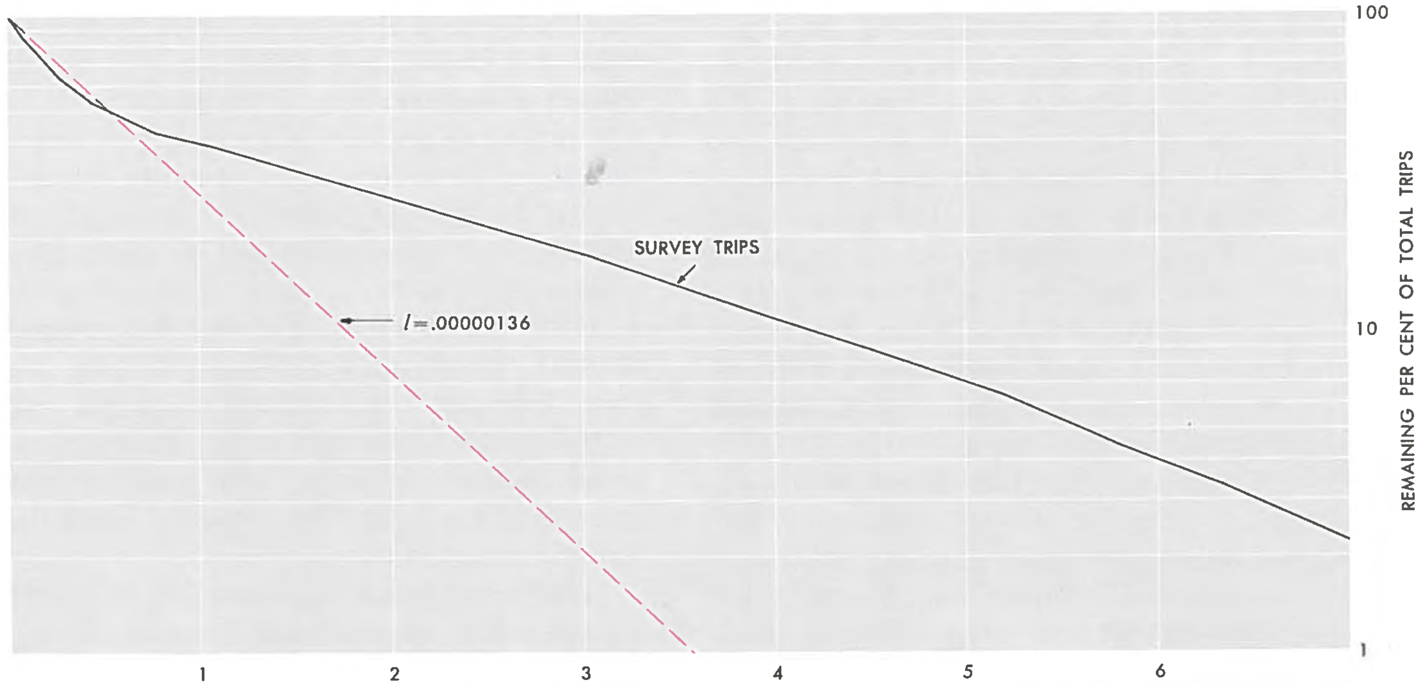


FIGURE 39—CUMULATIVE DISTRIBUTION OF VEHICULAR TRIPS FROM ZONE 001 ACCORDING TO NUMBER OF OPPORTUNITIES: SURVEY DATA COMPARED TO ASSUMPTION OF A CONSTANT RATE OF DECLINE

See Table 53 in Appendix.

With V described operationally, it is possible to measure the characteristics of the l term. To do this, it will be most useful to examine the evidence regarding the existence of a mixture of l values associated with the trips from any zone. In Figure 39 all destination zones have been ordered according to their travel time from Zone 001—a zone in the Central Business District. The bottom axis represents how far any particular zone is from the origin, Zone 001, not in time, distance or cost, but rather in the number of competing potential destinations. The left axis, at logarithmic scale, gives the percentage of all trips from this zone that will not yet have stopped, having considered all zones to that point. The dashed line is one drawn on the assumption that all trips from Zone 001 have the same l value—i.e., $1.36/10^6$ or 1.36 in a million—the particular value required to have half of the computed trips terminated at the same V value as the known trips. The solid line is plotted from the actual data. The two lines are significantly different. So the assumption of a uniform value of l is shown to be unwarranted.

The difference is readily explained by assuming that there is some mixture of l values associated with the actual trips leaving the origin zone. Any mixture in actual values would cause the real data to drop faster as the high l value trips connect with nearby destinations. And this would also explain why there is a steady reduction in rate of drop off at each subsequent group of opportunities, because the remaining trips become increasingly selective—i.e., have progressively lower l values. In fact, if a random distribution of kinds of destinations is assumed, the changing slope of the curve of actual data describes the distribution of l values.[4]

While this supports the general theory advanced, it does not prove it. And proof with a statistical universe made up of individual trips, which are a sample of the true universe, is not easy. Nonetheless, some more critical tests can be constructed once an operational method can be found for approximating the distribution of trips with respect to l at any origin zone.

Any method for approximating the distribution of trips at a zone, with respect to l must also be useful in establishing similar measures for future trips. The mathematics and basis for computing and using a particular distribution of l values for every zone is difficult and not presently feasible for computers. Accordingly, a simple means of approximating this effect was sought.

With a little experimentation, a workable answer was obtained and found to produce reasonable results. The method consisted of classifying trip origins into two groups at every zone —those with high and low l values. The trips expected to have relatively low values—i.e., those likely to travel farther, were additionally divided into two classes depending upon whether they originated from residential or nonresidential land uses.

Two working assumptions were made with respect to these trips: (1) that all trips in all zones falling in either one of the two groups could be represented by a single value of l, and (2) that the group of trips with the lower l value—i.e., the longer and more specialized journeys—would be restricted, so that trips from residential origins could connect only with nonresidential destinations and vice versa.

The two l values were determined empirically. The higher l was fixed so as to satisfy approximately the typical proportion of intra-zonal journeys—i.e., those which did not leave their origin zone. The lower l value was established so as to yield the appropriate total vehicle miles of travel in the network (trips carrying the lower value account for about ninety per cent of the vehicle miles of travel). These operational assumptions having been made, it was possible to test further the extent to which the theory fits the facts.[5]

Seven zones generating some 200,000 daily vehicular trips were selected to represent various types of zones in various parts of the region. The formula was used to compute the trips from

[4]If, on Figure 39, a tangent to the curve of actual data were drawn, it would represent the assumed l value for the still undelivered trips.

[5]The actual formula used is number [6] in the Appendix, page 111.

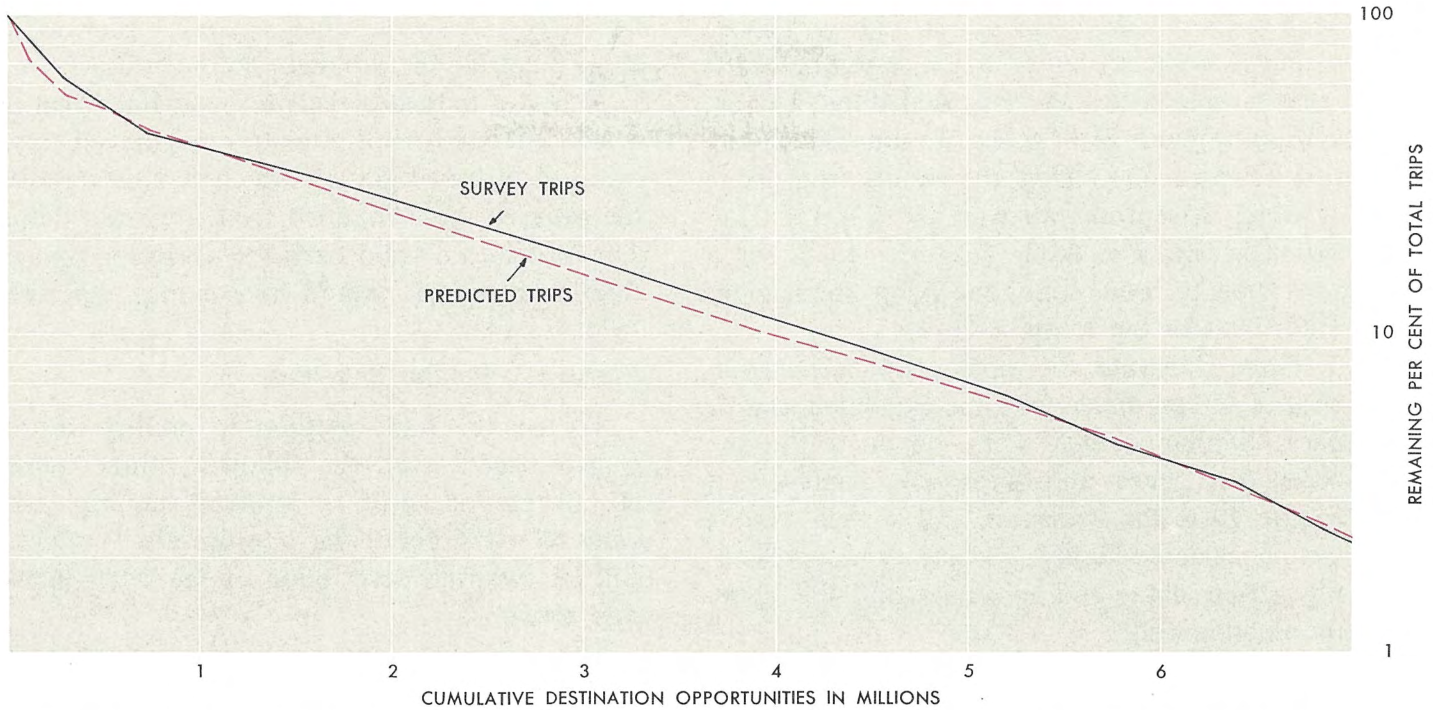


FIGURE 40—CUMULATIVE DISTRIBUTION OF VEHICULAR TRIPS FROM ZONE 001 ACCORDING TO NUMBER OF OPPORTUNITIES: SURVEY DATA COMPARED TO PREDICTIVE FORMULA RESULTS

See Table 53 in Appendix.

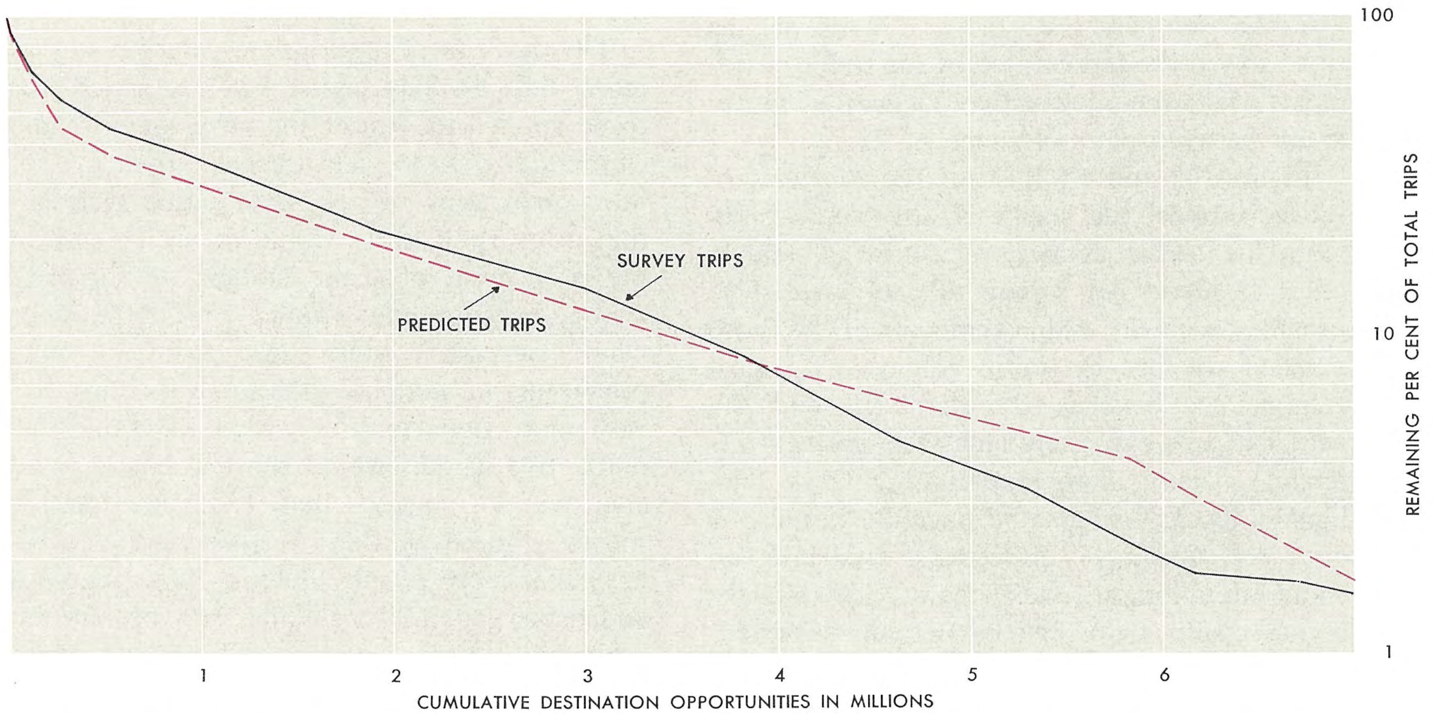


FIGURE 41—CUMULATIVE DISTRIBUTION OF VEHICULAR TRIPS FROM ZONE 067 ACCORDING TO NUMBER OF OPPORTUNITIES: SURVEY DATA COMPARED TO PREDICTIVE FORMULA RESULTS

See Table 53 in Appendix.

each of these zones to all zones. The correspondence of predicted values[6] to the results obtained from sample data was very good. Plots for two substantially different zones are illustrated. The first (Figure 40) shows the results from Zone 1, which is representative of the Central Business District. The other (Figure 41) is for a high density residential zone lying about eight miles west of the Loop.

These illustrate the very good correspondence of the predicted with the expanded sample data. Similar results were obtained for the other test zones and these are displayed in Figure 49 in the Appendix. All of these results were considered highly satisfactory in representing actual data, and in supporting the hypothesis advanced.

As a more complete test, all zonal interchange volumes were calculated in a large computer and were assigned to the quickest travel route between each pair of zones. This process provided a distribution of zone-to-zone movements over the existing highway network. Actual zonal interchanges, as obtained from surveys, were also allocated to the same highway network in the same fashion. The two resultant, loaded networks then could be compared. This is a more complete test, since the real problems to be solved are represented by the traffic movements over streets rather than by detailed movements between pairs of zones.

Figures 42 and 43 illustrate the comparison. In each model the height of any block represents the traffic density, measured in vehicle miles of travel per square mile of area. This provides a quick, visible summary of the more detailed tracings of traffic volumes. The correspondence between the predicted and the actual trips is extremely high. The greatest difference occurs along express highways (the highest blocks) where the formula, because it does not, under this procedure, take into account limitations of road capacity, yields slightly higher results than do trips actually reported. This can be interpreted to mean that more travelers would make trips with routings along the Outer Drive or other express highways if it were not for the problem of congestion.

This test indicates that the formula, when it is carried out for all zone-to-zone movements, produces a travel pattern which is substantially the same as that obtained from reported data. This provides a valid basis for assuming that a similar approach would reasonably describe 1980 travel.

Future Vehicular Trip Patterns

To use the same method to predict future zone-to-zone travel, the following three items of information must be known: the trip volumes at each zone, the appropriate *l* values, and an accurate description of the 1980 highway network.

The estimated 1980 vehicular trip volumes at each zone have been reported in Chapter V. These had to be further detailed either as local or as special trips—i.e., those suited to the higher or lower *l* values. In addition, the more specialized trips had to be classified according to their residential or nonresidential terminal characteristics. This was readily accomplished, because the trip forecast had been detailed with evidence as to type of trip as well as by land use characteristics of each trip.

The problem of appropriate values for *l* was more difficult. The higher *l* value, which was to be applied to shorter journeys, was initially calibrated so as to yield typical proportions of intra-zonal trips. If the same value were retained for 1980, there would be an increase in the proportion of trips retained within most zones, because the volume of destinations would increase in most zones. With the same probability of stopping (the same *l* value) and with more opportunities within the same distance, trip lengths would shorten. There is no evidence to suggest that trips are getting shorter. Moreover, there is good reason to believe that more people, making more journeys and being generally wealthier, will become increasingly selective and this will cause *l* values to drop.

Therefore, it was assumed that, for 1980, the proportion of trips satisfied without leaving their own zones would be the same as in 1956.

[6] The higher *l* value was $21/10^6$ and the lower one $2.3/10^6$.

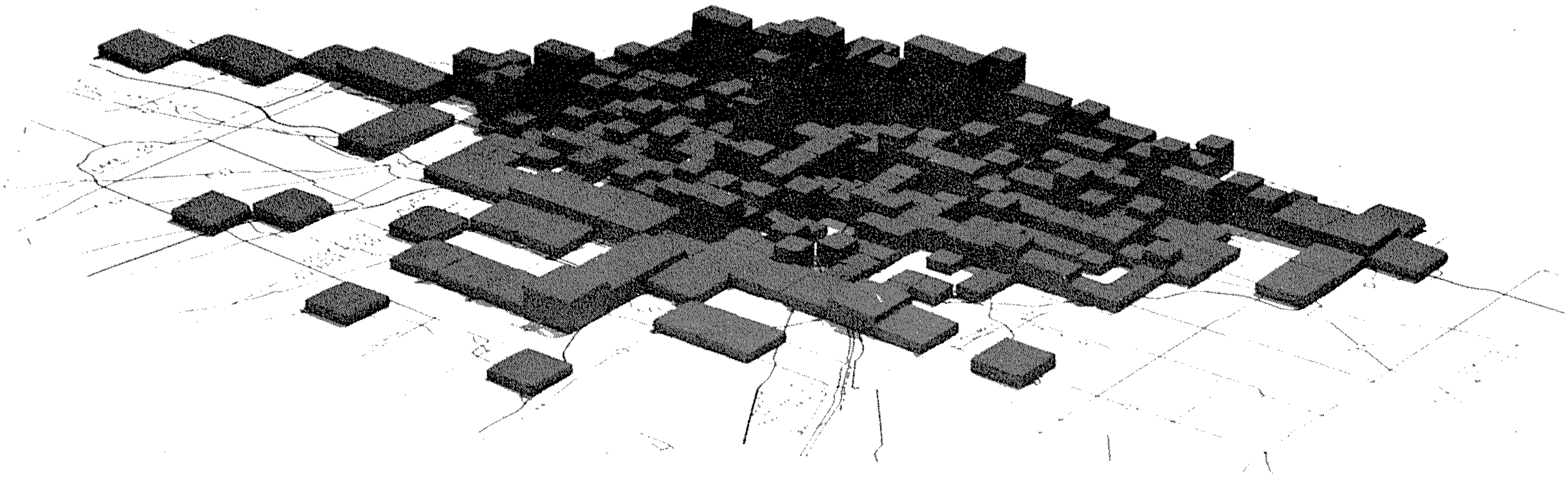


FIGURE 42—ACTUAL 1956 VEHICLE MILES OF TRAVEL ON EXISTING ARTERIAL STREETS AND EXPRESS HIGHWAYS

Actual zone to zone vehicle trips were assigned to the fastest routes between zone centers. This produced 35,800,000 vehicle miles of travel (trucks weighted) on the major street system. The height of each block represents the recorded miles of travel or density of vehicle miles of travel per square mile of area. The unusually high blocks are caused by having major express highways in these locations.

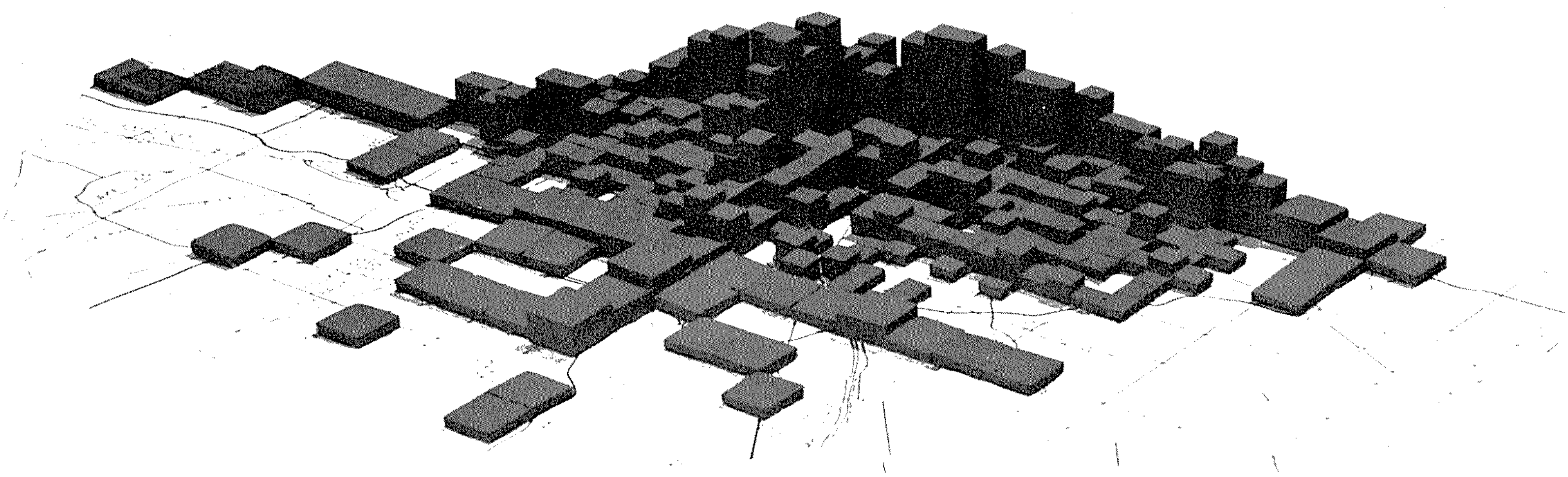


FIGURE 43—COMPUTED 1956 VEHICLE MILES OF TRAVEL ON EXISTING ARTERIAL STREETS AND EXPRESS HIGHWAYS

To prepare this model, zone to zone travel was computed by the predictive formula, using the known number of trips starting at each zone. Computed vehicle trips were then assigned to the major street system and a model built as described under Figure 42. The total of 36,400,000 vehicle miles of travel and its distribution within the Study Area illustrates the correspondence of computed to actual trips.

This means that $l_{s\ 1956} \times V_{is\ 1956} = l_{s\ 1980} \times V_{is\ 1980}$ where l_s is the probability of a local trip origin finding a randomly selected local trip destination suitable and V_{is} is the number of local vehicle equivalent trip destinations in a typical zone. The total number of trips in mature or completely built up zones is expected to change very little—possibly increasing on the average by as much as thirteen to eighteen per cent. Growth in the remaining parts of the area tends merely to bring sparsely settled zones closer to full development, so the typical value of $V_{is\ 1980}$ can be best calibrated from growth of travel in mature or fully developed zones. Since, in these zones, typical increase in local trips is about fifteen per cent, it follows that the expected 1980 l value for shorter trips will fall by about fifteen per cent. Accordingly, the 1956 value of $21/10^6$ was reduced to $18/10^6$ for the group of 1980 trips in the local, non-specialized category.

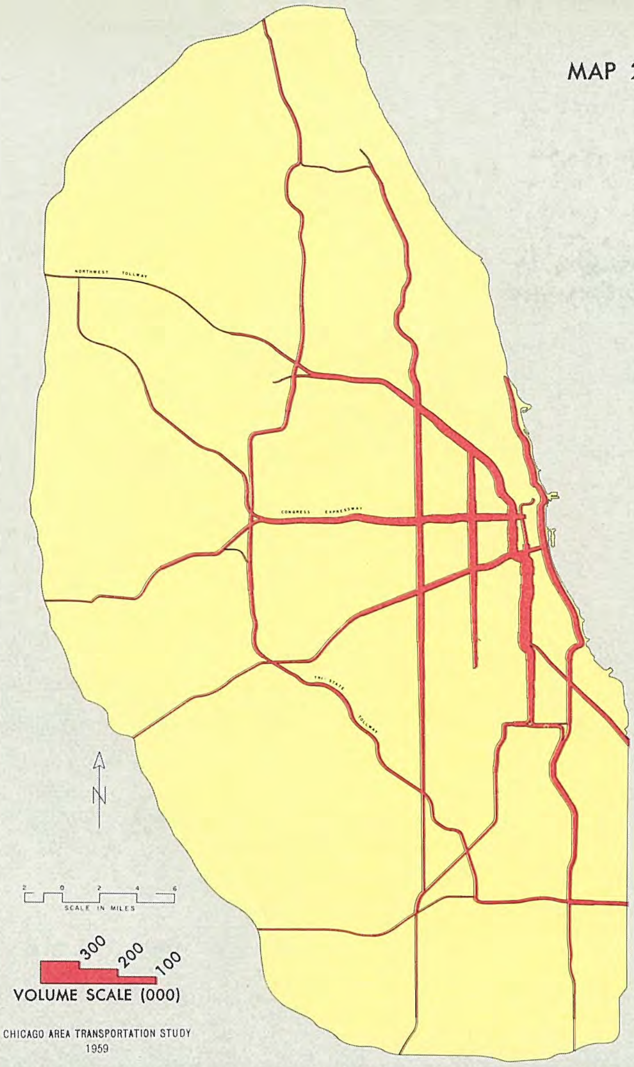
The l value of 1980 for the more specialized trip poses somewhat different problems, but this value is established by much the same reasoning. In this case, the value represents, again, the likelihood of finding a satisfactory destination within a particular V volume of chances. This value would be expected to fall with an increased population because of the increasing number and diversity (specialization) of trips. A maximum drop would be to decrease the 1956 value by nearly half, because total trips nearly double. But this would presume that every zone doubled in number of trips and this is not so. Trips from zones which are now vacant or thinly settled will increase most and the average journey lengths of these travelers would tend to decrease because a much more complete array of opportunities will be found close by. The reverse will take place at zones which grow less rapidly than the entire area. Travelers in these zones will have more specialized types of trips and, because there is a less than average increase in destination opportunities close by, they will be expected to range somewhat farther than before. Therefore, the 1980 value of l, for the specialized trips, should lie between the 1956 value and a value of almost one-half that size. The final estimate—$1.75/10^6$ (in contrast to the 1956 value of $2.3/10^6$)—was obtained by making a trial assumption, computing total travel mileage and then computing the value which would most closely conform to the previously computed total mileage estimate.

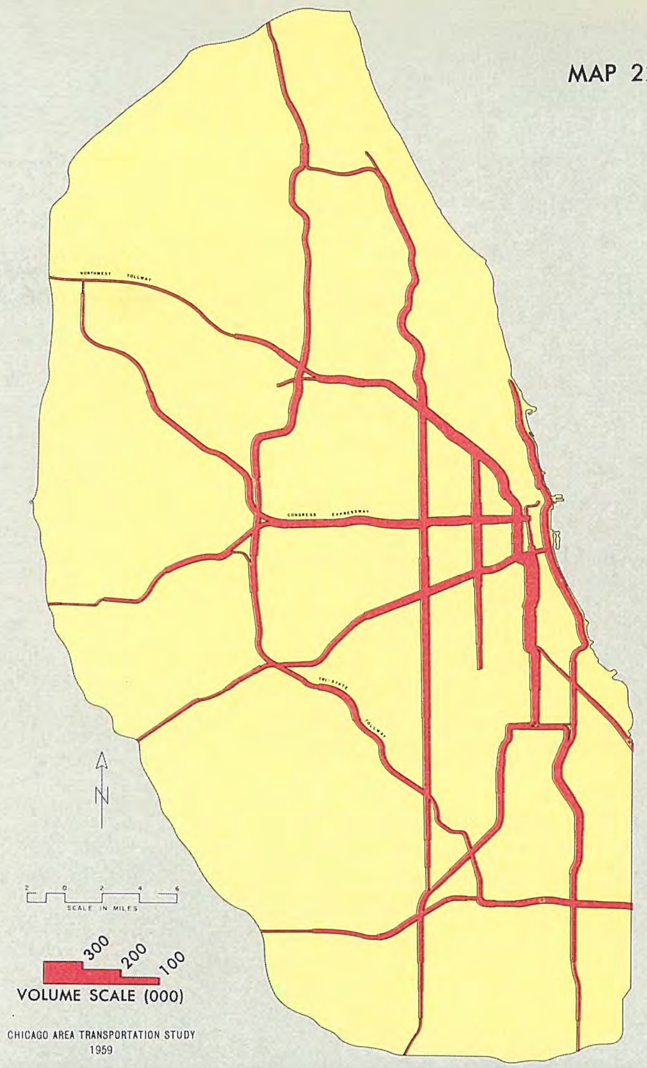
Even with zone volumes and 1980 l values determined, zone-to-zone movements could not be calculated without a description of the network of travel facilities—the very thing being planned. This poses a dilemma. Zone-to-zone travel cannot be estimated until a network is specified, yet the 1980 travel is an important consideration in fixing the amount and location of new facilities. Fortunately, this problem can be solved operationally without prejudice to the planning process.

At present, a complete road system is in place and all zones in the Chicago area can be reached readily. Further improvements may enlarge the capacities of this network, or may change the level of performance (i.e., building expressways rather than widening surface streets), but such changes will not severely alter the relative closeness of zones to one another.

It is this element of relative proximity that determines the V value in any calculation. If speeds on all streets were arbitrarily doubled or halved, the zone-to-zone calculations would not change. Distance remains a major component in computing relative closeness, and this cannot be changed appreciably by new roads, because there are roads nearly everywhere today. Accordingly, the present roadway network, plus all changes presently made or contemplated by the highway building agencies, can be used as a base network for computing 1980 zone-to-zone travel. Other network changes which may be planned or wanted will not severely alter the zone-to-zone calculations or the vehicle miles of travel. The greatest effect of network changes is to alter the routes of travel chosen and the loadings found on the several parts of the network.

Using this more complete street system, 1980 zone-to-zone movements were calculated and were also allocated to travel routes. For con-





1956 TRAVEL VOLUMES
ALLOCATED TO EXPRESSWAY SYSTEM

1980 TRAVEL VOLUMES
ALLOCATED TO EXPRESSWAY SYSTEM

Express routes currently planned or discussed are shown, with usage estimated by computer assignment. In 1956, 16,333,000 vehicle miles of travel—48 per cent of the total driven each weekday—are estimated to use these routes. By 1980, the assignment indicates 25,191,000 vehicle miles on expressways—38 per cent of the total. Toll routes are treated as free expressways in both cases.

trol and comparison, the 1956 travel was also re-computed over the new and enlarged network. To illustrate the effect of a network change on vehicle miles of travel, it is of interest that the 1956 vehicle miles computed and traced over this network totaled 34,350,000 in contrast to a total of 34,200,000 computed over the existing street system.

The main objective of computing 1956 and 1980 travel over the same network is to show the changes in the location of travel demand. The results of the two assignments are illustrated on Maps 21 and 22 and in Figures 44 and 45. The two models illustrate the travel volumes assigned to the arterial streets, whereas the two maps show the volumes assigned to the assumed network of express highways.

The usage of arterial streets changes most severely. As in prior illustrations, the elevation of a block gives the density of traffic on arterial streets per square mile of land area—i.e., the total vehicle miles of travel made on streets in each zone is divided by the area of the zone in square miles. The very great growth in travel on outlying arterial streets illustrates the effect of the projected shifts in location of trip origins and destinations. This gives a three dimensional image of the gradual changes from year to year, carried all the way to 1980.

Maps 21 and 22 show the shifting usage anticipated if this express network had been in place in 1956 and was unchanged in 1980. The same outward growth is apparent, but the growth in the outer parts of the region does not appear to be so great as in the case of arterial streets. This is expected, since the wider spacing of expressways in this outer region makes them less suited to the bulk of new suburban

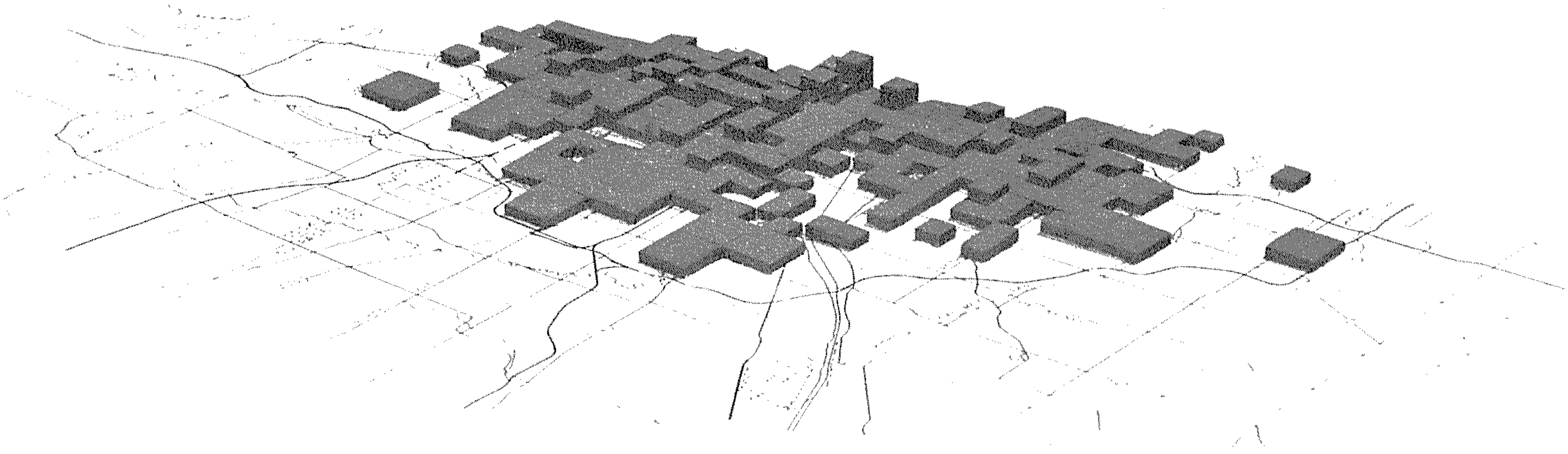


FIGURE 44—1956 COMPUTED VEHICLE MILES OF TRAVEL ON ARTERIAL STREETS WITH A LIMITED EXPRESSWAY SYSTEM ASSUMED TO BE COMPLETED

This model shows the distribution of 17,906,000 weighted vehicle miles of travel assigned to the arterial streets. Travel on expressways has been extracted and is presented on Map 21. The lowest block represents 25,000 vehicle miles of travel per square mile which may be visualized as 12,500 vehicles per day on each of two one-mile arterials within a square mile. The highest block represents 158,000 vehicle miles of travel per square mile.

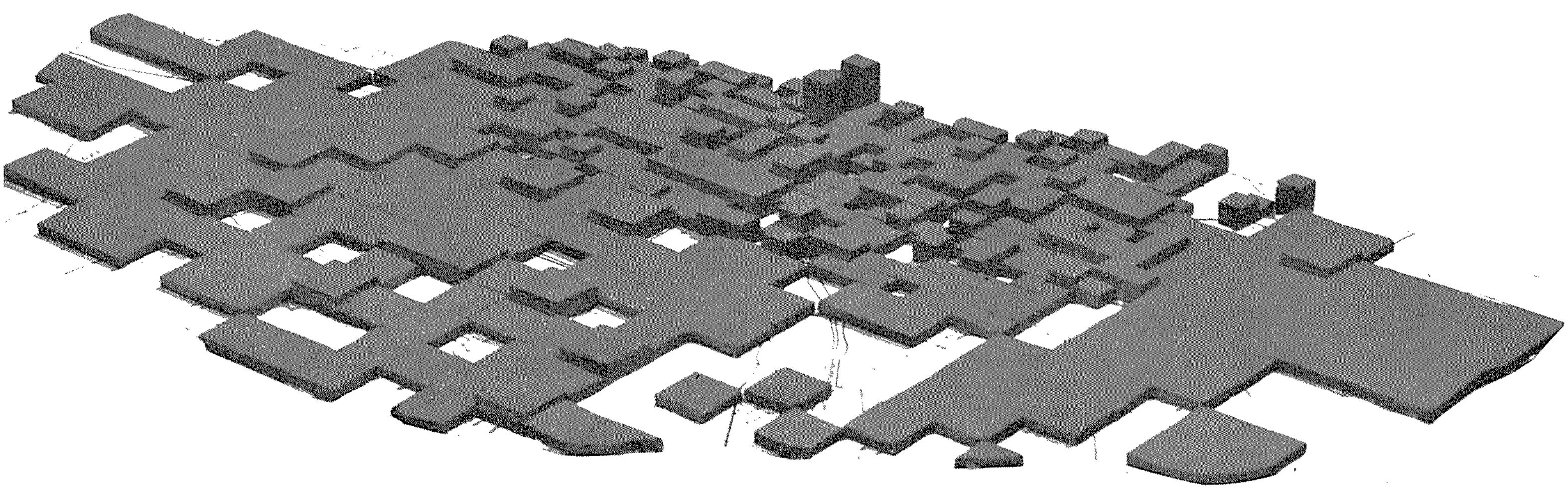


FIGURE 45—1980 COMPUTED VEHICLE MILES OF TRAVEL ON ARTERIAL STREETS WITH A LIMITED EXPRESSWAY SYSTEM ASSUMED TO BE COMPLETED

1980 assigned travel on the arterial streets totals 41,695,000 weighted vehicle miles, nearly three times that of 1956. The greatest increases are in suburban regions, but arterial streets in Chicago have 25 per cent more travel than in Figure 44. This assumes that only the expressways shown in Maps 21 and 22 are built by 1980. The lowest block above represents 25,000 vehicle miles of travel per square mile, the highest, 186,000.

TABLE 26

VEHICLE MILES OF TRAVEL AS ESTIMATED OVER THE PRESENTLY COMMITTED ROAD SYSTEM, 1956 AND 1980

Vehicle Miles of Travel in Thousands

Ring	Arterial Streets		Expressways		Total		Percentage Change 1956 to 1980
	1956	1980	1956	1980	1956	1980	
0 and 1	1,106	1,307	1,484	1,627	2,590	2,934	+ 13
2	1,506	1,774	1,941	2,173	3,447	3,947	+ 15
3	2,094	2,523	2,222	2,552	4,316	5,075	+ 18
4	3,050	4,072	2,298	2,849	5,348	6,921	+ 29
5	3,211	5,493	2,097	3,102	5,308	8,595	+ 62
6	3,469	10,042	3,538	6,648	7,007	16,690	+ 138
7	3,470	16,484	2,860	6,408	6,330	22,892	+ 262
Total	17,906	41,695	16,440	25,359	34,346	67,054	+ 95

travelers. Most of these people use the arterial streets, because expressways are out of the way for the bulk of their journeys.

Table 26 summarizes these two displays according to distance ring, and illustrates the heavy outward growth in traffic demands. The relative stability at the center is expected, because the land is presently saturated with uses and only very small increases in traffic are possible. As the table shows, growth rates in vehicular travel vary from six per cent in the Central Area to 262 per cent in Ring 7.

This great shift in the location of travel demand is difficult to believe in terms of the short range observations of traffic. The direction is known to be correct, but the magnitude is surprising. In the period from 1954-1958, fairly complete counts of traffic volumes on the street system of the area were made. These counts, although only samples, provided evidence of the extent of change in traffic demand over a shorter time period. The outward growth of vehicle miles of travel showed up clearly even over this relatively short period. The average annual increase was at a rate of about 4.0 per cent per year, just slightly more than the rate of increase in vehicle registrations. Growth was greatest in Rings 5, 6 and 7, and quite stable in the built up center. (See Table 27.) The growth trend observed over this short period was at a slightly faster rate than has been forecast from 1956 to 1980, but the observed changes in travel are all in the direction being forecast.

This completes the description of the picture of future vehicular travel demand. The vehicle miles of travel on principal streets are expected to double, growing from thirty-four million vehicle miles of travel in 1956 to about sixty-seven million on an average weekday in 1980.

The outward shift of 1980 travel volume densities presents a radical change from present travel patterns, but this is a natural extension of currently observed trends. The current tendencies toward suburban living and increasing car ownership are magnified significantly by the expected addition of 2,600,000 residents. The computed travel demands provide the real dimension of the highway planning problems. Substantial capacity increases must be provided for these new vehicles and their travel, if congestion is to be avoided. So much growth in such a short period will require careful plan development in order to stretch the resources of

TABLE 27

CHANGES IN VEHICLE MILES OF TRAVEL BY RING, 1953 TO 1957-1958

Ring	1953	1957-1958	Percentage Change
0 and 1	2,346	2,381	+ 2
2	2,879	2,908	+ 1
3	3,827	4,114	+ 10
4	4,859	5,199	+ 7
5	4,398	5,454	+ 24
6	3,977	6,026	+ 51
7	3,311	4,602	+ 39
Total	25,597	30,683	+ 19

the community to meet these fast growing demands.

To complete the entire picture of travel demands of 1980, transit travel demands must also be described.

PREDICTING TRANSIT JOURNEYS BETWEEN ZONES

In Chapter V the mass transportation trips of 1980 were identified as being either central or local. Central trips were those having one, but not both terminals in the Central Area—the remainder were local. Accordingly, future zone-to-zone transit trip estimates are made in two parts; first central transit trips and then local transit trips.

Central Transit Trips

Central mass transportation trips are already defined as moving only between the twenty central zones and the remainder of the urban area. It has been well documented that each journey from an outlying zone to the center will have a reciprocal journey, in the course of a day, from the central zone back to the outlying zone. Therefore, the problem of zone-to-zone prediction can be stated as estimating how many of the central transit trip origins at any non-central zone will go to each of the twenty zones in the Central Area.

The most specialized activities of the urban region will be found in these central zones. These are the kinds of activities that serve a metropolitan region and that attract people from all parts of that region. The activities at any one of the central zones, likewise, should draw travelers from all parts of the region. It follows, then, that travelers from any non-central zone will distribute their destinations among the twenty central zones in the same proportion as all destinations are divided. For example, there are 515,800 central transit destinations projected for the twenty central zones. Of these, 295,600 or fifty-seven per cent are expected to be in the Loop proper. It was reasoned, therefore, that fifty-seven of every hundred central transit trips from any outer zone of origin would be directed to the Loop. The proportions to every other central zone were handled in the same fashion.

Figure 46 illustrates the number of central transit trips projected in 1980 to each of the

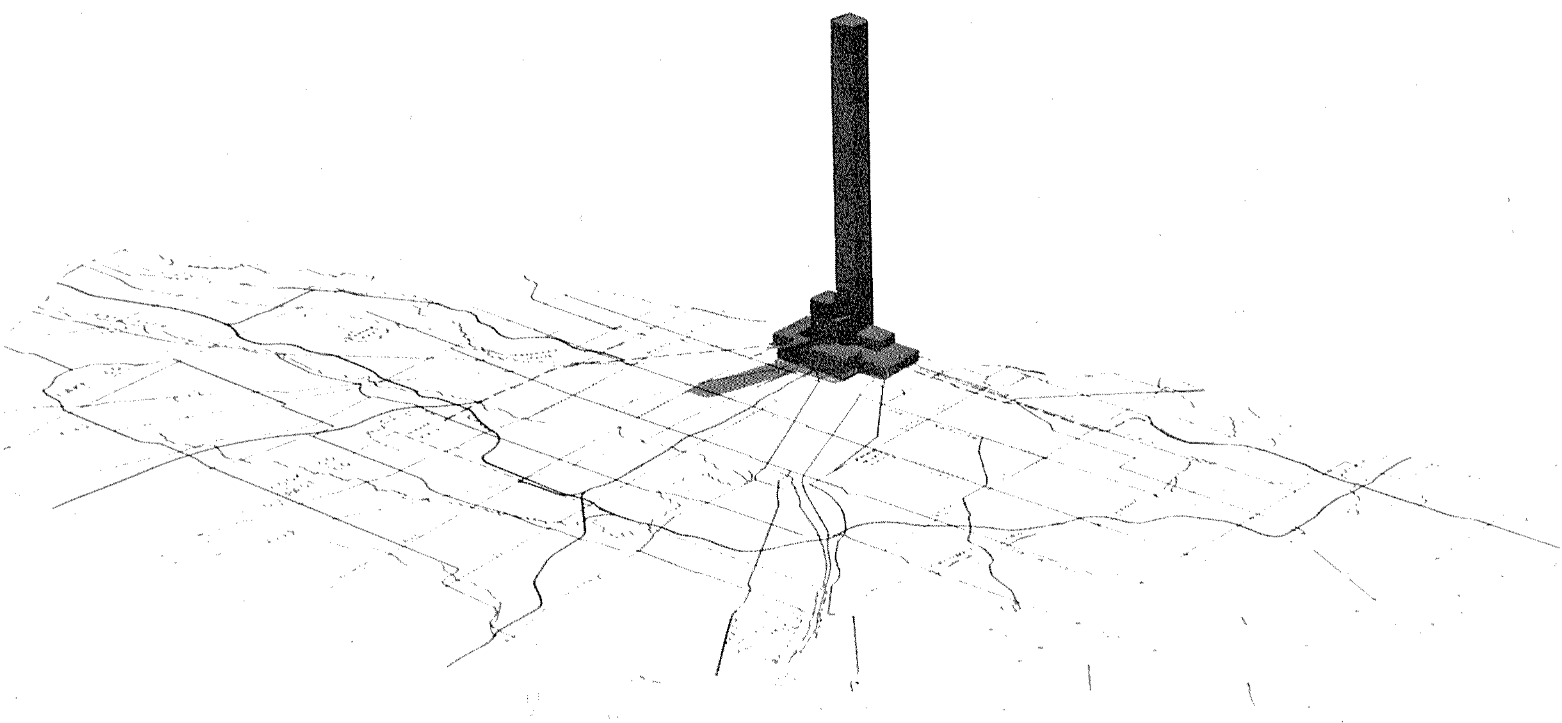


FIGURE 46—ESTIMATED 1980 DESTINATIONS OF MASS TRANSPORTATION TRIPS IN THE CENTRAL AREA

In 1980, an estimated 516,000 mass transportation trips will be destined to the Central Area—i.e., the area covered by blocks. The highest block corresponds roughly to the Loop and accounts for 57 per cent of all Central Area transit trip destinations. Additional destinations, amounting to 30 per cent, are found in zones adjacent to the Loop. This model provides a visual image of the probable location of terminal requirements in 1980.

mile square segments of the Central Area. This model also illustrates the proportional distribution of the destinations of transit travelers from any outlying origin zone. Current data indicate a slight tendency for transit trips going to zones at the perimeter of the Central Area to be more local than regional in origin distribution. This is partly because the land uses in these less dense central zones are less specialized than in the Loop proper, and partly because these outer zones are not so uniformly accessible to all places by transit. To the extent that this tendency perseveres to 1980, there may be some slight error in the assumptions used in estimating 1980 origin-destination patterns. On the other hand, by 1980 these outer zones should be somewhat more specialized in land uses and should also have generally improved transit accessibility to all parts of the region. These changes would reinforce the proportional assumption used in distributing mass transportation trips to Central Area zones.

Local Transit Zone-to-Zone Estimates

Prediction of zone-to-zone connections of local transit trips poses a different problem. These trips are predominantly short, and they are most frequent in the densely developed parts of the city. These travelers are known to have the same tendency as most other travelers—i.e., to go no farther than necessary. It was reasoned, therefore, that such trips could be described in the same fashion as trips by vehicle drivers. They would have a measured probability of stopping at a randomly chosen local transit destination, and they would try to keep their travel distances as short as possible.

Following this reasoning, a typical probability of stopping, or *l* value, was established for the local transit trips originating in each zone. This value was determined empirically so as to produce the typical median trip length occurring in each ring. In sparsely settled outer zones, for example, local transit trips are quite infrequent. Most of those reported are school bus trips. In such places, the probability that any destination is linked to a nearby origin is relatively great and *l* values are correspondingly high. In contrast, within the city of Chicago, local transit trips are more frequent—the bus and, occasionally, the elevated system being used for trips to work, to shop, and other purposes, as well as to go to school. In these areas the large number of trips reduces the chance that a destination point will be connected with a particular origin and, of course, *l* values must be lower. Actual *l* values were established for each zone's local mass transportation origins. These were computed by measuring the number of destinations encountered within a search radius equal to the median local transit trip length of that ring.

These predictive assumptions having been made, complete zone-to-zone travel movements by transit were computed for the presently known trips, so that the predictions could be compared to the actual data. Again two tests were made. First, calculated movements from selected sample zones to all other zones were compared with survey data. Then the entire

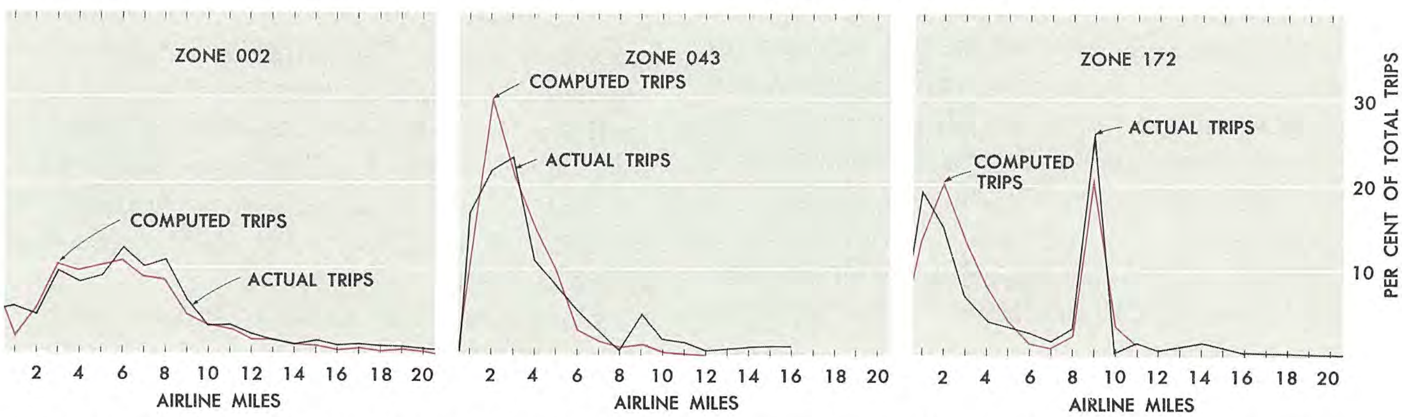


FIGURE 47—COMPUTED TRIPS COMPARED TO ACTUAL TRANSIT TRIPS FROM SELECTED ZONES 002, 043 AND 172

See Table 56 in Appendix.

group of computed interchanges was assigned to the transit network, and these results were compared to the assignment of the reported survey trips.

Zone-to-zone trips, both computed and actual, are shown for three selected zones in Figure 47. The correspondence of computed to actual data is very high. As an additional test, the same methods were used to compute existing zone-to-zone transit movements for all zones. These trips then were assigned to the quickest transit route connecting each pair of zones. This was accomplished by a computer in much the same fashion as vehicle trips were assigned to highways. The results are displayed on Map 23. This shows the volume of daily trips assigned to rail facilities, both commuter railroads and elevated-subway lines. The remaining travel is on bus routes and is shown as a general density of travel, i.e., passenger miles of bus travel per square mile, represented by density isolines.

A comparable assignment of trips was made by using actual journeys. The results of this allocation are not shown, because the eye could not detect any difference between the two maps. Statistical measures were made comparing the computed with the actual volume on each link of the entire network. Statistical correspondence was very great and showed that there were no significant differences on the several parts of the system.[7]

The computed volumes on rail lines also check very well with actual travel habits as observed both by CTA and railroad personnel. This means that not only are the zone-to-zone movements accurately represented, but that the description of the network and the method of selecting travel routes are also reasonably described. From this it can be inferred that, if the basic assumptions leading to estimates of zonal transit trips are valid, the estimates of 1980 zonal interchanges will likewise be valid. And of particular significance is the ability to distribute these journeys over any assumed future network in a realistic way.

1980 Transit Miles of Travel

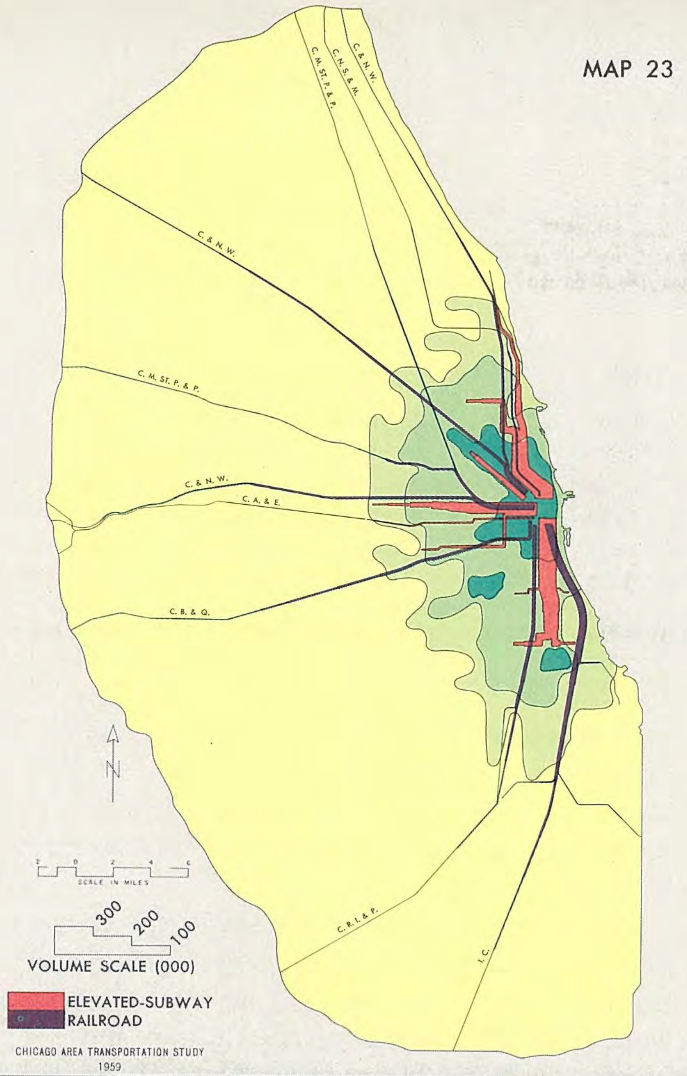
The 1980 zone volumes and the techniques indicated above were used to compute the 1980 zone-to-zone transit journeys. Using the same approach, the central trips were readily computed. The local trips were computed by assuming that median trip distances would remain the same in 1980 as currently measured.

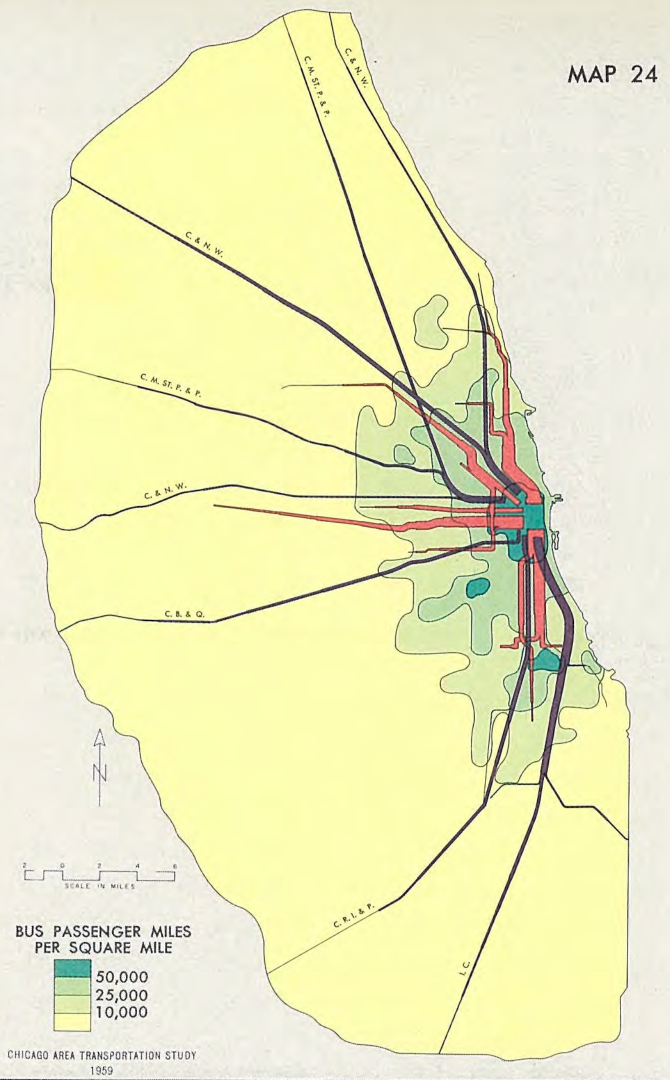
These computed 1980 trips then were allocated to a particular 1980 transit network. In establishing what this network would be, it was reasoned, as in the case of highways, that the new facilities completed since 1956 and all other currently proposed changes would be in effect. In the main, these involved the completion of the Congress Street subway and of rapid transit improvements in the rights-of-way of the Northwest and South expressways. Also, for this test, it was assumed that the Chicago, Aurora and Elgin, and the Chicago, North Shore and Milwaukee electric lines had discontinued passenger service. Because of this, it was assumed that limited extensions of the CTA service were added along these abandoned service routes for a portion of their length.

The computed 1980 trips allocated to this network are shown on Map 24. This can be compared with Map 23 which shows 1956 transit travel in the same way. At first glance, the two displays look very much alike. And, by contrast with the changes expected in highway usage, this is true. On closer inspection, however, it can be seen that certain changes in lines have caused significant changes in usage on particular routes. The Congress subway shows substantially larger volumes than the old Garfield "el," but much of this is diverted from the Lake Street route. The Northwest route shows an increase, and the new South route gains, but in part at the expense of the older Englewood elevated route.

The greatest shift of basic demand for railroad and elevated-subway travel is in the outward shifting of trip origins destined to the Central Area. This is the natural consequence of the anticipated suburban development. This

[7]When the volumes on each of the 1,436 links representing the transit network were compared, so that volumes with reported trips would be correlated with volumes obtained when trips were computed, the correlation coefficient was .98—a very high correspondence. Rail links (282 in number) showed a coefficient of .99.





1956 TRANSIT TRIPS
ALLOCATED TO 1956 TRANSIT FACILITIES

1980 TRANSIT TRIPS
ALLOCATED TO IMPROVED TRANSIT FACILITIES

The distribution of 15,000,000 miles of passenger travel over the 1956 mass transportation system is compared with 18,000,000 miles estimated for 1980 over a system with major elevated-subway improvements. These improvements and suburbanization increase 1980 estimated rail usage. Surface mass transportation is thinned as a result of both population shifts and rail improvements.

creates expected longer journeys and also more customers using railroad facilities. The elevated-subway system—serving territory which is presently built up—has less growth and, in places, some declines in usage. This has occurred because the enlarged suburban development has shifted much of the centrally oriented travel to suburban railroads.

In Map 23, the surface system usage is identified by isolines to describe the general density of passenger miles of travel. While there is a lessening of such surface system usage in the central city, the bulk of this travel continues to fall in the same area of highest land use densities.

Table 28 summarizes the total passenger miles of travel by rail and by surface routes for both maps. Rail usage shows an increase by 1980 because of greater journey length and because of increased trips to the center from suburban zones. Over-all miles of travel show an increase of 1.21 per cent. The most marked change is the shift of travel mileages outward, which results from the distribution of a small increase in mileage over a much larger region.

Summary—1980 Transit Travel Demands

The consequences of outward growth and changing population distribution are shown to create shifts in the patterns of transit travel demand. These changes, however, depart much less from current patterns than is the case in vehicular travel estimates. The reasons are clear. Transit journeys are linked heavily to the Central Area and to the high density portions of the region. Thus, two elements in future transit demand remain quite stable. Central Area

TABLE 28

ASSIGNED PASSENGER MILES OF MASS TRANSPORTATION TRAVEL
BY RING AND FACILITY TYPE, 1956 AND 1980

Ring	Surface Routes			Rail Routes			Totals		
	1956	1980	Growth Factor	1956	1980	Growth Factor	1956	1980	Growth Factor
0, 1 and 2	2,079,738	1,739,757	.84	4,099,619	4,196,596	1.02	6,179,357	5,936,353	.96
3	1,322,723	1,046,302	.79	1,415,592	1,858,997	1.31	2,738,315	2,905,299	1.06
4	1,739,267	1,348,673	.78	1,275,684	1,812,563	1.42	3,014,951	3,161,236	1.05
5	688,677	703,328	1.02	655,264	1,206,104	1.84	1,343,941	1,909,432	1.42
6	336,155	650,887	1.94	652,904	1,439,613	2.20	989,059	2,090,500	2.11
7	201,996	998,480	4.93	451,743	1,076,787	2.38	653,739	2,075,267	3.18
Total	6,368,556	6,487,427	1.02	8,550,806	11,590,660	1.36	14,919,362	18,078,087	1.21

transit trips are the same in number, but some thirty per cent longer. Being focussed at the same point in both years, the pattern cannot shift violently. The local transit trips are most frequent in densely developed parts of the region, so that, even in 1980, the bulk of these journeys continues to be found in the places having highest residential densities—Rings 1-4.

This pattern does pose problems of a gradually shifting demand, and the need to adapt existing facilities to meet this change. The growing suburban volumes may increase the pressure for railroads to run fully loaded trains into the Loop without close in stops. And it will likewise be necessary for rapid transit service to stretch outward to maintain its centrally oriented passenger volume.

The principal problem illustrated by this sketching of 1980 transit travel demand is one of adjusting services to a gradually shifting market, and at the same time maintaining fast and convenient services into the Loop and Central Area. The passenger miles of travel which can fall on rail facilities is a significant portion (about eleven per cent) of the total weekday travel requirements of the region, measured in person-miles of travel. The rail facilities are of particular importance to the region because of their ability to meet peak hour travel demands. This preliminary evidence as to estimated future travel demand then must be used to evaluate how this vital rail service can best be changed and improved to do the different work indicated by 1980 travel estimates. This is undertaken in Volume III.

CONCLUSION

In this chapter the technically difficult problem of describing future travel patterns has been undertaken. The problem is defined as predicting future zone-to-zone journeys of vehicles and of transit riders.

To accomplish this, substantial space has been devoted to a theory, its description and testing. This is essential as a step towards sharpening the outlines of the future, and towards clarifying the consequences likely to come from current planning decisions.

The theoretical explanation of travel patterns was sufficiently well supported by tests so as to provide the basis for describing future travel. While much remains to be done before any explanation is demonstrated to be exact, there are unique advantages to the methods developed in this study. First, there is no series of iterations used to make adjustments of unknown importance because initial estimates fall wide of the mark. Second, computed zone-to-zone vehicle trips take into account the obvious importance of the highway network and its particular properties in an explicit way. Finally, the prediction of travel is incorporated as a fixed part in the process of highway traffic assignment.

Transit journeys have been estimated under particular restraints. Those which go to the Central Area are differentiated from those making non-central or local journeys. The central trips—those most prone to use rail facilities—are controlled mainly by the growth of the center, and by the residential distribution of the populace. This insures a reasonable estimate which shows that, while the number of journeys holds constant, their length increases as more of the region's population lives farther out. Measured in passenger miles of travel, trips to the center will increase in their demand for services by some thirty per cent.

Local transit trips, on the other hand, are heavily oriented to bus usage. The bus appears best suited to serve a dispersed group of travelers living at densities lower than those in the Central Area, but substantially higher than in the suburbs. Future bus routes must fall on the surface streets. Because of this, the adjustment of routes and headways are much more easily accomplished for bus service than for fixed rail facilities.

The growth in travel demands indicates the order of magnitude of the planning and building programs which will be required to cope with these requirements. The estimated doubling of vehicle miles of travel presents a major challenge. Suburban growth will, of course, be at a faster rate. New highway facilities of substantial magnitude will be required.

The transit problem has different dimensions. Here the principal task will be that of continuing to provide a specialized form of service to an increasingly spread out supply of customers. Fortunately, the focal power of the Loop will do much to preserve the values of rail service for Loop travelers. But in the suburban areas, the provision of convenient bus service will be difficult because of the low density of customers.

These future travel demands are an expression of an urban community's need to interchange, to specialize, to live. Such weekday movements are essential to a thriving metropolis, and they reflect a busy and productive people. Clearly, substantial community resources must be allocated to meet these growing demands. This is the problem, and it remains now to fashion the most desirable way of coping with it. This will be the objective of Volume III —planning for the future.

Chapter VII

SUMMARY AND CONCLUSION

It is encouraging to review the 130 years since the founding of Chicago and to see the energy and even brilliance with which problems of urban growth were tackled. Early histories tell of measures against the Indians. When this threat had been removed, attention was focused on providing the necessities for a growing and increasingly urban population. Housing, water supply, sewage disposal, drainage, bridges, and transportation facilities — these were the elements necessary for continued growth. Their provision entailed some astonishing feats, as when the young city, in order to provide drainage in the low lying, swampy land, literally lifted itself out of the mud by raising the level of its streets some ten feet.

Conspicuous throughout its history was the far-seeing vision and confidence with which Chicagoans planned for the future. Public works were built at a scale large enough to take care of greatly enlarged populations. The Burnham plan for the lake front and the purchase of forest preserves are examples of big thinking which provided space for future generations, even though the architects of these schemes knew they would not live to see the accomplishment of their goals.

While the far-sighted men have been proven right, it is also true that in the struggle to build, many mistakes were made. Money and resources, not infrequently, were wasted. But there was no question of survival. Despite depressions and financial panics—which were extraordinarily severe—there was no thought that Chicago would disappear, or even be rendered impotent by the problems accompanying urbanization.

One of these problems was traffic congestion, which existed at all stages of growth. Even with horse-drawn vehicles, there were complaints of street congestion, delays and lost time in making deliveries. Congestion was synonymous with a city growing faster than it could build. It was not only an index of growth, but a spur for faster construction. And so, bit by bit, the streets were built, the rail lines laid, the bridges erected, and the growing, bustling city moved on to solve its next problems.

Now we are at a time when immediate prospects of growth, in absolute terms, are almost certain to outstrip that of any prior period. Within one generation, 2,600,000 persons are expected to be added to the population living within thirty miles of the Loop. To provide shelter, utilities, schools, workplaces and transportation for this additional population will entail Herculean efforts. More earthmoving, building, transportation construction and financing will have to be undertaken in two decades than in the first eighty years of Chicago's existence. More land will be urbanized in the coming generation than in the six preceding generations.

To deal with these problems of growth, plans must be prepared. Such plans must be based on understanding, and understanding on fact. The scale of growth must be anticipated. And goals or targets must be set which will match in boldness the size of the opportunities lying ahead.

The particular growth problem faced here is transportation—the daily movement of people and vehicles within the urban region. This movement is the blood stream of the community. It is essential to a much larger system of human cooperation in which the specialization of tasks multiplies the effectiveness of the individual, and returns to him materials and mechanical slaves which remove grinding toil and make possible a better life. If this transportation problem can be dealt with effectively, then the solution of many other problems will be eased.

To deal with the problems of transportation requires first an understanding of the nature of its causes. But the causes are rooted in the daily needs of millions of people and their establishments. And all of these require interchange. Understanding, therefore, is not easy, particularly when the movement of so many millions of people and vehicles is involved. Fortunately, new equipment and new methods have become available which now permit great quantities of information to be reduced and refined. By these massive processes of fact digestion, the significant and orderly properties of travel behavior of an entire metropolis can be disclosed and measured. This highly ordered information leads to improved understanding of the nature of the problem.

Travel is seen as a repetitive expenditure of energy designed to overcome distance so that particular objectives can be obtained. When the energy requirements or costs of travel are balanced against the rewards obtained from journeying, an equilibrium is attained which produces the travel pattern of an urban community. For planning purposes, this pattern is best described as the aggregate movements on an average weekday of all of the people and vehicles of the region.

This balance or equilibrium occurs against the mosaic of land uses. Over the urban landscape are distributed numerous activities — homes, schools, stores, offices, parks, and many others. These are not arranged in any hit-or-miss fashion—they are arranged in an economical way.

The observed arrangement of land uses clearly reflects the need to economize on travel. Stores and schools are distributed in much the same way as houses. This helps to shorten daily journeys. More specialized activities—airports, office centers, manufacturing plants—must be located with an awareness of additional values, among them topography, the transportation of goods, and the economies occurring from being of a certain size. These location requirements and levels of specialization operate to stretch person travel distances; but, as the term stretch implies, all of these activities must also consider the need for travel economy as an integral element in location decisions. Thus the arrangement of urban activities is orderly and can be explained, in part, by recognizing a strong tendency to keep travel distances short.

Clearly, costs of travel are not the only factor affecting land use, arrangements and densities. If they were, more and more multi-story buildings would be built. Actual practice shows the reverse to be true — single-family houses on larger lots, and more spacious surroundings for nonresidential buildings are increasingly common. This occurs because there are values associated with more generous sites that are sufficiently great to counter the tendency to economize on travel. This comes about as a wealthier and more productive society, making its collective decisions known through the great number of individual choices, reflects a changing preference and the ability to afford it.

In sum, the physical array of urban activities is a basic determinant of a particular metropolitan travel pattern. It is against this set of locations that daily movements approach an equilibrium pattern where the costs and rewards of journey making are suitably balanced.

The future, however, poses larger and different problems than those of today. The urban structure is in evolution as population grows and as technology and people's requirements change. So the next task of transportation planning is to look ahead at the changing metropolis. If the future urban structure can be discerned, then the size and character of future transportation demands can be estimated. Both tasks have been taken up in this volume.

Forecasts of urban growth and changing structure have been fashioned step by step. Each step is described to aid in the evaluation of method and of accuracy. These future estimates have been controlled by sharply defined requirements, such as the space requirements for housing for the expanded population. The few assumptions used have been necessary and reasonably taken: the kinds of transportation available in twenty years, the inertia of existing land development, and the persistence of the needs of people for housing, workplaces, stores, schools and recreational facilities in particular balance.

The leading force for change is an estimated increase in population of fifty-one per cent over 1956; the year 1980 should find 2,600,000 more people in the Study Area than today. This population will be wealthier—economic studies resulted in a projection of a forty-six per cent gain in per capita wealth over the same period. Gains in population and per capita income combine to produce a regional income 124 per cent larger than today's. From these estimates, projections of automobile and truck ownership were derived. These yielded an estimated ninety-one per cent increase in the number of automobiles and trucks owned in the area by 1980. This increase in the number of vehicles would, in turn, lead to a virtual doubling of the daily miles of vehicle travel.[1]

Based on these initial indexes of growth, estimates were made to fix the density, location and character of future land uses. Using this distribution of people and activities, it was possible to estimate the levels of traffic generation in all parts of the region. Traffic generation was measured first in numbers of person trips and later refined into mass transportation trips and vehicular trips—i.e., the kinds of journeys expected to fall on the transit or highway systems. The consequences of low density development and the growth in vehicle ownership yielded a doubling in the number of person trips in autos but little change in the number of transit trips. Truck and commercial vehicle trips were expected to increase by about seventy-five per cent.

These progressive steps described the future metropolitan region as of 1980—the houses, the people, the businesses and, ultimately, the generation of trips and their probable selection of travel modes. To make this a dynamic picture, a means had to be developed to catch these trips in motion—to show where and how they traveled. This was accomplished by development of a workable mathematical description of travel. Methods were devised not only to predict the journeys, but to route them over a network of facilities from origin to destination. The result is a description of journeys as they interconnect the various land uses and lace them together into a closely knit and functioning community. And such journeys can be described as loads impressed on available highway or mass transportation facilities.

By means of this detailed construction of estimates, the range of planning vision has been extended two decades into the future. While it would be possible to project more distant images of the metropolis, their focus would be less clear. This would reduce the sharpness of problem statements and the possibility of outlining clear-cut courses of action. This does not mean that planning is for a static condition of 1980 but rather that transportation investment decisions will be made with a sufficiently clear view of the demands arising from growth and change.

This and the preceding volume, then, have provided the necessary basis for understanding transportation problems and needs, and for the projection of future needs. The true challenge, however, is to devise a plan which will serve this mounting need for travel in an economical manner, making the best use of available resources.

Today, the need for more precise planning is greater than ever before. Sheer size increases the complexities of planning and design. Further, large parts of the metropolis are already matured, so that new facilities must be fitted more exactly to a nearly stable demand for travel. Our society is constantly finding ways to cut waste and improve performance. A more efficient transportation system is a crucial part of these efforts to increase productivity.

Fortunately, tools are becoming available which permit more precise planning to be undertaken. The forecasting processes provide two of these tools: the means of estimating origin destination volumes and the simulation of future travel. With these it is possible to consider changes in highway or transit systems, to compute future usage, and to examine the resulting level of service provided to the community. These, with other tools to be described in Volume III, permit the planner to evaluate the performance of several plans so as to select the one most suitable.

The object of planning is gradually to change the existing transportation networks toward a system which will serve the needs of the community more efficiently than would any alternate development scheme. This requires not only sound estimates of the future community and its needs, but some perception also of the goals toward which people strive. Given a correct view of society's goals and the background of information and tools provided in Volumes I and II, it is possible to meet the challenge of growth as an exciting opportunity — an opportunity to make the most of the chances lying ahead to build a better, more livable urban environment.

[1]For a summary of all forecasts in Volume II, see Appendix Table 57.

Appendix

NOTES ON MAP COMPILATION

The graphic presentation of the results of the forecast of population, land use and of trips has required some modification of the cartographic methods used in Volume I of this report.[1] The base unit of area for each forecast was the zone and, as such, represents a considerable loss of geographic detail when compared to the one-quarter square mile used as a base in presenting 1956 data. A further problem in presenting forecast data is that precise positioning of detail is impossible. Human judgment, based on all available information, must necessarily become a factor in the development of this type of presentation.

Starting with those maps for which the highest level of geographic detail could be plotted, compilation proceeded to maps which were related, but for which less precise geographic detail was available. With the exception of the Growth Map (Map 2); forecast data were prepared at the zone level, thus each map presenting 1980 patterns has a common statistical base. The maps of 1956 data used the one-quarter square mile base. Some modification in method was required to balance these with the 1980 maps.

Public Open Space and Manufacturing Land (Maps 6 and 7)

These maps were compiled to show, as accurately as possible, the exact location of their respective land uses. They do not in any way depict a density of use.

Residential Land (Map 8)

As with the preceding maps, the Residential Land Map depicts the location of this land use, rather than a density. Using the Public Open Space and the Manufacturing Land Maps as a base, additional *nonresidential* land uses were plotted. These included railroad yards, airports, large public buildings, major commercial areas and other areas, such as quarries and unusable land, where they could be defined. The land remaining, after the extraction of the above from the total, was defined as being residential, or at least residentially oriented. This land necessarily includes many small nonresidential land uses such as stores and schools, as well as all streets within the limits defined on the map.

Population (Maps 9 and 10)

Using the Residential Land Map as a base and working within the limits defined, gross population figures were plotted for zones (1980) and one-quarter square mile units (1956), and isolined. The isolines, however, *do not* define either a gross or a net density in the usual sense. They describe a gross density per square mile of land *within* the isoline.

The Population Maps are the first of a series in this report which depict patterns for both 1956 and 1980 in the external ring of zones. This is the area defined as Ring 8 on Map 28 of this Appendix. In general, the same procedures, as described above, were used in mapping data for the external ring, even though far less geographic detail was available for these zones.

Growth Map (Map 2)

The compilation of the Growth Map shown in this volume (and in Volume I) was based on the visual extraction of development limits from historical maps and, in the case of the 1955 line, from aerial photography. The 1980 line is based on forecast data by zone, as developed in the land use and population maps, and adjusted somewhat to match the criterion of the earlier lines.

The several maps in this report which show patterns for the target year of 1980, have been included primarily as a means of summarizing forecast data. As pointed out, they are subject to human judgment. However, they serve as a check on the reasonableness of the forecast. If the patterns developed from the zone data were unrealistic geographically, then the forecast itself would be subject to question. This is not the case; the patterns shown appear to demonstrate a reasonable and realistic growth in the Chicago area over the next twenty years.

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[1] See Volume I, pp. 95-96.

To insure their adequacy, plans for new transportation facilities must be subjected to test against expected travel loads. One of the most important tests is known as traffic assignment. This consists of allocating a known supply of trips to a particular network of travel facilities in accordance with certain specified rules.

Techniques of allocating vehicular trips to highway networks, and of passenger trips to transit networks, are rapidly being refined and improved. Several innovations were pioneered by staff personnel of the Study. This section will provide a brief technical discussion of the methods used.

The traffic assignment procedure developed by the Chicago Area Transportation Study was designed to handle a large transportation network and many trips. The arterial network for the Study Area included nearly 3,000 miles of arterials and expressways. The mass transportation network had more than 1,900 route miles of bus, elevated-subway and suburban railroad routes. These are the networks which were inventoried in the survey of transportation facilities described in Chapter VI of Volume I. Map 25 shows the arterial network.

This assignment procedure — which is used for transit as well as for highway networks — is based on the selection of a minimum time-path between zones. To accomplish this task, the network is coded and stored in the memory of an electronic computer. The computer selects minimum time-path routes and assigns trips to these routes. Traffic volumes are accumulated for each route section.

The following sections include details of (a) network mapping and coding, (b) calculation of minimum time-paths, (c) assignment to a network with limited capacity, (d) computer output, and (e) transit assignment.

Network Mapping and Coding

The transportation network had to be mapped and coded so that it could be used by a computer in the assignment program. Coding had to be flexible in order to permit planned additions or changes to be included for testing. It also had to be sufficiently detailed so that ramp volumes and turning movements at critical intersections could be obtained for highways, and so that transfer volumes could be recorded on transit networks. Finally, codes had to be sufficiently compact so that thousands of route sections could be stored within the computer memory.

For coding purposes, route sections were considered to be the part of a route lying between two intersections. They are referred to as "links." Intersections are points at which two or more route sections meet, allowing the possibility of a change in travel direction. Intersections are referred to as "nodes." The nodes at which trips are permitted to enter or leave the network are called "loading nodes." There is one "loading node" for each of the 582 zones within the Study Area.

The geographic ordering of network location is basic to the coding scheme. Zones in the Study Area were either one quarter square mile, one square mile or four square miles in area. Within each zone, trips were allowed to enter and leave the transportation network through only one intersection, i.e., the load node. Thus, all trips beginning or ending in a particular zone must be channeled through one intersection in that zone. However, trips passing through a zone have the opportunity of choosing any other routes through the zone.

Nodes were identified by four digit numbers. These numbers were applied systematically and a complete record of all node numbers was kept. Route sections were identified by the node number at each end of the section. Thus, an eight digit number was used to identify each route section. (See inset on Map 25.)

Other information coded for each route section included the length, the speed, the travel time, the capacity, type of route and whether travel was one-way or two-way on the route section. Additional information such as the

MAP 25

ARTERIAL NETWORK

This map shows the extent of the arterial network used in preparing the arterial assignment network coding maps. The insert contains a portion of this map in coded form.

compass orientation of the route section was coded, i.e., north-south, northeast-southwest, east-west and southeast-northwest. This allowed for future summaries of capacities or assigned volumes, by direction.

Turning movements and ramp volumes are obtained, but only by identifying the desired movement as a specific route section. For example, if it is desired to know the traffic moving between the west leg and the south leg at an intersection, a route section connecting these two legs must be inserted. The traffic assigned to this route section represents the turning volume between the west and the south legs. Trips are allowed to turn at all intersections, even though special turning links are not inserted. It is not possible to know the volume making the turn unless the movement is coded as a specific link, as described above. Traffic using expressway ramps or connections between interchanges is determined in the same manner.

After the coding is complete, the data are key punched into standard punched cards which are used as an input to the computer. These cards then are subjected to detailed machine contingency checks. Such checks guarantee that the network is continuous, i.e., that there are no missing links or nodes; that there are no dead ends; that each node has the correct number of links associated with it; that there are no duplicate numbers of either nodes or links; that the information coded for each link falls within certain specified ranges; and that there are no blank columns or double punched columns in the cards. These checks are made before the cards are used as an input to the computer. They guarantee that the computer will not fail because of coding inconsistencies, inaccuracies or incompleteness of a network. This description of mapping and coding is, of necessity, very brief. The interested reader is referred to *Arterial Network Coding Procedure* (34,300), (Chicago: CATS, 1960), which gives details on mapping and coding.

Calculation of Minimum Time-Paths

Selection of the quickest route from one zone to all others is the key to the assignment procedure as well as to the trip distribution. The minimum time-path is a route from a loading node in one zone to the loading node in any other zone. This route is determined by the computer. All minimum time-path routes from one loading node to all others are referred to as a "tree." The transportation network is stored in the computer memory and the computer accomplishes the minimum time-path selection through a systematic search and accumulation of travel time from data stored in the memory. In effect, the network is re-mapped in the memory of the computer. The operations performed in the computer are based on a modification of work done by Moore.[1]

The computer, in selecting a minimum path, compares the travel time between adjacent nodes and then sweeps gradually outward in circles around the starting node until the quickest path to all nodes has been determined. The computer program is designed in such a way that the absolute minimum time-path is guaranteed. At each node in the network, the computer records the travel time back to the start or loading node and the direction of travel to return to this node. Thus the travel time and the route between the starting node and all others is recorded.

Refer to Figure 48 for an illustration of this minimum time determination. With N as a starting point, the computer searches outward recording the travel direction and travel time at each point, so that the minimum time-paths from all points to N are known. By starting at any point and following the arrows, the quickest path to N is found. The number shown adjacent to each circled arrow is the travel time to reach point N by the quickest route.

Next, given the trips to be sent from a zone, the total trips originating at all zones, and the minimum travel time to all zones, the computer determines the number of trips to be sent to each of the other zones. (Refer to Chapter VI for a more complete explanation of the trip distribution process.) With the zone-to-zone trips

[1] Moore, Edward F., "The Shortest Path Through a Maze," a paper presented at the International Symposium on the Theory of Switching, Harvard University, 1957.

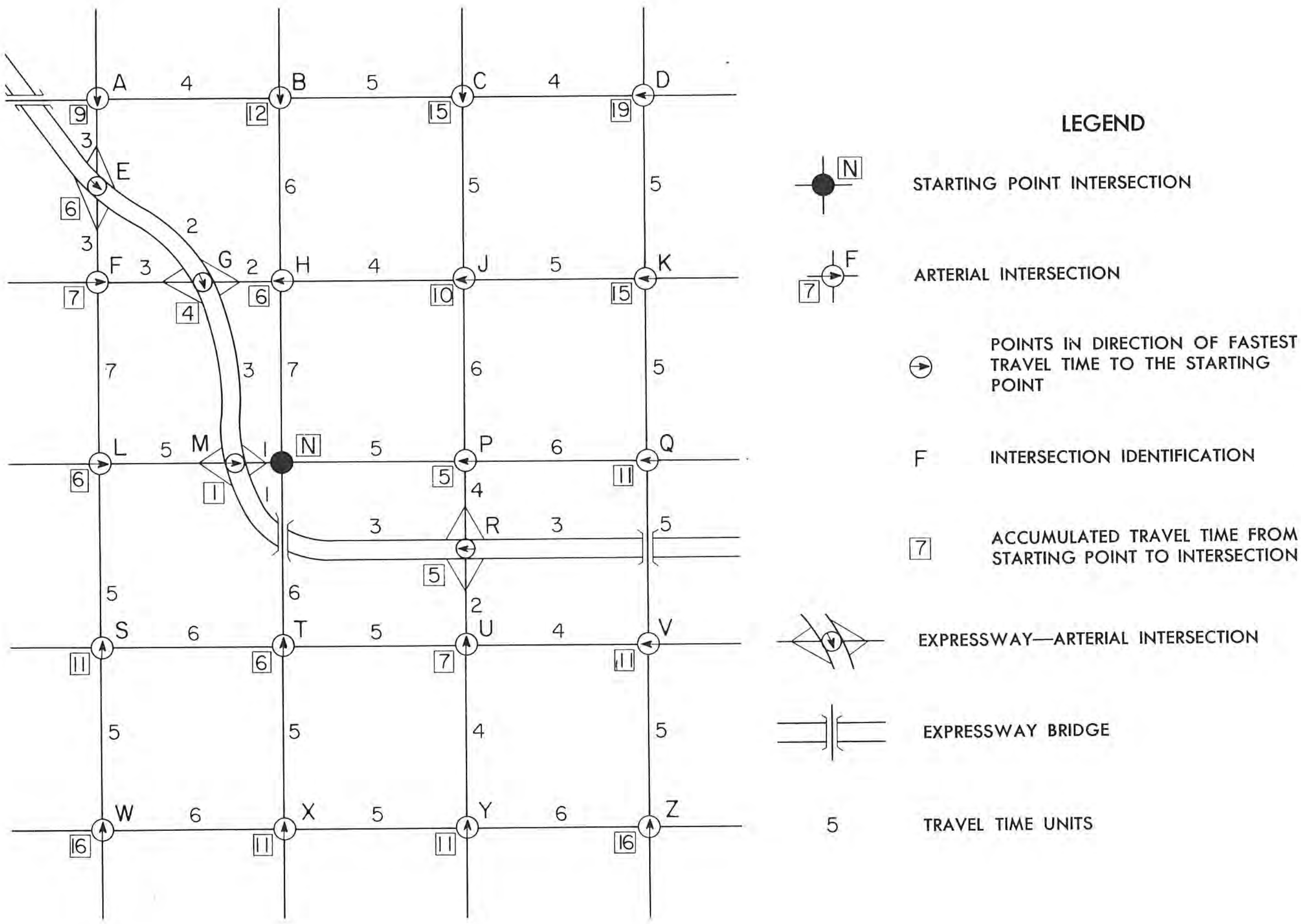


FIGURE 48—EXAMPLE OF MINIMUM TIME-PATHS ON A NETWORK

determined, and the minimum path route marked in its memory unit, it is a simple matter for the computer to load the trips on the individual route sections comprising the minimum path routes between zones.

After the trips have been assigned from one zone, the computer then selects the next zone, determines the minimum path, computes the number of trips to be sent to each destination zone, and distributes and assigns them to the selected minimum time-path route sections. These assigned volumes are stored in the computer memory for each route section in the network. This process is repeated until all of the 582 zones are inspected and all trips are sent. The result is a network loaded on the basis of all trips using the quickest travel route.

This type of assignment is useful in location planning. However, this approach does not take into account the increase in travel time resulting from heavy traffic demand and fixed capacities. Since speeds are not related to the volume using a facility, this assignment technique could produce impossible traffic loads on high type facilities. To eliminate this problem and to provide data useful in geometric design, a second assignment is made, with explicit accounting of the capacity limits. This has been used only for highway assignments and is described in the following section.

Assignment to a Network with Limited Capacity

The assignment used to obtain traffic loads useful for geometric designs differs from the "free" assignment in two respects. First, capacities of the route sections are calculated and used to restrain the number of trips assigned to a particular route section. Second, a specific ordering is used to load trips into the network, thus preventing distortion and uneven loading due to the sequence of adding trips.

A design capacity is part of the record stored in the computer memory. After the trips from each zone have been computed and added to the network, the computer calculates the ratio of the assigned volume to the capacity for each route section and adjusts the travel time according to a predetermined relationship. This relationship says that the more the capacity of a link is used, the greater the travel time becomes.

Thus the speed necessary to travel the route section is lowered as more and more trips are assigned to it—in much the same way as increasing congestion causes speeds to be lowered in real situations.

The use of a capacity restraint to modify assigned traffic results in a more realistic distribution of traffic in the system. It is impossible for one route to be heavily overloaded if its neighboring streets are lightly used. Traffic is distributed through the system according to minimum time-paths which are constantly modified by the ability of the network to accommodate the trips.

Computer Output

The computer is programmed to produce standard information for each assignment to each network. The following information is obtained as a direct output of the computer:

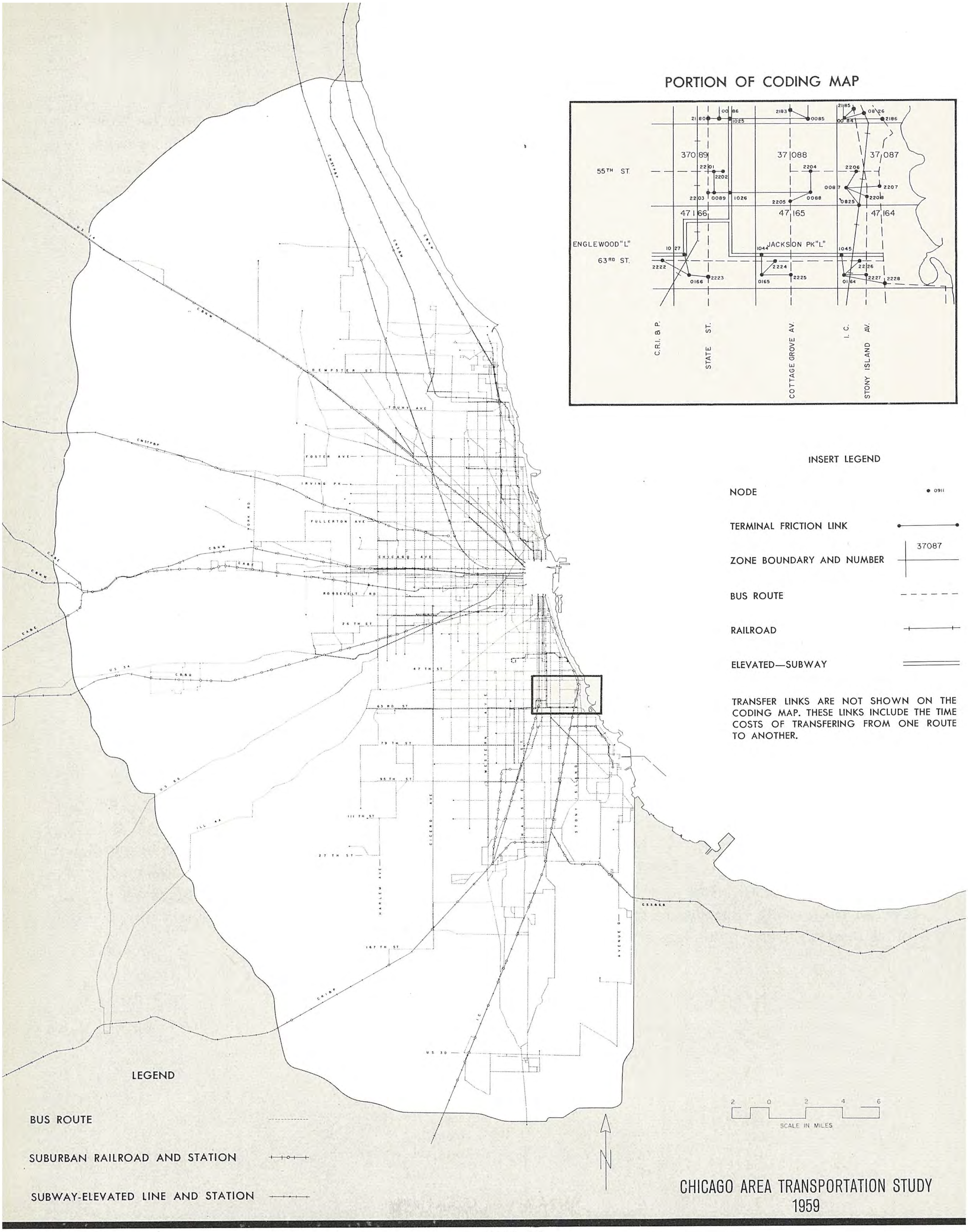
1. The total number of trips assigned to each route section in the network (including directional volumes where wanted).
2. The total travel time in minutes required for all trips from each zone to reach their destination, as well as total system travel time.
3. A frequency distribution by travel time ranges for all trips.
4. A frequency distribution of trips which use an expressway for any or all of their trips, grouped by travel time ranges.
5. The total number of trips any part of which are over an expressway link.
6. The number of trips provided and received at each zone.
7. The number of trips from each zone which use expressways.
8. For each link the following data are obtained from the computer: twenty-four hour assigned volume; ratio of assigned volume to design capacity; average speed (related to the assigned volume); and total operating, accident and travel time cost for operating over that link.

The output is converted from tape to standard punched cards for further summaries and tabulation. Using standard card equipment, summaries are made of vehicle miles of assigned volume by analysis zone, district, ring and sector. Total travel cost and average cost per vehicle mile are computed for each zone, district, ring, sector and total. Summaries of ratios of assigned volume to design capacity, by zone, are made for each route type.

These summary cards can be used for statistical studies or as a direct print out for a map. Where maps are desired, the zonal summary cards are arranged in a particular order so that the print out appears on a gridded sheet in the same physical arrangement as the zones occur (see page 96, Volume I for a description of the method). This then becomes the base manuscript for the preparation of maps.

With the information from the computer, plus the summaries and tabulations made on card equipment, it is possible to spot deficiencies in capacity in a network, compare average speeds in one network with those of another, make economic comparisons of one network with another, and many other studies. Flow maps to expressways are made which show volumes assigned to expressways. These maps give an immediate visual impression of a planned network. These and many other comparisons provide evidence useful in selecting the most suitable plan.

This system provides twenty-four hour assigned volumes to a full network including expressways, arterials and ramps. Turning movements are available at all expressway interchanges plus selected arterial intersections. This work is accomplished in a computer for a complete network for the Study Area in about four hours for a "free" assignment and about



MAP 26

MASS TRANSPORTATION FACILITIES

This map shows the extent of the mass transportation facilities used in preparing the transit assignment network coding map. The insert contains a portion of this map in coded form.

seven for a "capacity restrained" assignment. On the average, for each zone, it takes about twenty seconds to develop a minimum path to all other zones, five seconds to compute the trip interchange, fifteen seconds to load trips on the network and, in the restrained assignment, five seconds to scan the network and adjust travel times.

Transit Assignment

The procedure described above is readily adaptable, with minor adjustments, to transit assignments. The major difference in procedure is that for transit the zone-to-zone trips are calculated first by a separate computer program. (Refer to Chapter VI for details.) From this point on, the procedure is very similar. That is, the minimum path is calculated and the predetermined zone-to-zone movements are loaded to the minimum path and accumulated, to obtain the total assigned volume for each link.

There are several problems in representing travel in the network which are unique with transit. Map 26 shows how the transit network is represented. For example, there is the problem of accounting for transfers from one system to another or from one vehicle to another. Another difficulty is in accounting for persons who drive or ride in an automobile to a transit station and "change mode" to become transit riders. And finally, there is the problem of accounting for walking and waiting time at the beginning and end of a trip.

Each of these problems is handled by inserting an artificial link into the network. To account for waiting time due to transferring, a link is inserted between the lines at points where transfers are allowed. The travel time for this link is equal to the estimated waiting time, which is a function of the headway of the line transferred to. Thus, to transfer from one line to another, the trip is routed over the transfer link and absorbs a time penalty equivalent to the transfer time. This transfer time penalty has the very real effect of minimizing transfers unless they are necessary to the completion of the trip.

To account for walking and waiting time at each end of the trip, an artificial link is inserted into the network connecting each load node with the transit system. The travel time for this link is equal to the walking and waiting time at each end of the trip. In order to get into and out of the network, trips must use these links, thus absorbing a travel time equal to the walking and waiting times at the trip terminal.

The trips to rapid transit stations by passenger car are handled in a similar manner. Again artificial links are created, linking zone centers to rapid transit stations in appropriate areas. By this device, persons from certain zones where no transit service is provided are allowed to use the transit system. The accumulated person trips on these artificial links represent those persons who drive, ride as automobile passengers, or, in a few cases, ride buses to rail transit stations.

The computer output of the transit assignment is the same as that for highways except that travel speed resulting from assignment and the data relating to travel costs is not collected. This assignment technique provides loads for a complete network of bus and rail rapid transit facilities.

The premise taken to govern trip distribution may be stated: total travel time from a point is minimized, subject to the condition that every destination point has a stated probability of being accepted if it is considered. If the probability of a destination point being acceptable is independent of the order in which destinations are considered, the order that will minimize travel time is clearly that of time proximity—from near to far. And the premise may be restated: a trip prefers to remain as short as possible, but its behavior is governed by a probability of stopping at any destination it encounters—it cannot always just go to the nearest destination and stop; it must consider the nearest destination, and if that is unacceptable, consider the next nearest, and so on. To cast this into mathematical language: the probability that a trip will terminate within some volume of destination points is equal to the probability that this volume contains an acceptable destination, times the probability that an acceptable destination closer to the origin of the trip has not been found. But the latter two probabilities may vary from point to point, so the problem must be stated in terms of limitingly small quantities. This leads to:

$$dP = (1-P)l\,dV. \qquad [1]$$

P is the probability the trip has terminated within the destination volume, V, lying earlier in the order of consideration (or *subtended volume*); l is the probability density (probability per destination) of destination acceptability at the point of consideration.

If l is constant, the only case discussed here, the solution of [1] is:

$$P = 1-ke^{-lV} \quad (k \text{ is the constant of integration}). \qquad [2]$$

But $k = 1$, since P must be zero when V is zero, so:

$$P = 1-e^{-lV}. \qquad [3]$$

The expected interchange from zone i to zone j is simply the volume of trip origins at zone i multiplied by the probability of a trip terminating in j, that is:

$$\begin{aligned} V_{ij} &= V_i[P(V+V_j) - P(V)] \\ &= V_i\,(e^{-lV} - e^{-l(V+V_j)}). \end{aligned} \qquad [4]$$

An obvious extension of this is the supposition that, although l is constant for each trip, different trips have different l's.

The more general equation that then arises is:

$$V_{ij} = \int_{l\,\min}^{l\,\max} (e^{-lV} - e^{-l(V+V_j)})Z_i\,dl, \qquad [5]$$

where Z_i is the distribution of V_i with respect to l; i.e., $Z_i = \frac{dV_i}{dl}$. Further, it can be argued that the destinations are also distributed in their affinities. This may be allowed (without going into detailed reasoning) by construing V and V_j in [5] as effective volumes, and functions of l. The computation of [5] cannot be realized in practice without far more understanding. But an attempt to adjust [4] in the direction of [5] can be made by clustering trips into "kindred" sub-populations with all members of a given sub-population being governed by the same l. The approximation to [5] is then:

$$V_{ij} = \sum_s V_{is} \left[e^{-l_s V_s} - e^{-l_s (V_s + V_{js})}\right]. \qquad [6]$$

The subscript s is the sub-population index. This is quite analogous to the stratification commonly used with gravity, iteration and other models, but a little different in concept.

TABLE 29
CHANGES IN RESIDENTIAL LAND, POPULATION AND
NET RESIDENTIAL DENSITY IN CHICAGO BETWEEN 1940 AND 1956

Distance From Loop In Miles[a]	Residential Land (In Thousands of Sq. Ft.)		Population (In Thousands)		Thousands of Persons Per Sq. Mi.	
	1940[b]	1956	1940	1956[c]	1940	1956
0- 0.9	1,547	1,864	28.3	34.7	514.5	517.9
1.0- 1.9	21,250	20,514	135.7	146.6	178.1	199.5
2.0- 2.9	68,558	68,109	323.0	337.4	131.4	138.1
3.0- 3.9	79,654	76,966	306.5	304.8	107.3	110.4
4.0- 4.9	123,194	130,025	454.4	449.7	102.8	96.4
5.0- 5.9	151,280	153,469	462.3	425.2	85.2	77.2
6.0- 6.9	191,668	201,757	482.0	461.9	70.1	63.8
7.0- 7.9	209,939	236,021	440.0	433.9	58.4	51.3
8.0- 8.9	160,376	204,485	274.4	298.4	47.7	40.7
9.0- 9.9	139,317	218,061	200.7	255.1	40.2	32.6
10.0-10.9	71,937	158,864	88.5	158.7	34.3	27.9
11.0-11.9	58,317	108,523	57.4	93.9	27.5	24.1
12.0-12.9	63,598	106,650	63.1	90.6	27.7	23.7
13.0-13.9	44,400	77,479	51.1	69.4	32.1	25.0
14.0-14.9	16,471	27,372	15.3	27.5	25.9	28.0
15.0 and over	8,897	22,256	8.9	20.2	27.9	25.3
Total	1,410,403	1,812,415	3,391.6	3,608.0	67.0	55.5

[a]For this table, square miles formed by a mile grid aligned with State and Madison Streets were grouped into mile rings, according to the distance of their centers from the intersection of State and Madison Streets. The areas and population for these rings are different from the rings formed from census tracts (Table 6, Chapter III) and rings formed from square miles based on a grid offset by one-half mile from State and Madison Streets. (Table 30 this page.)

[b]Source: *Land Use in Chicago* (Chicago: City of Chicago, 1943) Vol. II.

[c]Does not include institutional population. The 1950 Census reported 11,481 persons in this category.

TABLE 30
CAPACITY USAGE OF POTENTIAL RESIDENTIAL LAND BY DISTANCE FROM THE LOOP,
1956 AND ESTIMATED FOR 1980

Distance From Loop In Miles	1956		1980		Capacity Population*
	Population	Percentage of Capacity	Population	Percentage of Capacity	
0- 1.9	131.1	84	156.1	100	156.1
2.0- 3.9	565.7	92	560.3	91	615.0
4.0- 5.9	947.8	95	935.8	94	1,000.6
6.0- 7.9	872.6	94	864.7	93	928.1
8.0- 9.9	817.1	91	817.4	91	899.7
10.0-11.9	494.4	78	608.4	96	635.0
12.0-13.9	416.9	66	579.8	92	628.9
14.0-15.9	229.6	50	415.9	90	462.5
16.0-17.9	191.4	36	455.0	86	529.1
18.0-19.9	133.6	23	470.6	82	572.7
20.0-21.9	121.1	21	440.3	78	566.0
22.0-23.9	84.2	14	449.1	75	598.2
24.0-25.9	86.4	13	478.1	71	670.6
26.0-27.9	34.6	9	255.7	69	372.2
28.0 and over	43.2	9	314.8	69	456.4
Total	5,169.7	57	7,802.0	86	9,091.1

*Capacity population is that population which can be accommodated in a given area at the estimated density, and with the estimated percentage of land in residential use. Capacity within two miles of the Loop is set by the Central Area Plan.

TABLE 31

HISTORICAL POPULATION GROWTH FOR THE U. S., THE STATE OF ILLINOIS, THE CITY OF CHICAGO, THE CHICAGO STANDARD METROPOLITAN AREA, AND THE STUDY AREA

(In Thousands)

Year	U. S. (Continental Only)[a]	Illinois[b]	Chicago[c]	Metropolitan Area[d]	Study Area[e]
1830	12,866	157	......	......	......
1840	17,069	476	4.5	......	......
1850	23,192	851	30.0	......	......
1860	31,443	1,712	112.0	......	......
1870	38,558	2,540	299.0	......	......
1880	50,156	3,078	503.2	......	......
1890	62,948	3,826	1,099.9	1,389.7	......
1900	75,995	4,822	1,698.6	2,092.4	......
1910	91,972	5,639	2,185.3	2,752.8	......
1920	105,711	6,485	2,701.7	3,521.8	......
1930	122,775	7,631	3,376.4	4,675.9	4,086.4
1940	131,669	7,897	3,396.8	4,825.5	4,174.7
1950	150,697	8,712	3,621.0	5,495.4	4,676.8

[a]Source: *Census of Population: 1950; Vol. II, Characteristics of the Population; Part 1, United States Summary;* U. S. Department of Commerce, Bureau of the Census, Washington, D. C.: Government Printing Office, 1953, Table 2, p. 1-3.

[b]Source: *Census of Population: 1950; Vol. II, Characteristics of the Population; Part 13, Illinois.* U. S. Department of Commerce, Bureau of the Census, Washington, D. C.; Government Printing Office, 1952, Table 1, p. 13-7.

[c]Ibid., Table 4, p. 13-9.

[d]Source, years 1930-1950:

For Illinois Counties Cook, Lake, Du Page, Kane and Will. Ibid., Table 5, p. 13-12.

For Lake County, Indiana. *Census of Population: 1950; Vol. II, Characteristics of the Population;* Part 14, Indiana. Washington, D. C.: Government Printing Office, 1952, Table 5, p. 14-11.

Source, years 1910-1920:

Abstract of the Fourteenth Census of the United States, 1920. U. S. Department of Commerce, Bureau of the Census, Washington, D. C.: Government Printing Office, 1923.

Source, years 1890-1900:

Abstract of the Thirteenth Census of the United States, 1910. U. S. Department of Commerce, Bureau of the Census, Washington, D. C.: Government Printing Office, 1913.

[e]*Census of Population: 1950; Vol. II, Characteristics of the Population; Part 13, Illinois.* Washington, D. C., Government Printing Office, Table 6, pp. 13-16 to 13-26.

TABLE 32

MASS TRANSPORTATION TRIPS TO CENTRAL AREA PER 100 RESIDENTS, 1956 AND ESTIMATED 1980, AND 1956 CENTRAL AREA EMPLOYEES RELATED TO POPULATION, BY RING

Ring	Mean Distance From Loop In Miles	Mass Transportation Trips Going To Central Area Per 100 Residents		
		1956	1980	Going From Home To Work—1956
2	3.5	15.4	12.3	7.8
3	5.5	13.5	10.8	8.4
4	8.5	11.4	9.2	7.9
5	11.5	7.0	5.2	5.0
6	16.0	5.7	3.9	4.4
7	24.0	5.2	3.5	4.3

TABLE 33

PERCENTAGE DISTRIBUTION OF TRIPS BY LAND USE RELATED TO TRIP MAKING PER FAMILY

Trips Per Family	Residential	Manufacturing	Transportation	Public Buildings	Public Open Space	Commercial
2	54.8	14.6	4.1	5.2	1.1	20.2
4	55.1	10.9	2.8	6.6	1.6	23.0
6	56.2	8.0	2.6	8.0	2.2	23.0
8	56.3	6.9	2.5	7.5	3.0	23.8
10	54.7	4.5	2.2	10.1	2.9	25.6
12	52.9	4.6	2.2	9.8	3.6	26.9
14	53.4	4.0	2.6	9.2	4.7	26.1
16	51.8	3.4	3.4	9.3	5.6	26.5

TABLE 34
INCOME DATA AND FORECASTS FOR THE CSMA
(In 1956 Dollars)

Year	Average Income Per Consumer Unit[a]	Aggregate Income[b] in Billions of 1956 Dollars
Estimates of Actual Income		
1939	4,929	8.24
1947	6,311	11.53
1954	7,074	14.56
1956	7,750	16.71
Income Forecasts		
1960	7,919[c]	18.52
1965	8,664[c]	22.38
1970	9,483[c]	26.81
1975	10,330[c]	31.73
1980	11,297[c]	37.45

[a]*Consumer units* refers to the 1959 Census of Population category "families and unrelated individuals." A family is a group of two or more persons related by blood, marriage, or adoption and living together. Unrelated individuals are those persons who are not living with any relatives. The category obtained by combining families and unrelated individuals appears roughly the same as *dwelling places*. In the 1950 Census of Population, the CSMA population (in thousands) was 5,495; the number of families and unrelated individuals (in thousands) was 1,918; and the ratio of the latter to population was .349.

[b]*Income* is "consumer income," which is the money income of families and unrelated individuals, plus their imputed income (primarily the rental value of owned homes).

[c]Projected from 1947 at a growth rate of approximately 1.8 per cent. For a detailed description of methods and sources, see *Forecasting Economic Activity: Income and Taxes* (36,121) (Chicago: CATS, 1958).

TABLE 35
PERCENTAGES OF STUDY AREA POPULATION AND LOOP EMPLOYEES BY RING OF RESIDENCE, 1916 AND 1956

Distance From Loop In Miles	1916		1956	
	Population	Loop Employment	Population	Loop Employment
0- 0.9	2.8	3.7	0.1	2.4
1.0- 1.9	10.8	11.0	2.4	3.7
2.0- 2.9	13.4	11.4	4.7	4.8
3.0- 3.9	14.2	15.6	6.2	6.5
4.0- 4.9	16.6	15.7	7.2	8.1
5.0- 5.9	14.7	12.9	11.2	10.1
6.0- 6.9	11.3	10.5	7.5	10.3
7.0- 7.9	8.1*	9.6*	9.4	10.6
8.0- 8.9	4.0*	4.8*	8.9	10.6
9.0- 9.9	2.1*	2.4*	6.9	7.4
10.0-10.9	1.0*	1.2*	5.0	4.2
11.0-11.9	0.5*	0.6*	4.6	4.1
12.0-12.9	0.3*	0.4*	4.3	2.8
13.0-13.9	0.1*	0.1*	3.8	1.8
14.0-14.9	0.1*	0.1*	2.3	1.6
15.0-15.9	...	...	2.1	1.5
16 and over	...	...	1.5	1.5
Total	100.0	100.0	100.0	100.0

*Estimated

TABLE 36
RATIO OF STUDY AREA TO METROPOLITAN AREA POPULATION, 1930-1956 AND 1980 ESTIMATED
(In Thousands)

Year	Metropolitan Area	Study Area	Percentage Ratio
1930	4,675.9	4,086.4	87.4
1940	4,825.5	4,174.7	86.5
1950	5,495.4	4,676.8	85.1
1956	6,208.0	5,200.0	83.8
1980 (est.) .	9,500.0	7,802.0	82.1

TABLE 37
ESTIMATED POPULATION GROWTH FOR THE UNITED STATES, THE STATE OF ILLINOIS, THE CSMA AND THE STUDY AREA
(Excludes Armed Forces and others overseas. In Thousands)

Year	U.S. (Continental)[a]	Illinois[b]	CSMA[c]	Study Area[d]
1956	167,261	.....	6,208.0	5,200.0
1960	179,226	10,000	6,603.6	5,550.0
1970	212,910	11,602	......	......
1980	259,081	13,775	9,500.0	7,802.0

[a]Year 1956 is the July 1, 1956 figure given in "Provisional Estimates of the United States January 1, 1950, to July 1, 1959" in *Current Population Reports, Population Estimates*, Series P-25, No. 204. Washington, D.C.: U.S. Department of Commerce, Bureau of the Census, August 17, 1959. Years 1960, 1970, and 1980 from the "Series II" projections in Table 1, page 16 of "Illustrative Projections of the Population of the United States, by Age and Sex, 1960 to 1980" in *Current Population Reports, Population Estimates*, Series P-25, No. 187. Washington, D.C.: U.S. Department of Commerce, Bureau of the Census, November 10, 1958. Note that each figure shown above is 900,000 less than in the publication cited; this is an adjustment for armed forces overseas, recommended on page 14 of the same publication.

[b]The state of Illinois population projections for the years 1960 and 1970 as shown in Series 1, Table 1, page 9, Series P-25, No. 160, have been adjusted by the ratio of the total population of the United States (armed forces overseas excluded) as shown in "Series II" Table 1, page 16, Series P-25, No. 187 to the total population of the United States as shown in "Series I," Table 1, page 8, Series P-25, No. 160.

The 1980 projection was obtained by extrapolating the ratio of the state of Illinois population to the total population of the United States to the year 1980 by assuming a decline in the ratio of the same magnitude as observed in the projections of 1960 to 1970. This ratio was then applied to the 1980 estimate of total population of the United States to obtain the 1980 estimate for the state of Illinois. The full titles of the reports cited are "Illustrative Projections of the Population, by States, 1960, 1965, and 1970" in *Current Population Reports, Population Estimates*, Series P-25, No. 160, Washington, D.C.: U.S. Department of Commerce, Bureau of the Census, August 9, 1957, and "Illustrative Projections of the Population of the United States, by Age and Sex, 1960 to 1980" in *Current Population Reports, Population Estimates*, Series P-25, No. 187, Washington, D.C.: U.S. Department of Commerce, November 10, 1958.

[c]Year 1956 from Table 1, page 2 in *Population Growth in the Chicago Standard Metropolitan Area, 1950-1957*. Chicago: Chicago Community Inventory, University of Chicago, February, 1958. Year 1960 is estimated from preliminary census releases.

Year 1980 is the Study's estimate.

[d]Year 1956 is from the Study's home interview survey as shown in *Summary: Population Estimate* (31,210) (Chicago: CATS, 1958) Table 1, p. 4. Year 1960 is estimated from preliminary census releases.

Year 1980 is the Study's estimate.

TABLE 38

OUTPUT AND EMPLOYMENT BY INDUSTRY TYPE FOR THE CSMA AND STUDY AREA, 1947, 1956 AND 1980 FORECAST[a]

	Output: CSMA	CSMA Output[b] (In Millions of 1956 Dollars)			Employment[c] (In Thousands)				
	US				CSMA	CSMA	CSMA	Study Area	
Industry	1947	1947	1956	1980	1947	1956	1980	1956	1980
1. Agriculture and Forestry[d]	.005	236.3	162.5	197.3	21.0	16.5	9.0	7.9	4.2
2. Mining	.005	58.2	65.9	126.5	3.0	3.6	3.8	2.5	2.5
3. Food and Kindred	.079	3,629.7	3,753.1	6,683.3	105.7	103.5	85.5	97.7	77.4
4. Tobacco	.006	18.2	29.7	58.8	0.7	0.6	0.6	0.5	0.5
5. Textiles and Apparel	.027	747.0	586.3	906.8	58.5	46.0	37.1	42.3	32.8
6. Lumber and Wood	.014	104.2	111.3	267.3	8.4	9.6	8.5	8.4	7.2
7. Furniture and Fixtures	.085	307.9	374.9	906.5	25.0	24.4	32.8	19.4	25.0
8. Paper and Allied	.043	382.3	497.0	1,462.0	23.2	26.0	29.9	23.1	25.5
9. Printing and Publishing	.117	955.4	1,198.6	2,694.1	87.4	87.9	139.3	81.3	123.7
10. Chemicals	.072	1,249.0	1,539.8	3,414.0	41.2	41.1	42.3	29.3	28.9
11. Petroleum and Coal	.090	1,025.7	1,442.2	3,578.4	17.9	19.4	28.2	3.5	4.9
12. Rubber	.017	64.4	140.6	340.3	3.4	5.2	7.3	4.7	6.3
13. Leather	.043	199.6	174.7	294.4	14.0	10.9	12.6	10.3	11.4
14. Stone, Clay, Glass	.041	191.1	312.9	669.1	17.5	20.0	22.6	13.1	14.3
15. Primary Metal	.118	2,581.3	4,799.1	9,902.6	129.1	136.0	213.4	62.7	94.3
16. Fabricated Metal	.101	1,357.4	2,257.5	5,063.4	90.2	108.1	187.1	96.3	160.0
17. Machinery (Except Elect.)	.090	1,827.8	2,592.7	5,919.6	142.0	143.6	229.5	128.5	196.9
18. Electrical Machinery	.160	1,564.4	2,050.3	5,147.3	122.5	139.5	175.6	133.9	161.6
19. Motor Vehicles	.024	389.0	618.0	1,518.2	13.8	14.5	15.7	12.5	12.9
19. Other Transportation Equipment	.070	349.7	621.9	958.5	28.4	31.8	33.2	27.0	27.0
20. Professional Instruments	.114	283.5	434.7	1,105.4	25.0	26.2	43.6	22.8	36.4
21. Miscellaneous Manufacturing	.083	519.2	453.6	1,233.9	35.9	44.6	59.6	39.7	50.8
22. Telecomm. and Utilities	.048	540.6	1,037.5	1,901.6	52.1	62.9	95.2	54.9	79.8
23. Railroads	.066	824.2	855.9	834.0	97.0	84.0	66.0	71.9	54.2
24. Trucking	.067	327.3	592.2	1,821.1	40.0	54.0	84.8	50.0	75.3
25. Warehousing	.070	47.3	66.6	198.4	9.4	11.3	15.1	10.5	13.4
26. Water Transport	.015	55.8	53.7	322.0	3.0	3.3	8.8	2.9	7.3
27. Air Transport	.049	48.3	144.1	652.6	5.6	9.2	16.3	8.4	14.3
28. Pipe Lines	.012	5.4	10.5	15.7	0.2	0.2	0.4	0.2	0.3
29. Wholesale Trade	.080	1,610.2	1,878.7	4,495.3	159.0	185.5	280.6	171.6	248.9
30. Retail Trade	.045	1,441.4	1,639.1	4,019.2	345.0	371.2	573.7	304.4	451.3
31. Local and Highway Transportation	.076	307.4	251.5	290.7	38.1	30.5	26.7	28.5	23.9
32. Eating and Drinking Places	.056	925.9	1,051.9	2,833.6	87.0	99.2	158.8	87.5	134.3
33. Banking, Finance and Insurance	.060	949.0	1,764.5	2,971.6	90.2	105.4	220.4	96.8	194.1
34. Hotels	.063	108.7	112.1	244.9	27.7	29.0	45.8	27.0	40.9
35. Real Estate and Rentals	.047	1,636.5	2,490.0	5,249.5	49.6	55.8	124.0	52.5	111.9
36. Personal Services	.064	351.3	374.2	1,040.0	69.1	63.6	137.4	56.5	117.2
37. Business Services	.109	693.9	1,471.9	3,475.2	41.8	64.4	146.0	60.5	131.5
38. Automobile Repair Services	.042	207.2	320.2	715.0	9.0	10.4	18.6	8.9	15.2
39. Other Repair Services	.052	103.2	122.4	188.4	8.8	12.0	21.7	10.5	18.1
40. Entertainment	.058	211.7	171.5	704.1	18.9	22.6	33.7	20.1	28.6
41. Medical, Dental and Other	.053	588.6	982.7	2,809.9	66.5	107.7	264.0	94.0	221.3
42. Non-Profit	.041	375.5	668.3	1,667.6	86.2	122.5	295.5	105.1	243.3
43. Construction	.047	1,677.0	3,357.9	8,054.7	110.0	184.0	304.7	153.3	243.5
46. Federal Government	.025	340.1	408.1	710.1	60.8	68.4	90.0	59.7	75.4
47. State and Local Government	.040	391.5	824.6	2,010.8	67.3	96.1	170.0	84.3	143.0
49. Households	.030	122.6	224.2	376.7	57.8	71.5	100.0	61.4	82.3
Manufactures	.073	17,746.8	23,988.9	52,123.9	989.8	1,038.9	1,404.4	857.0	1,097.8
Non-Manufactures	.039	12,675.1	21,102.7	47,926.5	1,624.1	1,944.8	3,311.0	1,691.8	2,776.0
Total	.053	30,421.9	45,091.6	100,050.4	2,613.9	2,983.7	4,715.4	2,548.8	3,873.8

[a]Data appearing in this table were obtained from: *Forecasting Economic Activity For The Chicago Region: Final Report* (36,100), (Chicago: CATS, 1959), Tables 7, 8, 10 and 57. The output and employment estimates presented in these tables were based on data from the following sources: *Census of Manufactures* (1939, 1947 and 1954); *Census of Business* (1948, 1959); *Census of Population* (1950); *Census of Housing* (1950); U. S. Department of Commerce, National Income Division (Tables appearing in *National Income, Business Statistics and Survey of Current Business*); U. S. Department of Labor, Bureau of Labor Statistics *Interindustry Flow of Goods and Services*, 1947, Table 1, 1953; Bureau of Labor Statistics *Employment, Hours and Earnings*; State of Illinois, Department of Labor, Division of Unemployment and Compensation *Chicago Metropolitan Area Employment, Hours and Earnings*. A detailed description of the utilization of this data appears in: *Forecasting Economic Activity: Regional Input-Output Analysis* (36,142), (Chicago: CATS, 1958) (p. 25 in particular), and *Forecasting Economic Activity: Employment Data* (36,101), (Chicago: CATS, 1958) (p. 4 in particular). The 1980 output and employment forecast is described in detail in *Forecasting Economic Activity: Production and Employment Forecast*, (36,143), (Chicago: CATS, 1958).

[b]Output, for industries (1) through (43), refers to "economic activity" as defined in the *BLS 1947 Interindustry Relations Study* of the U. S. economy. For manufactures, this measure is comparable roughly to the Census of Manufactures "value of shipments." For industries (46), (47), and (49), output refers to national income by industrial origin, as defined by National Income Division, Department of Commerce.

[c]Employment is based on Illinois Department of Labor employment data. "Employment" here covers all workers, including proprietors and unpaid family workers; it refers to number of jobs rather than number of people, so that a person with two jobs is counted twice.

[d]The industry "agriculture and forestry" does not correspond with the land use type "agriculture, forestry, and fisheries." The latter mainly measured land areas devoted to nurseries and greenhouses.

TABLE 39

AUTOMOBILE REGISTRATIONS PER THOUSAND PERSONS IN CHICAGO AND IN COOK (LESS CHICAGO) AND DU PAGE COUNTIES, 1930-1959 AND ESTIMATED FOR 1980

Year	Automobile Registrations		Population[c]		Automobile Registrations Per Thousand Population	
	City of Chicago[a]	Cook County (less Chicago) and Du Page Co.[b]	City of Chicago	Cook County (less Chicago) and Du Page Co.	City of Chicago	Cook County (less Chicago) and Du Page Co.
1930	406,600	188,000	3,376,438	697,683	120	270
1931	417,900	......	3,377,250	706,138	124	...
1932	396,900	......	3,378,062	714,593	118	...
1933	367,500	......	3,378,874	723,048	109	...
1934	368,700	......	3,379,686	731,504	109	...
1935	396,700	220,000	3,380,498	739,960	117	300
1936	461,500	......	3,381,310	748,416	137	...
1937	504,200	......	3,382,122	756,872	149	...
1938	507,900	......	3,382,934	765,328	150	...
1939	516,000	......	3,383,746	773,785	153	...
1940	549,500	240,000	3,396,808	769,992	162	310
1941	585,200	......	3,419,227	779,000	171	...
1942	545,800	......	3,441,646	787,654	159	...
1943	467,400	......	3,464,065	796,535	135	...
1944	433,900	238,800	3,486,484	805,516	124	296
1945	427,800	247,200	3,508,903	838,097	122	295
1946	461,700	266,500	3,531,322	873,678	131	305
1947	512,800	292,700	3,553,741	911,259	144	321
1948	567,700	302,300	3,576,160	949,840	159	318
1949	634,400	331,900	3,598,580	993,920	176	334
1950	705,200	378,100	3,621,000	1,042,400	195	363
1951	734,800	415,100	3,620,000	1,126,000	203	369
1952	725,700	446,300	3,620,000	1,210,000	200	369
1953	764,900	481,200	3,620,000	1,294,000	211	372
1954	792,900	522,500	3,620,000	1,378,000	219	379
1955	831,400	566,700	3,620,000	1,462,000	230	388
1956	870,500	594,800	3,620,000	1,546,000	240	385
1957	874,800	639,800	3,620,000	1,630,000	242	393
1958	856,400	680,000	3,585,000	1,714,000	239	397
1959[d]	857,500	721,500	3,550,000[d]	1,800,000	242	401
1980 (Est).	......	......	......	......	280	430

[a]Source: "Comparative Wheel Tax Statement" City of Chicago, City Collector's Office. Unpublished reports.

[b]Prior to 1944, estimated on basis of motor vehicle registration fee collections in Cook and Du Page Counties as a percentage of total Illinois registration fees, and adjusted by .86 to eliminate trucks. Years 1944 and after from Table VRC, Bureau of Research, Illinois Division of Highways.

[c]Source: U.S. Census, with intercensal years interpolated. Years since 1950 estimated on basis of Study survey.

[d]Estimated from early 1960 census reports.

TABLE 40
PASSENGER CAR AND TRUCK REGISTRATIONS FOR THE UNITED STATES, ILLINOIS, AND THE STUDY AREA, 1930-1959 AND ESTIMATED FOR 1980
(In Thousands)

Place and Time	Population	Passenger Cars	Trucks and Buses	All Vehicles	Passenger Cars Per 1,000 Persons	Trucks and Buses Per 1,000 Persons
UNITED STATES[a]						
1930	123,188	22,972	3,559	26,531	186	29
1935	127,362	22,495	3,735	26,230	177	29
1940	132,122	27,372	4,663	32,035	207	35
1945	139,928	25,691	4,947	30,638	184	35
1947	144,126	30,719	6,642	37,361	213	46
1948	146,631	33,214	7,343	40,557	227	50
1949	149,188	36,312	7,828	44,140	243	52
1950	151,683	40,185	8,415	48,600	265	55
1951	154,360	42,525	8,801	51,326	275	57
1952	157,028	43,654	8,998	52,652	278	57
1953	159,643	46,251	9,316	55,567	290	58
1954	162,409	48,286	9,546	57,832	297	59
1955	164,595	51,951	10,035	61,986	316	61
1956	167,440	54,004	10,408	64,412	323	62
1957	170,510	55,693	10,640	66,338	327	62
1958	173,000	56,870	10,777	67,647	329	62
1976 (Est.)	229,758	94,958	18,684	113,642	413	81
ILLINOIS[b]						
1930	7,630	1,429.0	209.0	1,638.0	188	27
1935	7,740	1,342.9	190.8	1,533.7	174	25
1940	7,920	1,707.5	228.9	1,936.4	216	29
1945	8,160	1,508.2	224.9	1,733.1	185	28
1947	8,320	1,747.6	290.7	2,038.3	210	35
1948	8,460	1,888.4	315.6	2,204.0	223	37
1949	8,590	2,064.5	332.9	2,397.4	240	39
1950	8,750	2,273.1	359.6	2,632.7	260	41
1951	8,817	2,393.1	378.9	2,772.0	271	43
1952	8,904	2,442.9	379.6	2,822.5	274	43
1953	9,005	2,566.9	373.9	2,940.8	285	42
1954	9,159	2,680.3	389.6	3,069.9	293	43
1955	9,316	2,844.6	405.7	3,250.3	305	44
1956	9,484	2,970.7	419.3	3,390.0	313	44
1957	9,699	3,061.6	431.3	3,492.9	316	44
1958	9,889	3,112.4	436.3	3,548.7	315	44
1959	10,000	3,206.0	451.1	3,657.1	321	45
1976 (Est.)	12,110	4,967.0	614.0	5,581.0	410	51
STUDY AREA[c]						
1947	4,470	808.3	102.3	910.6	181	23
1948	4,529	873.4	109.2	982.6	193	24
1949	4,601	970.1	111.2	1,081.3	211	24
1950	4,676	1,087.6	117.1	1,204.7	233	25
1951	4,732	1,154.5	122.4	1,276.9	244	26
1952	4,804	1,176.7	121.1	1,297.8	245	25
1953	4,882	1,250.9	116.6	1,367.5	256	24
1954	5,011	1,320.0	119.7	1,439.7	263	24
1955	5,119	1,403.0	124.2	1,527.2	274	24
1956	5,200	1,470.3	130.4	1,600.7	283	25
1957	5,317	1,519.6	134.0	1,653.6	285	25
1958	5,433	1,541.3	133.5	1,674.8	284	24
1959	5,550	1,584.3	137.1	1,721.4	285	24
1980 (Forecast)	7,808	2,828.0	211.0	3,039.0	362	27

[a]United States: Automobile Manufacturers Association, *Automobile Facts and Figures, 1958 Edition.* Year 1958 from *Highway Statistics—1958,* U.S. Department of Commerce, Bureau of Public Roads, Washington, 1960. These figures do not include publicly owned vehicles. Population and vehicle estimates for 1976 from *Public Roads,* U.S. Department of Commerce, Bureau of Public Roads, February, 1960. Estimate includes publicly owned vehicles. Taxis included with passenger cars.

[b]Illinois: State of Illinois, Division of Highways, Bureau of Research and Planning, Table VRC. Population and vehicle estimates for 1976 from February, 1960 issue of *Public Roads.* All figures include publicly owned vehicles. Historical figures exclude taxis.

[c]Study Area: State of Illinois, Division of Highways, Bureau of Research and Planning, Table VRC. Study Area taken as Cook County, 0.86 of Du Page County, and 0.21 of Lake County. Year 1980 is Study's estimate. All figures include publicly owned vehicles, and exclude taxis. Institutional population is included.

District	Total Area in Sq. Miles	Land in Use						
		Residential	Manufacturing	Trans.[a] Commun. and Utilities	Commercial	Public Buildings	Total[b] Developed Land	Public Open Space
01	1.2	11.3	9.6	117.0	147.5	26.5	311.9	86.0
11	12.4	1,071.5	549.7	1,400.8	913.5	347.4	4,282.9	424.6
21	3.7	866.6	63.8	59.8	240.7	106.1	1,337.0	331.6
22	4.0	750.8	297.3	152.9	270.9	85.0	1,556.9	6.4
23	4.9	960.2	228.1	242.6	277.0	90.4	1,798.3	216.6
24	3.0	569.3	98.6	178.1	181.4	77.2	1,104.6	150.8
25	4.0	396.2	425.6	555.8	286.0	36.9	1,700.5	12.6
26	3.0	359.2	422.3	379.3	160.7	47.1	1,368.6	17.6
27	3.5	545.8	82.8	170.4	176.4	213.6	1,189.0	136.8
31	5.0	1,135.8	62.4	59.3	247.4	214.2	1,719.1	521.7
32	7.0	1,824.9	282.4	137.5	301.1	136.1	2,682.0	224.1
33	7.0	1,574.7	392.7	443.8	306.9	83.2	2,801.3	147.2
34	5.0	895.0	324.9	493.4	278.2	47.9	2,039.4	88.9
35	6.9	884.9	645.0	997.6	239.1	137.5	2,904.1	135.9
36	4.9	1,001.1	322.0	351.6	235.6	65.6	1,975.9	113.3
37	5.4	1,052.9	27.0	174.0	295.9	255.8	1,805.6	506.1
41	9.6	2,282.9	277.2	186.4	464.6	266.9	3,478.0	607.9
42	13.0	3,174.5	196.4	185.3	442.6	590.2	4,589.0	1,029.1
43	14.2	4,505.0	313.6	219.4	452.5	292.3	5,782.8	339.5
44	11.2	2,805.6	478.8	459.0	275.2	138.2	4,156.8	412.3
45	13.2	1,895.2	830.8	2,526.5	224.0	85.1	5,561.6	253.6
46	11.9	3,031.5	331.2	545.7	425.9	155.5	4,489.8	399.6
47	11.9	2,771.9	282.3	432.0	466.2	231.4	4,183.8	827.8
51	12.4	3,238.4	419.2	391.8	411.7	321.8	4,782.9	588.9
52	23.0	5,856.2	1,131.2	238.3	516.4	448.4	8,190.5	2,131.6
53	23.0	4,876.6	1,226.9	489.3	597.8	366.8	7,557.4	3,613.5
54	18.3	3,464.9	1,373.1	619.1	227.2	486.9	6,171.2	1,995.4
55	18.2	3,471.8	1,462.5	1,281.7	323.2	241.1	6,780.3	203.3
56	17.8	5,320.6	119.3	242.4	439.4	403.6	6,525.3	987.6
57	16.5	2,957.5	1,037.1	1,622.0	463.8	165.3	6,245.7	295.1
61	24.2	6,820.6	335.0	379.5	341.8	570.1	8,447.0	2,717.5
62	48.0	12,062.7	960.1	1,868.8	1,109.0	925.9	16,926.5	4,819.0
63	51.4	10,381.7	1,650.0	7,335.7	884.0	618.8	20,870.2	2,482.5
64	40.7	10,517.8	867.6	377.9	738.2	931.5	13,433.0	4,315.2
65	51.7	10,093.8	694.4	1,379.4	643.0	739.3	13,549.9	7,299.9
66	44.1	9,409.5	1,361.1	1,783.6	748.3	668.0	13,970.5	3,093.6
67	33.6	4,115.6	2,430.2	2,577.5	502.5	264.8	9,890.6	1,142.4
71	42.6	10,358.8	432.2	542.0	720.0	1,460.0	13,513.0	5,421.1
72	146.0	39,247.4	990.0	578.8	2,300.5	2,459.8	45,576.5	12,233.9
73	103.2	27,909.4	1,510.2	602.6	1,498.3	1,662.5	33,183.0	5,381.8
74	79.8	20,974.2	793.6	258.0	1,209.1	1,897.4	25,132.3	6,932.8
75	79.8	14,291.5	191.2	948.3	679.6	4,092.8	20,203.4	9,627.6
76	140.3	34,458.1	1,029.5	1,679.7	2,189.8	2,486.7	41,843.8	9,681.8
77	56.0	9,552.0	1,223.3	5,151.1	724.4	564.0	17,214.8	4,770.9
Total	1,236.5	283,745.9	28,182.2	40,815.7	24,577.3	25,505.6	402,826.7	96,725.4

[a]Includes a small amount of land in extractive industries, gravel quarries, etc.

[b]This is a subtotal of land in Residential, Manufacturing, Transportation, Commercial and Public Buildings. The sum of these land uses has been used as a base for the compilation of the developed land area map (Map 12, Chapter IV).

CHICAGO STUDY AREA BY DISTRICT—IN ACRES

			Vacant Land					
Parking	Streets and Alleys	Total Land in Use	Resi-dential	Manu-facturing	Commercial	Waterways and Unusable	Public Buildings	Total Land
65.6	210.1	673.6	.....	......	4.0	55.8	......	733.4
195.9	2,530.9	7,434.3	97.0	159.0	87.6	150.2	8.6	7,936.7
7.0	667.1	2,342.7	25.7	1.5	11.5	......	1.8	2,383.2
7.5	837.6	2,408.4	28.6	42.4	14.6	40.5	2.0	2,536.5
7.0	1,026.4	3,048.3	47.2	21.8	20.2	......	3.3	3,140.8
15.4	575.7	1,846.5	29.9	3.8	12.2	......	2.3	1,894.7
38.8	603.6	2,355.5	40.7	41.4	26.3	121.5	2.9	2,588.3
22.3	375.5	1,784.0	46.3	51.8	13.0	16.1	3.4	1,914.6
29.8	700.7	2,056.3	109.3	9.7	44.6	......	9.3	2,229.2
16.6	864.1	3,121.5	29.3	1.0	20.3	7.3	1.8	3,181.2
23.7	1,362.3	4,292.1	57.2	42.1	31.0	31.3	3.7	4,457.4
38.1	1,321.1	4,307.7	91.5	45.7	42.9	......	6.0	4,493.8
51.2	881.6	3,061.1	50.6	38.1	38.0	......	5.1	3,192.9
26.4	966.4	4,032.8	88.1	202.2	28.6	73.3	5.8	4,430.8
8.5	881.2	2,978.9	117.2	38.5	28.0	......	8.0	3,170.6
16.2	1,020.6	3,348.5	62.1	8.9	31.6	......	5.0	3,456.1
15.7	1,634.8	5,736.4	270.4	27.4	82.7	20.5	17.5	6,154.9
23.8	2,282.9	7,924.8	237.0	......	109.0	28.0	15.3	8,314.1
22.8	2,628.6	8,773.7	188.4	1.5	88.9	......	12.1	9,064.6
11.2	1,961.7	6,542.0	423.2	38.0	102.5	2.3	28.0	7,136.0
47.0	1,813.1	7,675.3	382.4	135.5	140.1	80.7	47.3	8,461.3
37.9	2,061.9	6,989.2	381.8	122.2	99.1	4.8	24.5	7,621.6
49.0	2,255.5	7,316.1	196.7	35.0	83.0	......	13.2	7,644.0
12.4	2,183.1	7,567.3	190.4	84.8	39.2	59.3	13.2	7,954.2
7.0	4,021.0	14,350.1	317.0	16.0	52.0	10.0	27.5	14,772.6
18.6	3,243.3	14,432.8	149.4	33.4	41.1	53.3	23.7	14,733.7
1.9	2,340.7	10,509.2	242.2	247.9	21.1	643.6	20.0	11,684.0
93.3	2,348.4	9,425.3	299.8	1,498.9	21.9	339.2	27.3	11,612.4
17.6	3,231.6	10,762.1	421.8	113.8	76.9	......	27.7	11,402.3
11.8	2,727.7	9,280.3	208.3	874.3	51.6	121.7	14.2	10,550.4
9.0	3,219.9	14,393.4	744.5	222.8	29.2	40.2	55.9	15,486.0
0.7	6,641.1	28,387.3	1,434.9	566.6	129.3	64.0	118.9	30,701.0
2.4	6,137.7	29,492.8	1,173.8	1,846.3	47.5	225.1	90.6	32,876.1
3.7	6,129.9	23,881.8	1,322.8	513.3	62.6	185.0	116.3	26,081.8
0.3	6,728.2	27,578.3	2,815.6	1,165.6	61.9	1,293.4	206.9	33,121.7
22.1	6,579.7	23,665.9	1,756.3	2,050.8	119.3	474.4	141.0	28,207.7
55.9	3,030.3	14,119.2	622.1	3,901.4	44.1	2,777.9	46.8	21,511.5
......	5,604.3	24.538.4	1,930.2	384.4	59.2	220.8	153.6	27,286.6
3.6	20,805.4	78,619.4	11,447.6	1,179.1	370.3	950.0	871.2	93,437.6
0.9	14,639.8	53,205.5	8,325.3	3,037.5	203.2	685.0	608.9	66,065.4
5.5	11,546.4	43,617.0	6,192.9	353.2	157.4	339.4	439.2	51,099.1[c]
......	9,231.9	39,062.9	8,360.4	1,353.6	212.7	1,464.6	594.4	51,048.6
8.4	21,096.5	72,630.5	13,923.4	1,432.6	472.2	253.7	1,060.0	89,772.4
......	6,304.8	28,290.5	3,433.1	2,757.9	152.1	901.8	266.0	35,801.4
1,052.5	177,255.1[d]	677,859.7	68,312.4	24,701.7	3,584.5	11,734.7	5,150.2	791,343.2

[c]A typographical error in Volume I listed the total land in District 74 at 59,099.1 acres. The total actually is 51,099.1 as indicated here.

[d]Differs from Table 7, page 31, which allowed approximately twenty-five square miles of additional land in streets for future expressway construction. This area was not allocated in the district totals above.

TABLE 42
PERCENTAGE USE OF MANUFACTURING LAND,
1956 AND ESTIMATED FOR 1980

Distance From Loop In Miles	Manufacturing Trip* Capacity	1956		1980	
		Trips To Mfg.	Per Cent Capacity	Trips To Mfg.	Per Cent Capacity
0- 3.9	278,193	225,132	.81	225,132	.81
4.0- 7.9	321,111	292,735	.91	302,310	.94
8.0-11.9	242,307	133,475	.55	185,193	.76
12.0-15.9	262,140	70,765	.27	128,125	.49
16.0-19.9	261,688	32,712	.13	115,556	.44
20.0-23.9	88,793	8,890	.10	37,553	.42
24.0-27.9	104,665	9,450	.09	34,459	.33
28.0 and over	11,783	638	.05	1,922	.16
Total	1,570,680	773,797	.49	1,030,260	.66

*Trips are a stable indicator of employment; 91.5 per cent of all trips to manufacturing land are made by employees.

TABLE 43
LAND USES IN THE CHICAGO AREA, 1956 AND ESTIMATED
FOR 1980, COMPARED WITH OTHER URBAN AREAS
(All figures in acres per 1,000 population)

Land Use	Chicago Study Area		Fifty-Three Central Cities[a]	Thirty-Three Satellite Cities[a]	Eleven Urban Places[a,b]	Detroit Study Area 1953	Pittsburgh Study Area 1958[c]
	1956	1980					
Residential	22.3	36.3	27.3	36.5	41.6	32.2	35.2
Streets and Alleys	18.1	24.8	19.4	24.0	41.0	21.8	19.8
Commercial	2.8	3.2	2.3	2.2	3.9	1.7	3.5
Manufacturing and Transportation	9.4	8.8	7.8	10.9	17.6	6.4	7.5
Public Buildings and Public Open Space	17.1	15.7	12.1	13.3	44.3	6.9	13.0
Total	69.7	88.8	68.9	86.9	148.4	70.5[d]	79.0

[a]Bartholomew, Harland, *Land Uses In American Cities* (Cambridge: Harvard University Press, 1955) p. 121.
[b]These, generally, are small cities and the averages per thousand population, therefore, vary substantially from the larger urban areas.
[c]*Land Use Forecast* (Pittsburgh: Pittsburgh Area Transportation Study).
[d]*Report on the Detroit Metropolitan Area Traffic Study* (Detroit Metropolitan Area Traffic Study, 1955) Part 1, p. 123. Total includes 1.5 acres per thousand of unclassified land use.

TABLE 44
NUMBER OF PERSONS ENTERING CENTRAL BUSINESS DISTRICT[a] DAILY—BY MODE

Year	Buses and Streetcars[b]	Subway and Elevated[c]	Suburban Railroad	Automobiles and Taxis[d]	Total
1926..........	339,349	256,286	118,857	166,367	880,859
1928..........	329,485	243,594	124,107	196,873	894,059
1929..........	351,851	236,575	132,723	203,996	925,145
1931..........	327,812	191,540	119,742	203,916	843,010
1935..........	296,993	169,690	84,251	204,760	755,694
1936..........	293,593	200,212	92,144	215,849	801,798
1937..........	306,052	209,590	103,505	226,868	846,015
1938..........	285,506	193,005	94,208	239,414	812,133
1939..........	289,282	205,142	99,970	244,980	839,374
1940..........	276,095	191,875	100,246	256,150	824,366
1941..........	276,655	191,851	103,405	251,962	823,873
1942..........	278,839	192,623	116,946	215,113	803,521
1943..........	296,947	212,825	139,966	165,087	814,825
1944..........	278,893	206,613	146,334	164,175	796,015
1945..........	286,191	212,215	148,964	170,422	817,792
1946..........	331,377	229,430	158,001	231,201	950,009
1947..........	320,572	229,164	152,082	238,163	939,981
1948..........	314,519	238,830	156,205	261,418	970,972
1949..........	286,591	224,932	142,521	274,094	928,138
1950..........	259,482	199,351	138,741	282,659	880,233
1951..........	231,152	216,288	139,188	292,014	878,642
1952..........	221,681	222,753	137,191	283,730	865,355
1953..........	207,237	228,853	132,678	260,574	829,342
1954..........	186,057	235,877	133,022	278,500	833,456
1955..........	178,029	236,544	130,600	285,873	831,046
1956..........	170,401	236,838	136,268	297,005	840,512
1957..........	163,412	242,389	140,425	304,854	851,080
1958..........	146,685	237,097	133,029	321,407	838,218
1959..........	144,232	254,452	122,311	317,139	838,134

Source: *Cordon Count Data of the Central Business District* (Chicago: City of Chicago, Department of Streets and Sanitation, Bureau of Street Traffic, 1959).

[a]Central Business District here defined as bounded by Lake Michigan on the east, the Chicago River on the north and west and Roosevelt Road on the south.

[b]Last streetcar line in service was converted to bus operation in 1958.

[c]Includes the Chicago, North Shore and Milwaukee Railroad.

[d]Passengers per automobile and taxi were considered as 1.8 from 1926-1929, 1.7 from 1929 to 1952, and 1.5 from 1953.

TABLE 45
VEHICLE TRIP DESTINATIONS—1956 AND ESTIMATED FOR 1980
(Trucks Weighted)

District	Passenger Car Trips		Truck Trips		Total Vehicle Trips	
	1956	1980	1956	1980	1956	1980
01	122,309	137,304	38,554	45,235	160,863	182,539
11	306,524	370,969	200,191	214,027	506,715	584,996
21	91,825	110,425	22,075	25,346	113,900	135,771
22	72,725	84,023	36,756	38,850	109,481	122,873
23	89,947	106,384	35,296	38,165	125,243	144,549
24	52,919	68,099	20,905	22,922	73,824	91,021
25	45,762	51,723	38,310	39,329	84,072	91,052
26	39,459	43,056	28,660	29,327	68,119	72,383
27	54,513	70,511	20,352	22,699	74,865	93,210
31	111,233	131,273	28,819	32,585	140,052	163,858
32	129,536	147,965	41,144	44,607	170,680	192,572
33	134,806	151,010	41,969	45,014	176,775	196,024
34	76,915	88,429	31,921	34,932	108,836	123,361
35	63,807	75,981	37,296	41,905	101,103	117,886
36	62,677	71,034	22,557	24,128	85,234	95,162
37	100,949	126,038	25,263	29,569	126,208	155,607
41	168,426	197,558	45,184	51,344	213,610	248,902
42	158,700	182,362	50,682	55,491	209,382	237,853
43	221,397	249,902	42,510	48,408	263,907	298,310
44	131,049	147,785	33,336	37,419	164,385	185,204
45	80,587	103,376	29,446	40,650	110,033	144,026
46	180,621	205,179	44,257	49,582	224,878	254,761
47	216,996	254,261	37,303	44,412	254,299	298,673
51	142,773	223,084	28,735	45,640	171,508	268,724
52	161,039	259,286	37,707	60,028	198,746	319,314
53	133,935	224,338	38,082	62,012	172,017	286,350
54	92,329	140,416	21,332	33,361	113,661	173,777
55	82,088	161,227	18,610	39,030	100,698	200,257
56	143,916	206,507	23,295	34,570	167,211	241,077
57	149,772	198,037	29,382	40,068	179,154	238,105
61	112,943	189,115	15,014	31,884	127,957	220,999
62	126,780	391,936	21,581	117,487	148,361	509,423
63	139,643	330,381	38,084	86,641	177,727	417,022
64	124,352	307,349	25,283	66,755	149,635	374,104
65	55,799	259,533	14,358	55,789	70,157	315,322
66	181,586	388,891	25,078	68,366	206,664	457,257
67	128,138	306,392	23,714	57,762	151,852	364,154
71	92,184	282,616	14,108	51,086	106,292	333,702
72	101,778	800,281	22,799	148,784	124,577	949,065
73	79,481	538,142	10,721	92,716	90,202	630,858
74	79,199	395,826	15,272	73,295	94,471	469,121
75	16,212	264,041	3,645	46,418	19,857	310,459
76	191,443	851,998	25,968	142,737	217,411	994,735
77	67,792	299,921	12,870	56,655	80,662	356,576
TOTAL	5,116,860	10,193,964	1,418,424	2,467,030	6,535,284	12,660,994

TABLE 46
SPEED OF TRAVEL[a] BY MODE[b] BY AIRLINE TRIP LENGTH
(All Figures in Miles per Hour)

Airline Trip Length In Miles	Automobile Driver	Suburban Railroad	Elevated-Subway	Bus
0- 1.9 ...	5.3	3.4	2.8	3.2
2.0- 3.9 ...	8.4	5.8	5.5	5.2
4.0- 5.9 ...	10.6	9.7	7.3	6.6
6.0- 7.9 ...	12.0	10.4	8.6	7.6
8.0- 9.9 ...	13.6	10.9	9.8	8.5
10.0-11.9 ...	14.6	13.1	10.5	10.3
12.0-13.9 ...	15.6	12.7	11.3	11.9
14.0-15.9 ...	17.1	14.2	13.0	11.4
16.0-17.9 ...	18.3	16.4	[c]	[c]
18.0-19.9 ...	18.9	15.8	[c]	[c]
All Trips..	11.1	14.4	8.9	6.2

[a]Airline journey speed, or elapsed time from door to door divided by airline trip length.

[b]Priority mode. Where two or more modes were used by a traveler, the mode of travel in the linked trip is defined as the mode having highest priority in the following list, taken in the following order: 1) suburban railroad, 2) elevated-subway, 3) bus, 4) auto driver, 5) auto passenger.

[c]Insufficient data.

TABLE 47
MEAN JOURNEY SPEED AND MEAN TIME IN TRANSIT BY MODE OF TRAVEL, CHICAGO AREA, 1956

Mode of Travel	Mean Journey Speed in Miles Per Hour[a]	Mean Time in Transit in Minutes[a]
Suburban Railroad	14.4	56
Automobile Driver	11.1	22
Automobile Passenger	10.4	21
Elevated-Subway	8.9[b]	48
Bus	6.2	35

[a]Both journey speed and time in transit are computed on a door-to-door basis—i.e., they include walking to and from mass transportation lines and/or parking lots.

[b]Mean journey speed rises to 10.0 miles per hour when only "unlinked" elevated-subway trips are considered, that is, only those without any other trip link using another mode of travel. All "linked" elevated trips—chiefly using bus at one end of the journey—had a mean speed of only 8.4 miles per hour.

TABLE 48
CHICAGO TRANSIT AUTHORITY AND PREDECESSOR COMPANIES' AVERAGE DAILY[a] REVENUE PASSENGERS BY MODE, 1920 TO 1959[b]

Year	Bus and Streetcar	Elevated and Subway	Total
1920	2,453,864	603,281	3,057,145
1921	2,399,654	571,604	2,971,258
1922	2,443,825	573,683	3,017,508
1923	2,679,641	645,391	3,325,032
1924	2,782,974	674,072	3,457,046
1925	2,847,133	683,689	3,530,822
1926	2,949,647	724,091	3,673,738
1927	2,980,157	715,861	3,696,018
1928	3,021,047	657,798	3,678,845
1929	3,058,754	622,704	3,681,458
1930	2,754,402	578,971	3,333,373
1931	2,473,630	482,324	2,955,954
1932	2,134,894	401,866	2,536,760
1933	2,218,041	395,119	2,613,160
1934	2,282,377	402,775	2,685,152
1935	2,240,252	403,352	2,643,604
1936	2,387,815	410,058	2,797,873
1937	2,411,972	405,080	2,817,052
1938	2,266,312	383,968	2,650,280
1939	2,273,072	384,261	2,657,333
1940	2,308,581	391,471	2,700,052
1941	2,390,644	402,322	2,792,966
1942	2,604,355	421,546	3,025,901
1943	2,805,857	445,902	3,251,759
1944	2,898,291	478,046	3,376,337
1945	2,919,905	497,706	3,417,611
1946	3,145,935	499,609	3,645,544
1947	3,083,450	461,394	3,544,844
1948	2,894,274	435,511	3,329,785
1949	2,555,991	386,898	2,942,889
1950	2,286,420	350,012	2,636,432
1951	2,108,984	356,984	2,465,968
1952	1,924,720	357,346	2,282,066
1953	1,819,056	353,603	2,172,659
1954	1,677,007	352,622	2,029,629
1955	1,615,834	357,247	1,973,081
1956	1,600,074	366,010	1,966,084
1957	1,486,662	355,318	1,841,980
1958	1,348,818	338,821	1,687,639
1959	1,369,254	358,642	1,727,896

[a]Yearly totals converted to average daily passengers by dividing by 316 weekday equivalents per year. Passengers were counted on system where fares were paid.

[b]Source: Schroeder, Werner W., *Metropolitan Transit Research Study* Chicago Transit Authority, 1956. Annual Reports of the Chicago Transit Authority, 1957-1959.

TABLE 49
SURFACE MASS TRANSPORTATION DAILY PASSENGERS AND AUTOMOBILES IN THE CITY OF CHICAGO RELATED TO POPULATION, 1946-1959

Year	Chicago Population In Thousands	Thousands Of CTA Surface Passengers Per Day[a]	Surface Rides Per 100 Persons Per Weekday	Thousands Of Automobiles Registered In Chicago[b]	Automobiles Per 1,000 Persons
1946	3,531.3	3,146	89.1	461.7	131
1947	3,553.7	3,083	86.8	512.8	144
1948	3,576.2	2,894	80.9	567.7	159
1949	3,598.6	2,555	71.0	634.4	176
1950	3,621.0	2,286	63.1	705.2	195
1951	3,620.0	2,109	58.3	734.8	203
1952	3,620.0	1,925	53.2	725.7	200
1953	3,620.0	1,819	50.2	764.9	211
1954	3,620.0	1,677	46.3	792.9	219
1955	3,620.0	1,615	44.6	831.4	230
1956	3,620.0	1,600	44.2	870.5	240
1957	3,620.0	1,487	41.1	874.8	242
1958	3,585.0	1,349	37.6	856.4	239
1959	3,550.0	1,369	38.6	857.5	242

[a]Schroeder, Werner W., *Metropolitan Transit Research Study* (Chicago: Chicago Transit Authority, 1956).

[b]"Comparative Wheel Tax Statement" City of Chicago, City Collectors' Office. Unpublished reports.

TABLE 50
PERSONS ACCUMULATED IN THE CENTRAL BUSINESS DISTRICT[a] AT 1:00 P.M., BY MODE OF TRAVEL, SELECTED YEARS 1926-1959[b]

Year	Automobile[c]	Bus and Streetcar[d]	Elevated-Subway	Suburban Railroad	Total
1926	22,400	126,893	117,331	88,331	354,955
1931	27,961	124,912	104,651	91,382	348,906
1935	30,869	129,925	93,788	67,480	322,062
1940	37,602	125,620	89,001	79,827	332,050
1945	28,295	95,471	94,750	103,349	321,865
1951	31,172	78,003	94,356	109,845	313,376
1955	34,722	53,710	108,299	108,938	305,669
1956	46,025	51,088	107,036	112,789	316,938
1957	39,511	48,063	112,574	113,913	314,061
1958	43,037	43,439	110,733	109,343	306,552
1959	36,043	45,038	113,017	103,272	297,370

[a]Area bounded by Roosevelt Road, Lake Michigan, and the Chicago River.

[b]Source: Cordon Count Data of the Central Business District (Chicago: City of Chicago, Department of Streets and Sanitation, Bureau of Street Traffic, 1959) and reports of previous years.

[c]Includes taxi passengers.

[d]Includes CTA and suburban bus lines.

TABLE 51

AIRLINE TRIP LENGTH FREQUENCY DISTRIBUTION OF AUTOMOBILE AND TRUCK TRIPS FOR SELECTED URBAN AREAS

Trip Length In Mile Frequency Groups	Automobile Trips			Truck Trips[b]	
	Pittsburgh	Detroit	Chicago	Detroit	Chicago
< 1	28.0%	22.7%	22.9%	40.7%	14.1%
1	24.4	20.1	21.2	18.1	38.1
2	14.2	12.8	12.6	10.6	13.7
3	9.3	9.2	9.0	6.7	8.9
4	7.1	7.8	7.1	5.4	6.3
5	5.0	5.9	5.4	4.0	4.2
6	3.7	5.3	4.4	3.5	3.3
7	2.5	3.9	3.8	2.6	2.8
8	1.8	3.2	2.9	2.0	1.9
9	1.4	2.4	2.0	1.3	1.7
10	1.0	1.9	1.8	1.3	1.1
11	.6	1.3	1.6	0.9	0.8
12	.4	1.0	1.2	0.7	0.7
13	.2	0.7	0.9	0.6	0.5
14	.1	0.5	0.7	0.4	0.4
15	.1	0.4	0.5	0.3	0.3
16	a	0.3	0.4	0.3	0.3
17	a	0.2	0.3	0.2	0.2
18	a	0.1	0.2	0.1	0.1
19	a	0.1	0.2	0.1	0.1
>20	a	0.2	0.9	0.2	0.5
Total	100.0%	100.0%	100.0%	100.0%	100.0%
Total Trips Represented In Internal Surveys	1,227,667	2,990,485	4,810,873	495,110	801,951

[a]Some trips, but less than .05 Per Cent.

[b]Note: Chicago truck trip lengths reported in groups of 0-.5 miles, .5-1.5 miles, etc., while Detroit trips were reported in groups of 0-1 miles, 1-2 miles, etc. A more complete report appears in "Trip Length Frequency Distribution and Its Effect on Highway Planning" *CATS Research News*, Vol. 3 (1959) No. 4.

TABLE 52

BUS TRIPS AS A PERCENTAGE OF ALL PERSON TRIPS RELATED TO AVERAGE FAMILY AUTOMOBILE OWNERSHIP

Number of Cars Owned Per Family[a]	Percentage Of Person Trips Made By Bus[b]
0	58.5
1	12.6
2	6.8
3 or more	5.0
All Families ...	18.2

[a]Actually, families and unrelated individuals.

[b]Includes trips by streetcar.

TABLE 53

COMPUTED VEHICULAR TRIPS COMPARED WITH SAMPLE SURVEY VEHICULAR TRIPS FROM ZONES 001 AND 067

Elapsed Time (Minutes)	Cumulative Destination Opportunities	Computed Vehicular Trips	Cumulative Percentage of Computed Trips	Sample Survey Vehicular Trips	Cumulative Percentage of Sample Survey Trips
Zone 001					
0- 2	112,600	9,714	27.4	6,181	17.4
2- 4	300,750	15,230	42.9	13,591	38.3
4- 6	493,000	16,950	47.8	17,050	48.1
6- 8	792,000	19,836	56.0	20,064	56.6
8-10	1,046,000	21,753	61.4	21,649	61.1
10-15	2,018,000	26,931	76.0	25,431	71.7
15-20	3,008,000	30,101	84.9	29,201	82.4
20-25	3,884,000	31,756	89.6	31,351	88.4
25-30	4,514,000	32,588	91.9	32,311	91.2
30-35	5,204,000	33,306	93.96	32,912	92.85
35-40	5,774,000	33,776	95.28	33,854	95.50
40-45	6,341,000	34,194	96.46	34,168	96.39
45-50	6,829,000	34,546	97.45	34,578	97.54
50-55	7,083,000	34,700	97.89	34,781	98.12
55-60	7,411,000	34,760	98.05	34,974	98.66
Over 60	9,508,000	35,445	100.00	35,448	100.00
Zone 067					
0- 2	23,000	2,929	12.4	3,032	12.88
2- 4	120,000	9,274	39.4	7,808	33.17
4- 6	275,000	12,818	54.45	10,247	44.29
6- 8	541,000	14,726	62.55	13,070	55.52
8-10	916,000	16,237	68.97	14,712	62.50
10-15	1,914,000	18,929	80.41	18,413	78.22
15-20	2,998,000	20,701	87.93	20,200	85.81
20-25	3,814,000	21,550	91.54	21,515	91.39
25-30	4,626,000	22,064	93.72	22,452	95.37
30-35	5,282,000	22,354	94.96	22,753	96.65
35-40	5,825,000	22,563	95.85	23,014	97.76
40-45	6,159,000	22,762	96.70	23,121	98.21
45-50	6,685,000	22,991	97.66	23,150	98.34
50-55	7,267,000	23,223	98.65	23,322	99.07
55-60	7,828,000	23,355	99.20	23,358	99.22
Over 60	9,508,000	23,541	100.00	23,541	100.00

TABLE 54

COMPARISON OF ACTUAL AND PREDICTED INTERCHANGES MEASURED IN WEIGHTED VEHICLE TRIPS FOR SEVEN ANALYSIS ZONES, BY TIME RINGS OUTWARD FROM EACH ZONE CENTER

Trip Time In Minutes (Min. Time Path)	Zone 001		Zone 003		Zone 012		Zone 067		Zone 118		Zone 487		Zone 553	
	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted
0 - 1.9	6,181	9,714	5,347	8,469	11,689	15,553	3,032	2,929	3,522	3,912	2,079	1,691	15,288	12,158
2 - 3.9	7,410	5,516	4,562	5,391	7,158	14,013	4,776	6,345	3,687	5,608	280	274	...	...
4 - 5.9	3,459	1,720	2,144	2,099	14,087	13,288	2,439	3,544	1,403	1,795	4,357	4,241	9,425	6,047
6 - 7.9	3,014	2,886	1,405	1,707	7,797	5,897	2,823	1,908	3,341	3,519	971	1,097	2,460	2,819
8 - 9.9	1,585	1,917	1,727	825	5,622	4,189	1,642	1,511	1,018	692	642	1,358	3,224	3,556
10 - 14.9	3,782	5,178	3,302	2,234	8,769	7,345	3,701	2,692	2,433	935	953	211	3,620	3,389
15 - 19.9	3,770	3,170	2,044	1,203	7,110	4,340	1,787	1,772	1,334	1,036	437	950	2,169	2,843
20 - 24.9	2,150	1,655	1,359	682	5,901	3,129	1,315	849	1,555	1,090	291	359	397	1,229
25 - 29.9	960	832	906	388	2,835	1,894	937	514	1,170	620	425	333	535	1,066
30 - 34.9	601	718	735	321	1,565	1,137	301	290	323	229	74	373	348	2,345
35 - 39.9	942	470	272	372	844	739	261	209	27	146	137	136	363	1,208
40 - 44.9	314	418	123	123	588	1,208	107	199	116	162	286	104	325	1,112
45 - 49.9	410	352	88	222	308	364	29	229	85	163	131	52	301	300
50 - 54.9	203	154	53	67	246	817	172	232	40	117	42	26	206	550
55 - 59.9	193	60	112	122	171	505	36	132	81	30	18	6	225	272
60 and over	474	688	401	355	929	1,201	183	186	12	93	117	29	282	274
Total	35,448	35,448	24,580	24,580	75,619	75,619	23,541	23,541	20,147	20,147	11,240	11,240	39,168	39,168

Time is established by minimum path computation, using 1956 actual street network. Trips are computed by formula reported in Chapter VI.

TABLE 55

TRIPS PER DWELLING PLACE BY MODE OF TRAVEL, BY NUMBER OF CARS OWNED, WITHIN RING OF RESIDENCE

Ring of Residence	CARS OWNED PER FAMILY								
	0			1			2 Or More		
	Auto	Transit	Total	Auto	Transit	Total	Auto	Transit	Total
0 + 1	.37	1.62	1.99	2.76	.87	3.63	4.91	1.55	6.46
2	.43	1.90	2.33	3.33	1.25	4.58	5.89	1.42	7.31
3	.51	2.00	2.51	3.72	1.17	4.89	6.44	1.07	7.51
4	.44	2.15	2.59	3.74	1.22	4.96	7.59	1.27	8.86
5	.71	1.86	2.57	5.29	1.09	6.38	8.28	.84	9.12
6	.93	2.12	3.05	5.79	.85	6.64	9.58	.73	10.31
7	1.45	2.00	3.45	5.64	.94	6.58	9.95	.64	10.59
All Rings	.49	1.93	2.42	4.35	1.11	5.46	8.07	.95	9.02

TABLE 56

COMPUTED MASS TRANSPORTATION TRIPS COMPARED WITH SAMPLE SURVEY MASS TRANSPORTATION TRIPS FROM ZONES 002, 043 AND 172

Airline Journey Distance In Miles	Computed Trips	Percentage	Sample Survey Trips	Percentage
Zone 002				
0- 1	5,567	5.6	4,645	5.0
1- 2	2,060	2.1	4,830	5.2
2- 3	5,236	5.3	4,099	4.4
3- 4	10,456	10.6	8,787	9.4
4- 5	9,718	9.8	7,537	8.1
5- 6	10,200	10.3	8,308	8.9
6- 7	10,859	11.0	11,346	12.2
7- 8	9,042	9.1	9,287	10.0
8- 9	8,630	8.7	10,037	10.8
9-10	4,794	4.8	5,782	6.2
10-11	3,017	3.1	2,860	3.1
11-12	2,926	3.0	3,109	3.4
12-13	1,818	1.8	2,167	2.3
13-14	1,758	1.8	1,411	1.5
14-15	1,191	1.2	951	1.0
15-16	1,118	1.1	1,279	1.4
16-17	738	.8	826	.9
17-18	912	.9	838	.9
18-19	476	.5	729	.8
19-20	677	.7	702	.8
20-21	423	.4	502	.5
Over 21	7,232	7.4	3,011	3.2
Total	98,848	100.0	93,043	100.0
Zone 043				
0- 1	114	1.6	31	.5
1- 2	912	13.1	1,087	16.6
2- 3	2,111	30.2	1,414	21.5
3- 4	1,471	21.1	1,513	23.0
4- 5	1,062	15.2	736	11.2
5- 6	713	10.2	541	8.2
6- 7	233	3.3	342	5.2
7- 8	143	2.0	185	2.8
8- 9	88	1.3	31	.5
9-10	112	1.6	306	4.7
10-11	15	.2	123	1.9
Over 11	8	.2	253	3.9
Total	6,982	100.0	6,562	100.0
Zone 172				
0- 1	573	7.4	842	11.4
1- 2	1,054	13.7	1,426	19.3
2- 3	1,564	20.3	1,097	14.9
3- 4	1,085	14.1	517	7.0
4- 5	677	8.8	307	4.2
5- 6	331	4.3	247	3.3
6- 7	125	1.6	202	2.7
7- 8	91	1.2	124	1.7
8- 9	200	2.6	246	3.3
9-10	1,600	20.6	1,927	26.2
10-11	290	3.8	31	.4
Over 11	126	1.6	418	5.6
Total	7,716	100.0	7,384	100.0

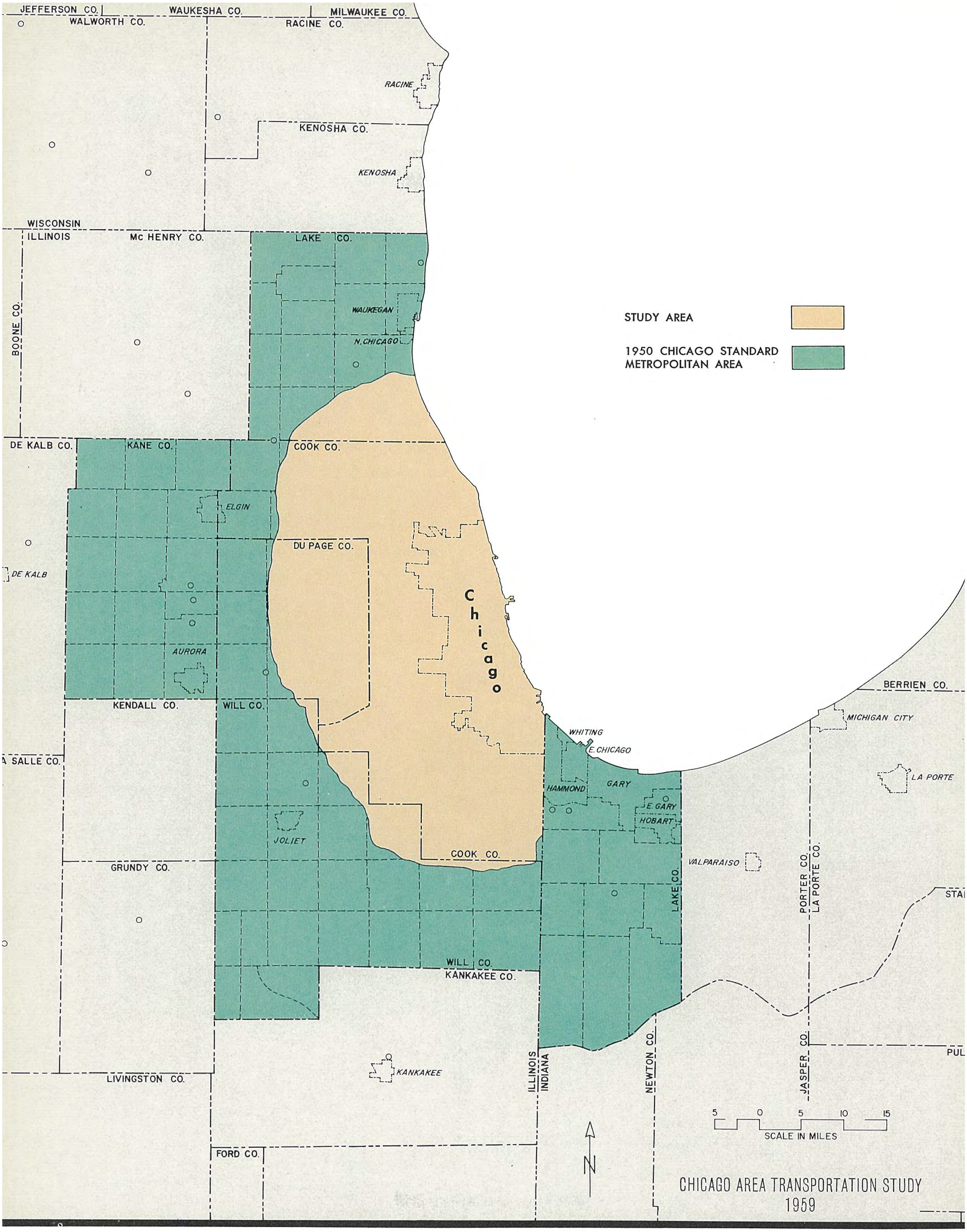
TABLE 57

SUMMARY OF PROJECTIONS FOR THE STUDY AREA—1956 TO 1980

Item	1956	1980	Ratio 1980/1956
Population	5,169,663	7,802,000	1.51
Land in Urban Use (Sq. Miles)	562.8	1,083.3	1.92
Mean Family Income	$7,750	$11,297	1.46
Median Family Income	$5,100	$ 7,400	1.46
Aggregate Consumer Income (in billions)	$16.71	$ 37.45	2.24
Employment	2,548,800	3,873,800	1.52
Motor Vehicle Registrations			
Automobiles	1,461,600	2,828,000	1.93
Automobiles garaged at residences	1,341,600	2,607,500	1.94
Trucks	130,000	211,000	1.62
Taxis	5,600	7,000	1.25
Total	1,597,200	3,046,000	1.91
Person Trip Destinations in Study Area			
By Automobile and Taxi	7,781,027	15,625,000	2.01
By Mass Transportation[a]	2,431,371	2,456,000	1.02
Total	10,212,398	18,081,000	1.77
Vehicle Trip Destinations in Study Area			
Automobile and Taxi	5,116,860	10,193,964	1.99
Truck (weighted)	1,418,425	2,467,030	1.75
Total	6,535,285	12,660,994	1.94
Miles of Person Travel (over-the-road)			
By Mass Transportation	14,919,000[b]	18,078,000	1.21
By Automobile	50,200,000	100,900,000	2.01
Total	65,119,000	118,978,000	1.83
Vehicle Equivalent Miles of Travel (over arterials and expressways)	34,240,000	67,054,000	1.96

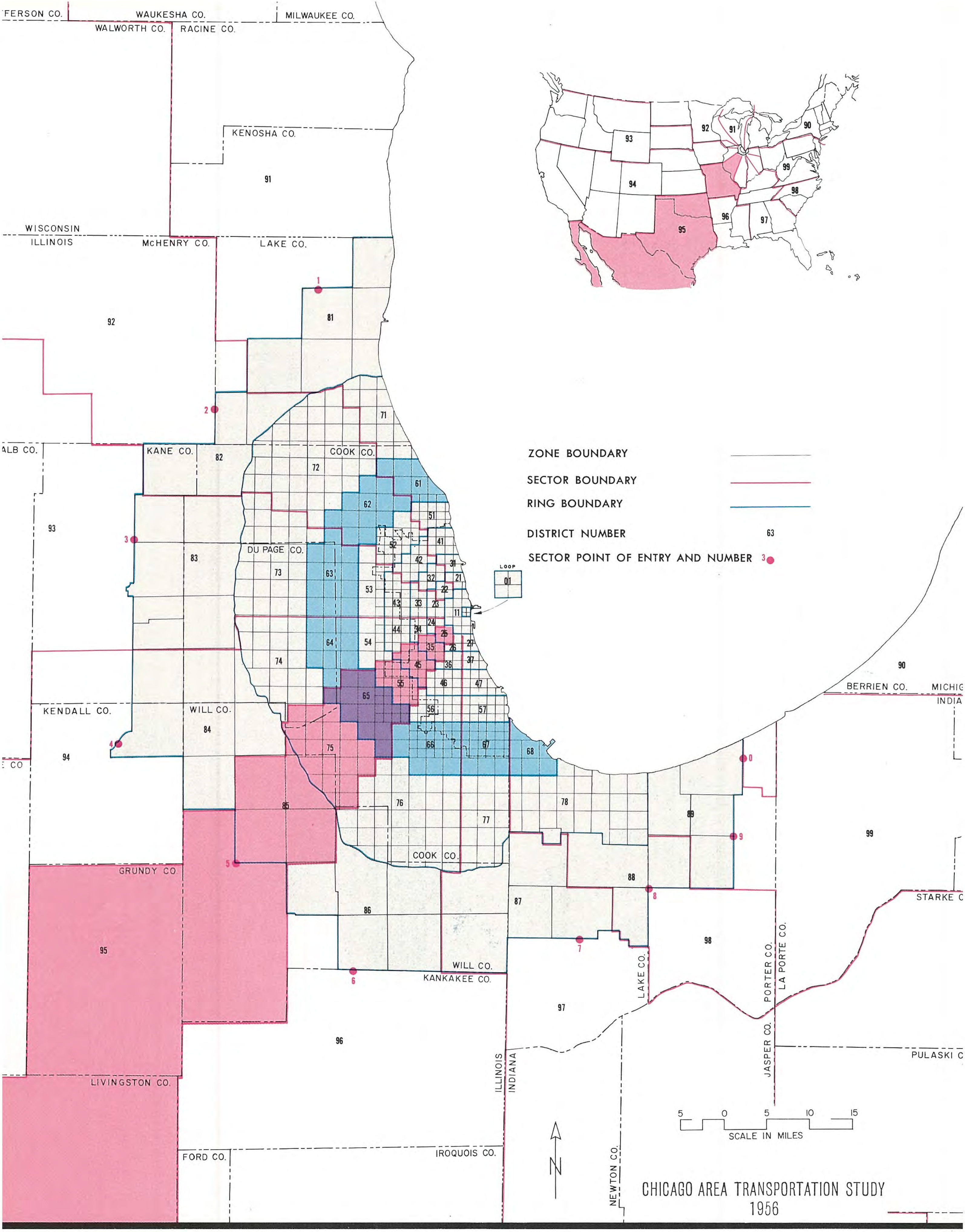
[a]Does not include destinations in Ring 8.

[b]These are computed route miles of person travel and will differ slightly from the figure given in Table 17 of Volume I.



MAP 27

STUDY AND METROPOLITAN AREAS

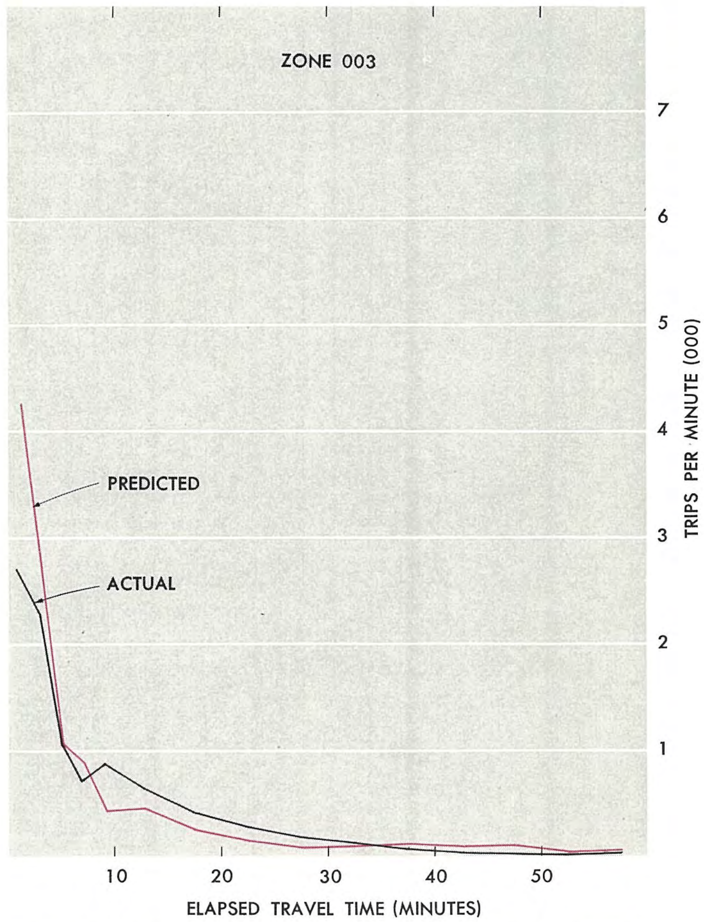


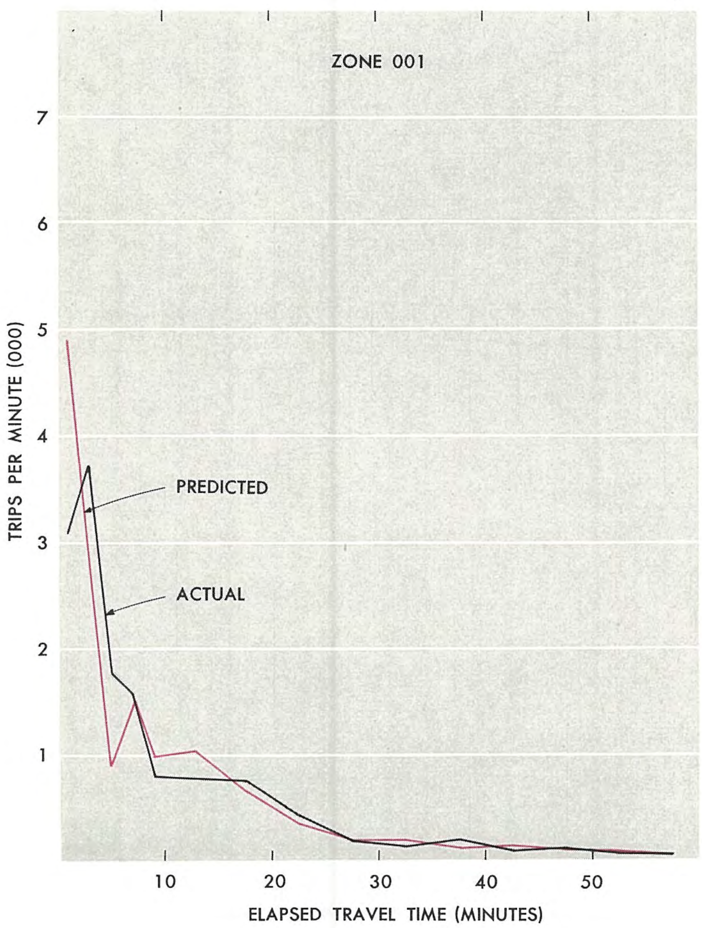
MAP 28
ANALYSIS ZONES, RINGS, SECTORS AND DISTRICTS

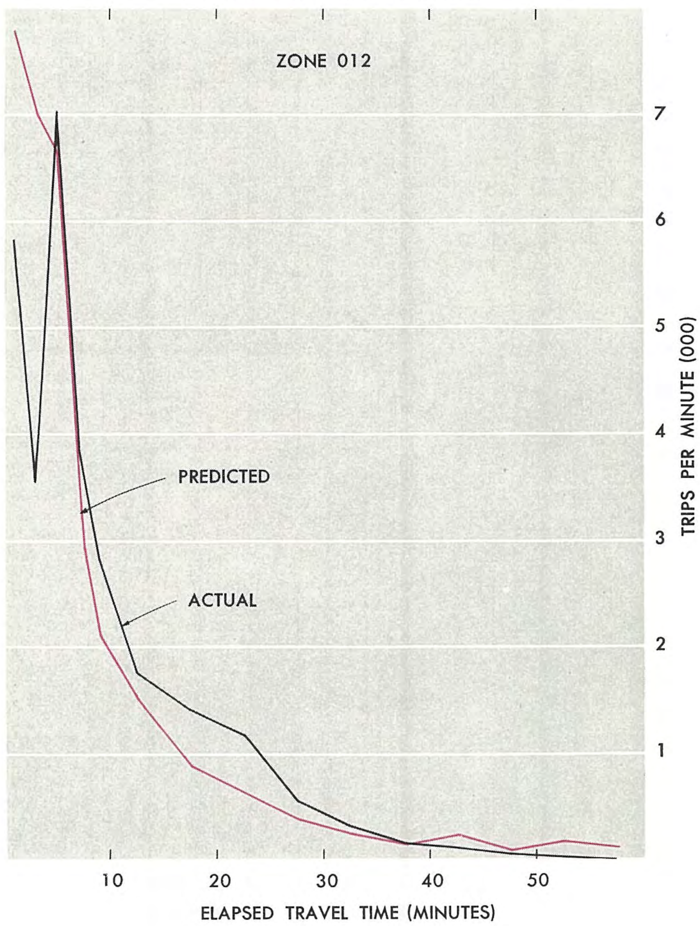
MAP 29
IDENTIFICATION OF ANALYSIS ZONES

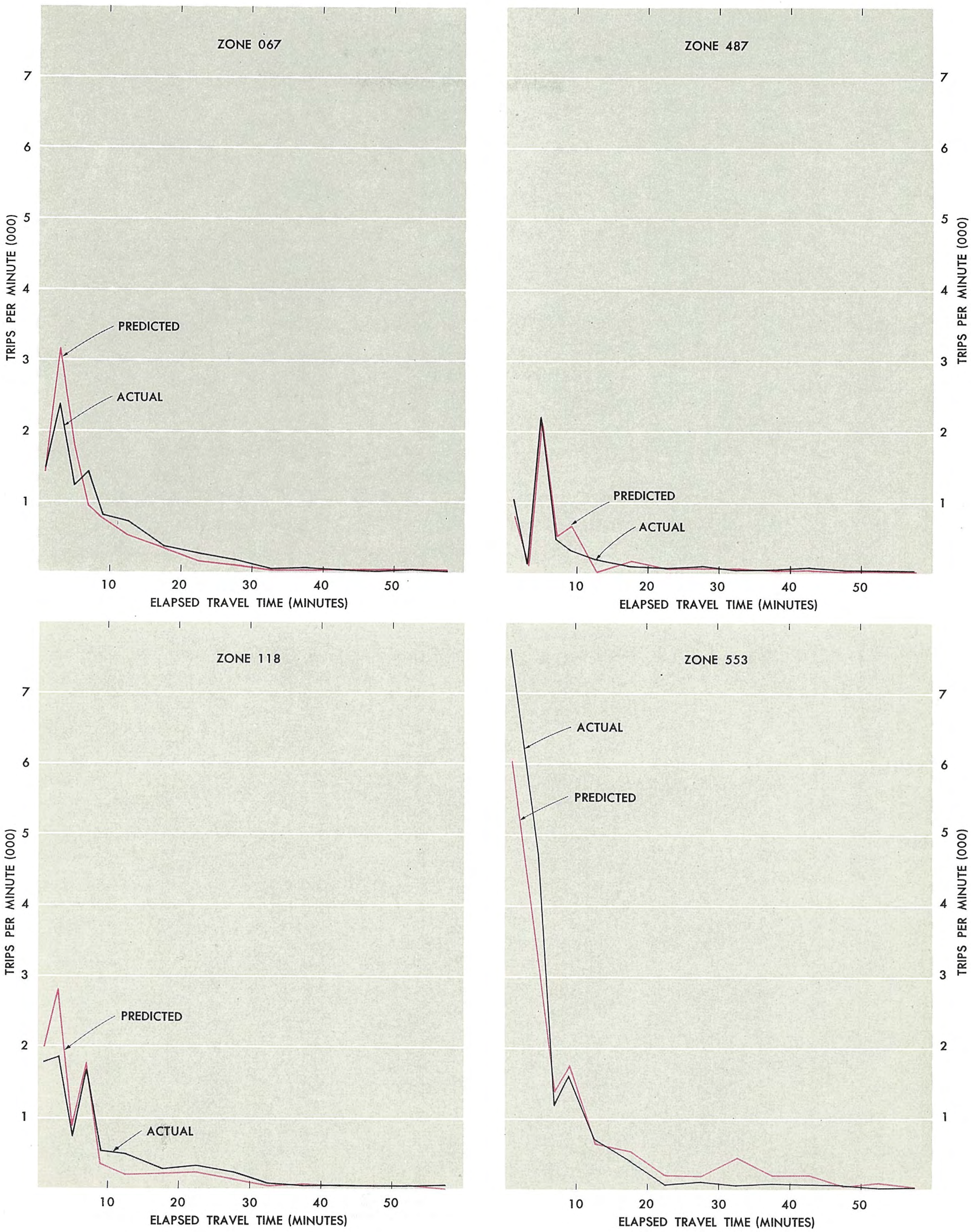
FIGURE 49—COMPUTED TRIPS COMPARED TO ACTUAL VEHICLE TRIPS FROM SELECTED ZONES 001, 003, 012, 067, 118, 487, AND 553

For each of seven test zones, travel times were established using the 1956 network and computing the shortest time paths from each origin to every destination zone. Destination zones were thereby arrayed in order of increasing time from origin zones; this permitted computing zonal interchanges by formula. In summarizing results, the size of the time frequency intervals varied. Consequently, volumes of trips were divided by interval size and are plotted in thousands of trips per minute of travel time. (Actual data are prescribed in Table 54.) The data, plotted in this fashion, illustrate the universal tendency for numbers of trips to decrease as journey time (or length) increases. But these charts also show that this is not a smooth property in real situations because of the variations in numbers of opportunities. The computed data tend to reflect these variations for the described range of different sized and differentially located zones.








ZONE 067
ZONE 487
ZONE 118
ZONE 553
PREDICTED
ACTUAL
TRIPS PER MINUTE (000)
ELAPSED TRAVEL TIME (MINUTES)
1
2
3
4
5
6
7
10
20
30
40
50