STREETS AND HIGHWAYS: A REGIONAL REPORT

Tri-State Transportation Commission

JANUARY 1968

CONNECTICUT • NEW JERSEY • NEW YORK

TRI-STATE TRANSPORTATION COMMISSION

The Tri-State Transportation Commission, an interstate planning agency, defines and seeks solutions to immediate and long-range transportation and land-use problems of the New York metropolitan region covering 22 counties in New York and New Jersey and six planning regions in southwest Connecticut.

Established by legislative action of the states of Connecticut, New Jersey and New York in 1965, the Commission succeeds the Tri-State Transportation Committee formed by the governors of these three states in 1961.

Although regional planning is its primary task, the Commission is also a central supporting resource for local planning. It provides assistance in solving problems that spread beyond local jurisdictional control. It also encourages coordination among all agencies charged with planning or providing transportation and related public facilities within the Tri-State Region.

The three states and the Federal government finance the work of the Commission. Federal funds come from highway planning aid administered by the U.S. Bureau of Public Roads and also from planning and mass transportation grants provided by the U.S. Department of Housing and Urban Development.

Commissioners representing the three states are appointed by the governors in accordance with the laws of their respective states. Federal representatives are appointed by the appropriate officer holding such authority within the Executive branch.

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2041-3112-15C 1/68

The preparation of this report was financed in part through Federal funds made available by the U. S. Department of Transportation, Federal Highway Administration, Bureau of Public Roads; an urban planning grant from the U. S. Department of Housing and Urban Development, under the provisions of Section 701 of the Housing Act of 1954, as amended; and in cooperation with the states of Connecticut, New Jersey and New York.

INTRODUCTION

The measurement of resident activities in the Connecticut-New Jersey-New York area by the Tri-State Transportation Commission included inventorying the kinds and intensity of of this Region's land uses. The characteristics of travel and the traveler were collected in a home interview survey and, simultaneously, the extent and use of the highway network was measured.

This report deals with the Tri-State Region's highway system. It reports measurement findings of highway facilities and observations made of vehicular flow on them. Field investigators examined 840 miles of limited-access highways and 5300 miles of arterials. Traffic was counted, speeds measured and the amount of travel occurring on the local streets estimated.

The relative supply of highway facilities in each part of the Region is shown in this report. Well-supplied areas can be identified as well as deficient ones. These data are also a measure of existing highway needs. The relationships presented can also be used to estimate the amount of construction that will be necessary to accommodate future population and vehicular travel increases.

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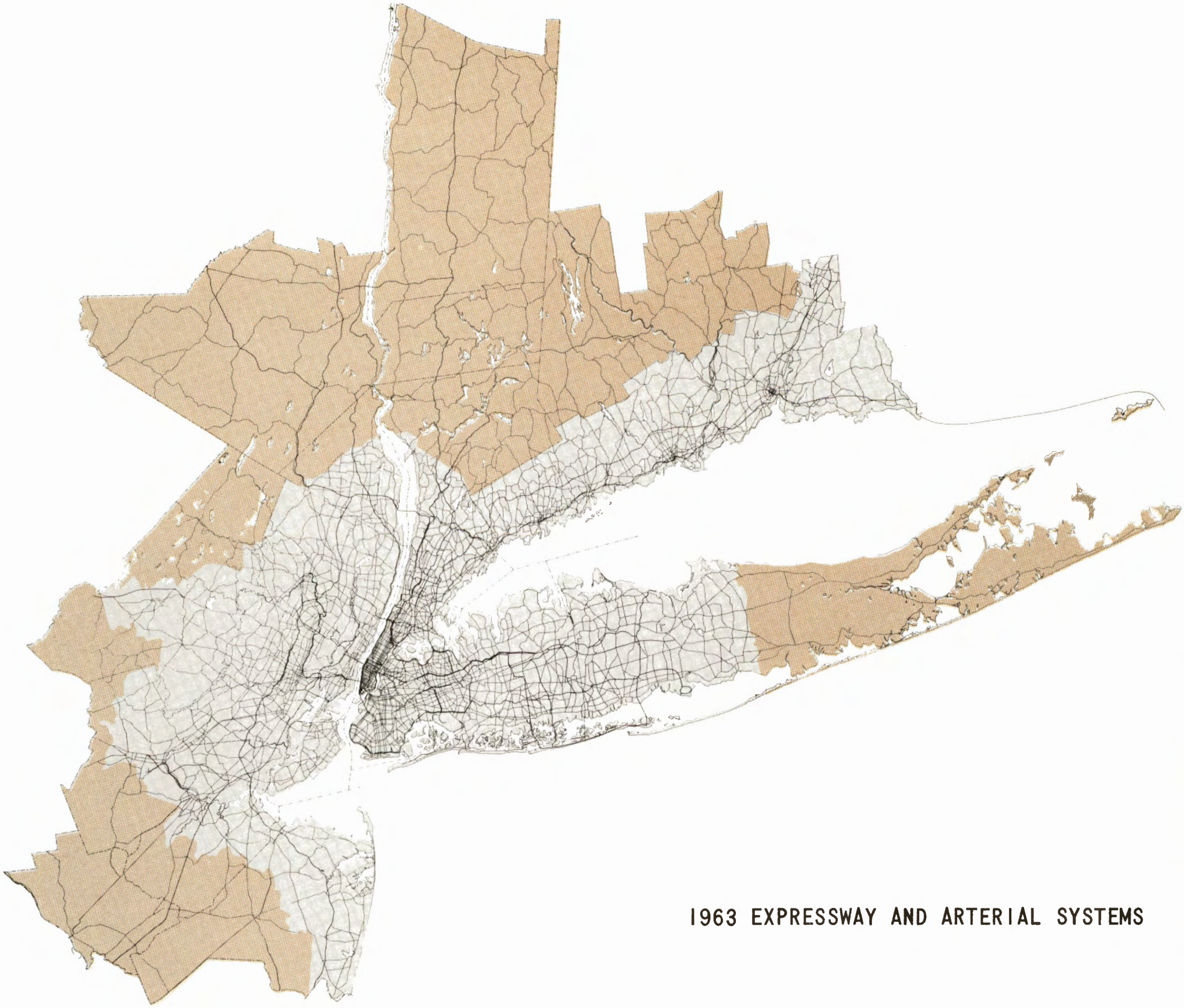
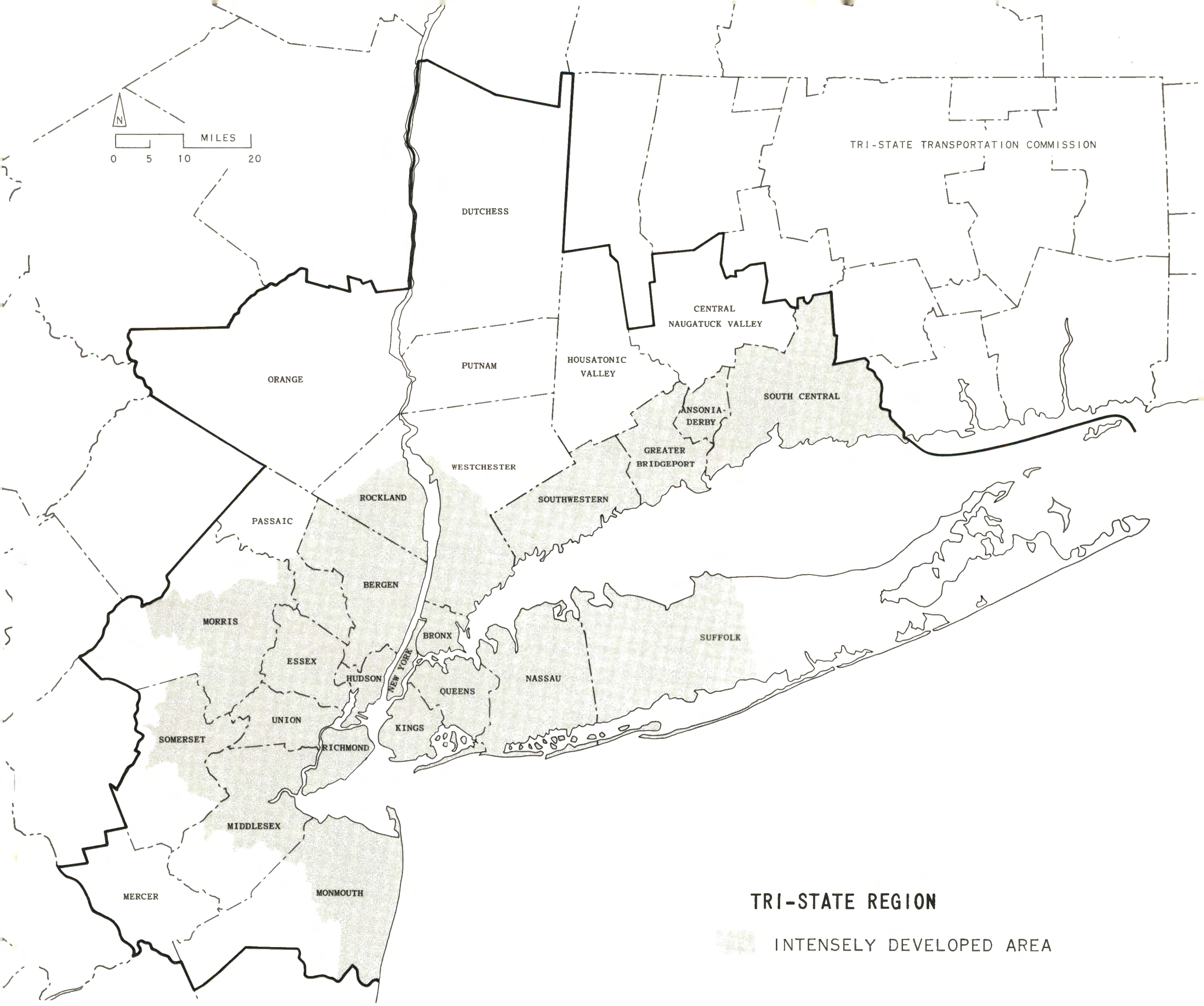


1963 EXPRESSWAY AND ARTERIAL SYSTEMS

Highlights

The Tri-State Region is served by 9000 miles of highways, which connect with 46,600 miles of local streets.

- Limited-access highways, which extend for 1100 miles free of traffic conflicts, have entrance and exit ramps and grade separations at road crossings. Despite the Region's size, this is far more road mileage than exists in any other metropolitan area.
- On a typical weekday in 1964, vehicles traveled 144 million miles on these streets and highways. The average vehicle travels 26 miles daily.
- If all the Region's vehicles were on the highway system at the same time,



three-fourths of the available pavement would be filled. However, less than a fifth of the vehicles are in motion at any time.

The 8000-square-mile Tri-State Region includes 28 counties and planning regions with 18.1 million residents. The Tri-State Transportation Commission made extensive surveys covering the inner 3509 square miles of the Region in 1963-65. There are 16.3 million inhabitants within this inner area. This report is based on an analysis of the information gathered by measurements of highways and travel within that area, which is map illustrated.

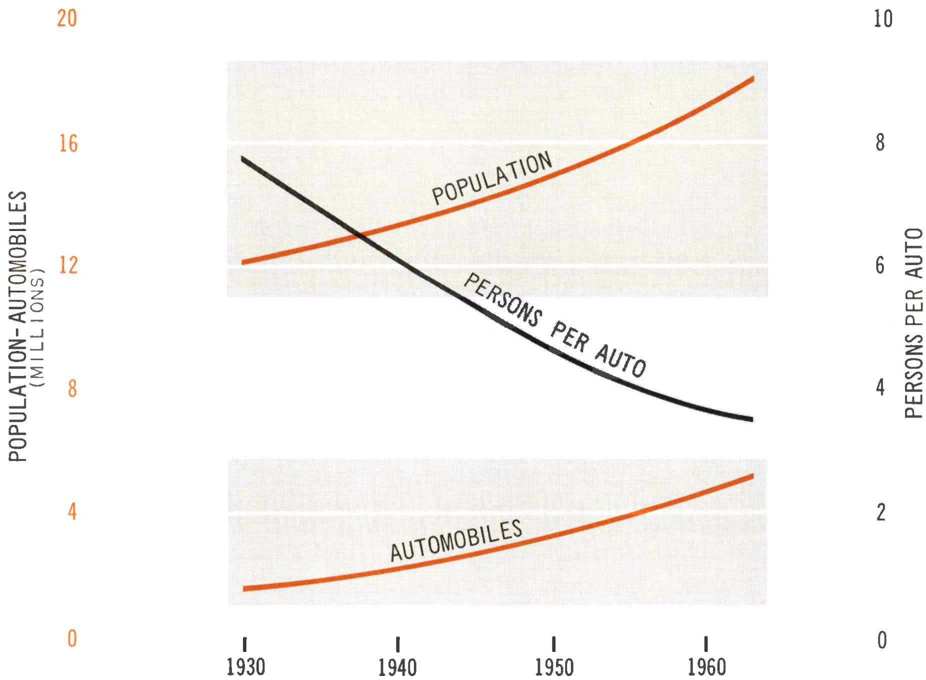
- The 4.7 million vehicles available to the area's residents are driven 26 miles per day, on an average. This travel is serviced by 843 miles of expressways, 5281 miles of arterials and 27,600 miles of local streets.
- In the intensely developed area shown above, 30 percent of the traffic is carried on limited-access highways, representing only 2.5 percent of the area's roadway mileage. Bronx, Queens, Westchester and Manhattan have the highest

proportions of travel on limited-access highways—43 to 47 percent. Counties with 10 percent or less: Richmond, Somerset, Morris and Passaic.

- During peak hours, 28 percent of the area's highways are overloaded. These roads carry 45 percent of the area's traffic. Nearly all centers of activity experience traffic congestion.
- Local streets are used for only 23 percent of vehicular travel, although they contain 82 percent of the total route mileage under consideration. The proportion of travel on local streets is lowest in the high-density areas; however, average local-street volumes are at their absolute highest in these downtown areas.
- Within one square mile around Rockefeller Center, 400,000 vehicle miles of travel per day were observed; however, the average square mile in the study experiences 33,000 vehicle miles of travel daily.
- The average traffic speed throughout the day is 26 miles per hour. The speed is lower in high-density areas; for example, Manhattan averages 16 mph. In outlying areas of New Jersey and New York, however, the average is 32 mph.

■ ■ ■

GROWTH OF POPULATION AND AUTOMOBILES
1930-1963



Components and Growth of Vehicle Travel Demand

The growth of automotive travel is logically related to changes in population, population density and car ownership. The basic patterns hold true for all parts of a metropolitan area, so that once the relationships are known, it is possible to predict confidently what the consequences of population and density changes will be on travel volume.

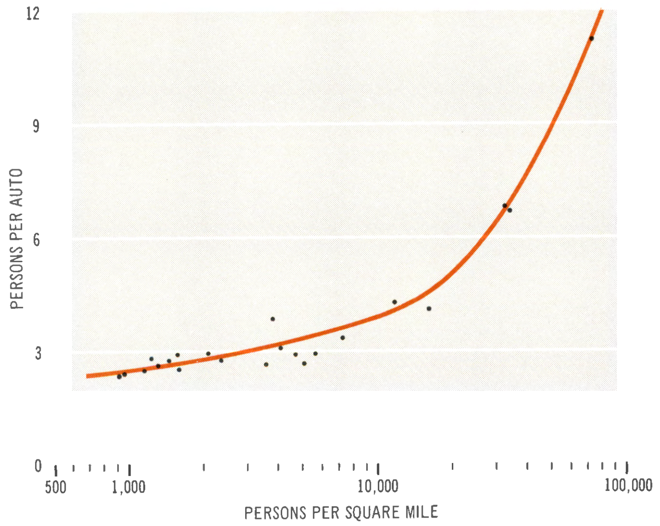
The growth of population and automobiles in the Tri-State Region has been charted for the 1930-63 period. Despite periods of depression and war, the growth rate of automobiles has consistently exceeded that of the population. Auto ownership has increased so that the overall persons-per-auto ratio dropped from 7.8 in 1930 to 3.5 in 1963. This overall ratio masks a considerable variation in different parts of the Region, ranging from 2.5 persons per auto in Monmouth County and southwestern Connecticut to 4.0 in Queens and 11.3 in Manhattan. Of course, there are also variations within counties, depending on each area's density.

The highly visible growth of automobile ownership is commonly attributed to increases in real income and changing life styles. Ownership increases are not limitless, however. A very real limit seems to be approximately 2.0 persons per car, a rate which several counties in the Region are already approaching.

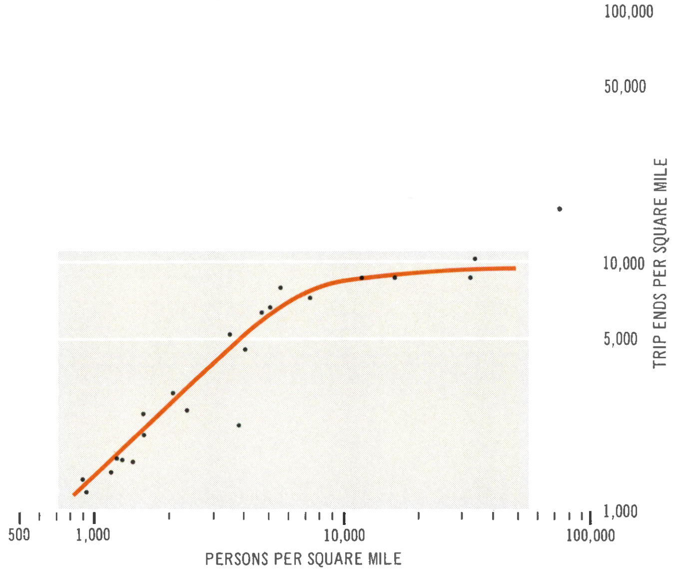
While other factors are also involved, the relationship of population density and persons per automobile is pronounced. Fewer cars are owned by persons living in denser areas. At any point in time, increasing population density is generally representative of lower incomes, more vexing problems of owning, insuring and parking a car and easier availability of mass transportation service. Within any county, specific local characteristics cause minor variations.

The number of persons per automobile in-

POPULATION DENSITY VS. PERSONS PER AUTO, 1963



POPULATION DENSITY VS. AUTO TRIP END DENSITY, 1963



creases from 2.5 to 3.6 as density is raised from 1000 to 7000 persons per square mile. (The latter ratio corresponds to houses on quarter-acre lots.) As density increases beyond this level, however, automobile ownership drops sharply, with 11.3 persons per car for Manhattan being the highest observation.

Auto trip-end density increases almost proportionately with increases in population density up to the level of 7000 to 10,000 persons per square mile. Beyond this level of development, increasing population density produces little additional automobile travel. More and more person travel is served by mass transportation. Even so, the variety of travel needs results in substantial vehicular traffic. Goods must be moved by truck in and out of stores, offices and industries in the dense business areas. Here, also, taxis are in the greatest demand.

This additional impact of truck and taxi travel is dramatically illustrated by Manhattan and, in particular, the Rockefeller Center area:

TRIP DESTINATIONS PER SQUARE MILE

	Manhattan	Rockefeller Center Area
Auto	16,100	49,100
Truck	16,300	47,000
Taxi	32,400	208,500

In lower density areas, it is evident that people own more cars, and there are more vehicle destinations per resident. Vehicle trip destinations per square mile, however, are highest in the dense areas because of the great concentrations of trip-attracting floor space.

▪ Supply of Roadways

There were 843 miles of limited-access and 5281 miles of arterial highways open to traffic as of January 1, 1964. The entire highway system is shown on page iv, and the number of lanes of limited-access highways is map illustrated on page 4.

Since early 1964, several stretches of limited-access highways have been opened to traffic. In New Jersey, I-80 from N. J. 20 to the George Washington Bridge is open. In New York City, the World's Fair approaches and the Staten Island Expressway, including the Verrazano Narrows Bridge, are in service. The Long Island Expressway extension east of Veterans' Memorial Highway and Connecticut's I-91 from New Haven to Hartford are open.

While the highway data could have been updated to reflect these developments, comparisons with the travel data would be less valid. This report, therefore, compares the highway network with measurements of travel made during the same period.

As can be seen on the arterial density map, page 5, the supply of arterial roads not only is distributed across the urban area but follows the pattern of development. The depicted business centers–Manhattan, Brooklyn, Newark, White Plains, Bridgeport and so forth–stand out clearly, as does the development along the Region's shores. In some areas, the impact of one or two major highways can be seen.

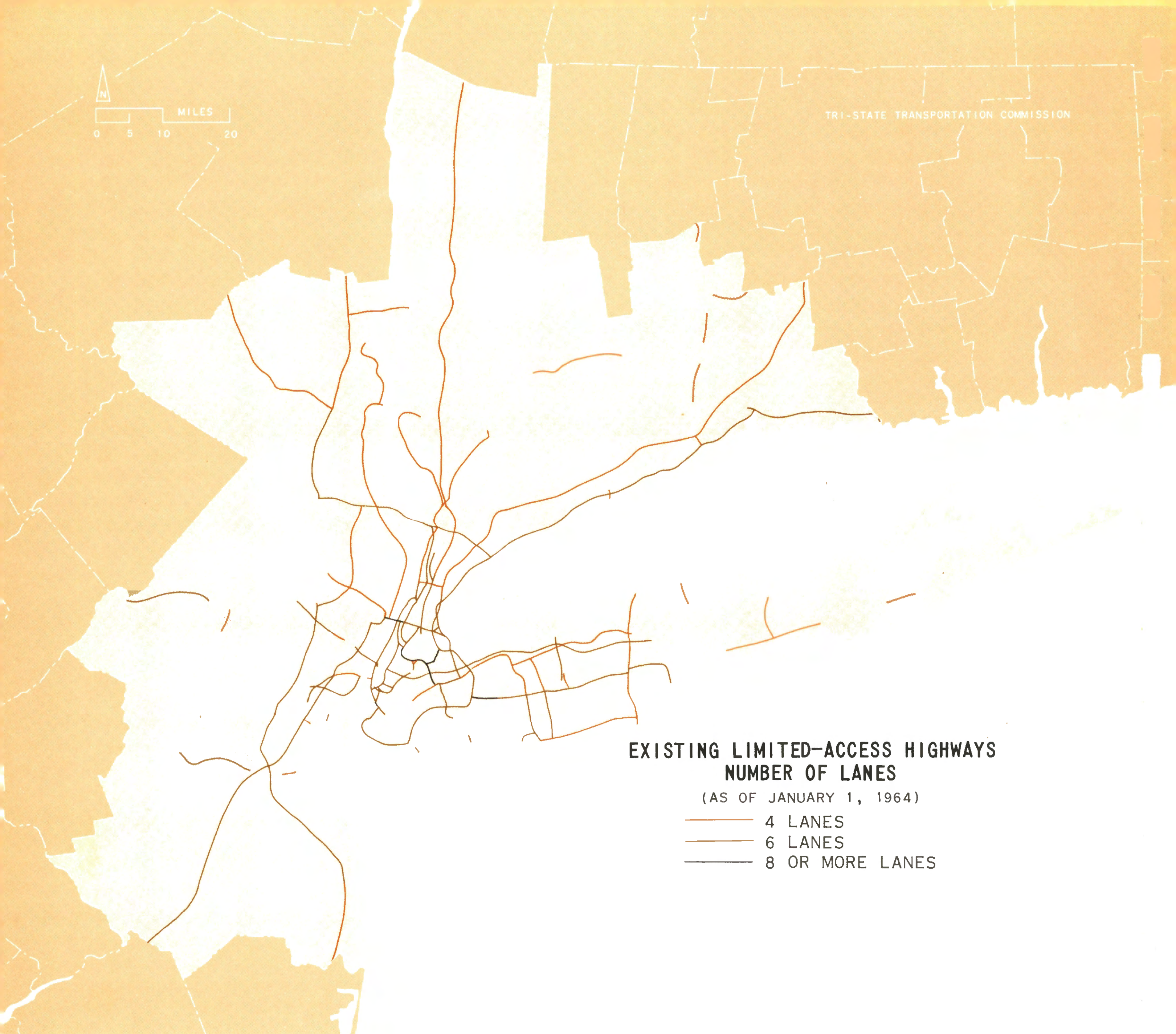
In the dense areas, the supply of arterial roads does build up, but this build-up has very real limits. Future increases in development intensity, if prolonged daily congestion periods are to be avoided, require that mass-transportation services be provided.

The clear and logical relationship between the highway network and development intensity can form a basis for projecting future network requirements.

INDEXES OF SUPPLY

Highway supply is expressed here in terms of lane miles, since roadway width is one measure of capacity.[1] The number of lanes of limited-access highways is evident, but for arterials a lane is considered to be a 10-foot-wide strip

[1] A "lane mile" is the driving surface encompassed by one mile of road one lane wide. In this scale, a road two lanes wide and one mile long is the same as a four-lane facility one-half-mile long.



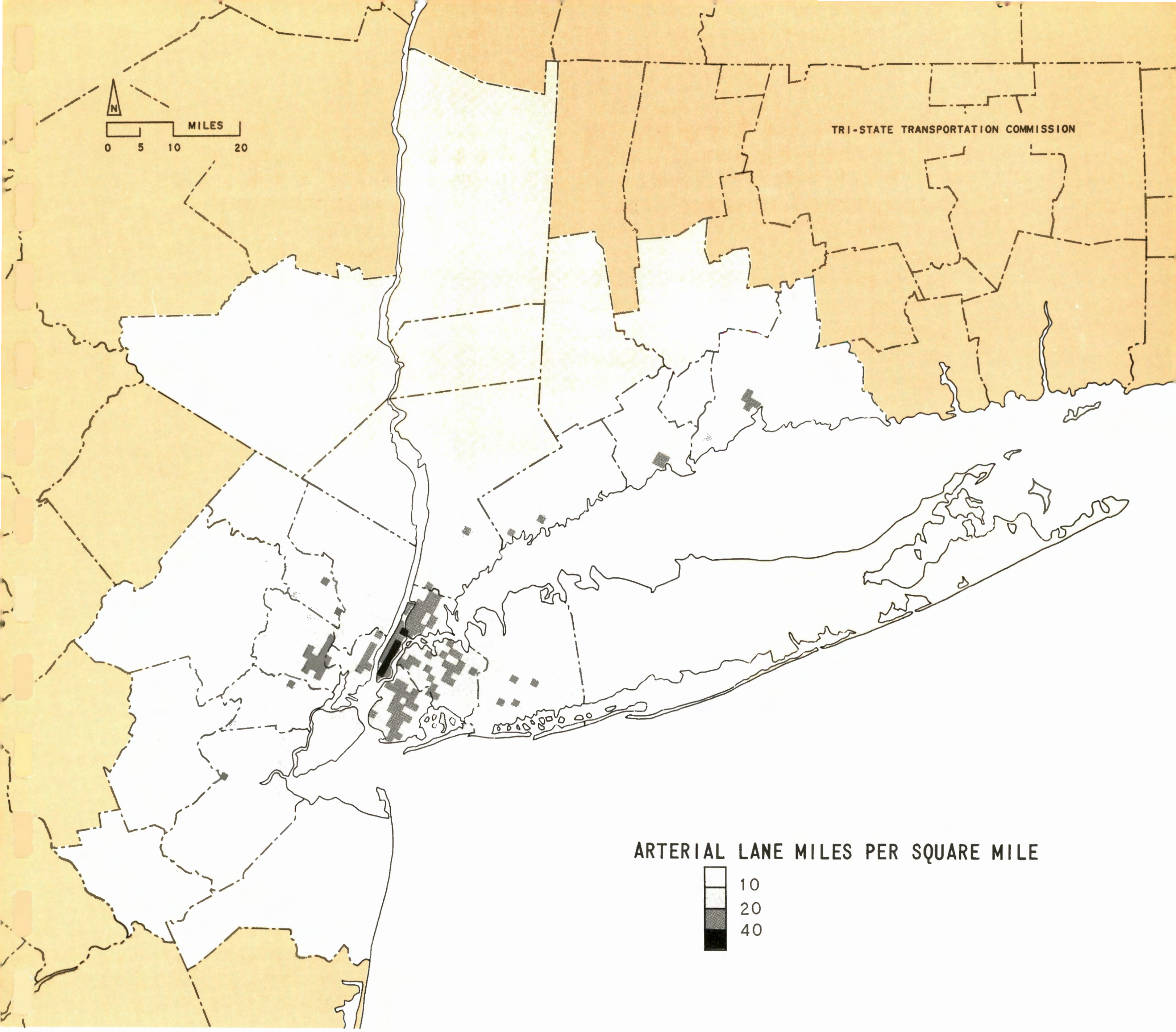
of pavement. Shoulders were not included in either case.

There are 23,300 lane miles of highway in the intensely settled area. This is one lane mile for every 701 residents or every 180 vehicles.

Three indexes of highway supply are charted on page 6. The lane miles of each county are related to its area, population and automobile trip destinations. The counties are listed in order of decreasing population density.

Lane mileage of limited-access highways per unit of area is highest in the densest areas. The exception to the pattern is Westchester County, which has an extensive parkway system. Arterial lane miles also increase with higher development density. As an area is built up, there is a steady demand for existing arterials to be widened, as well as for new highways.

A strikingly different pattern emerges when lane miles are compared to population. The most mileage per resident is found in low-density

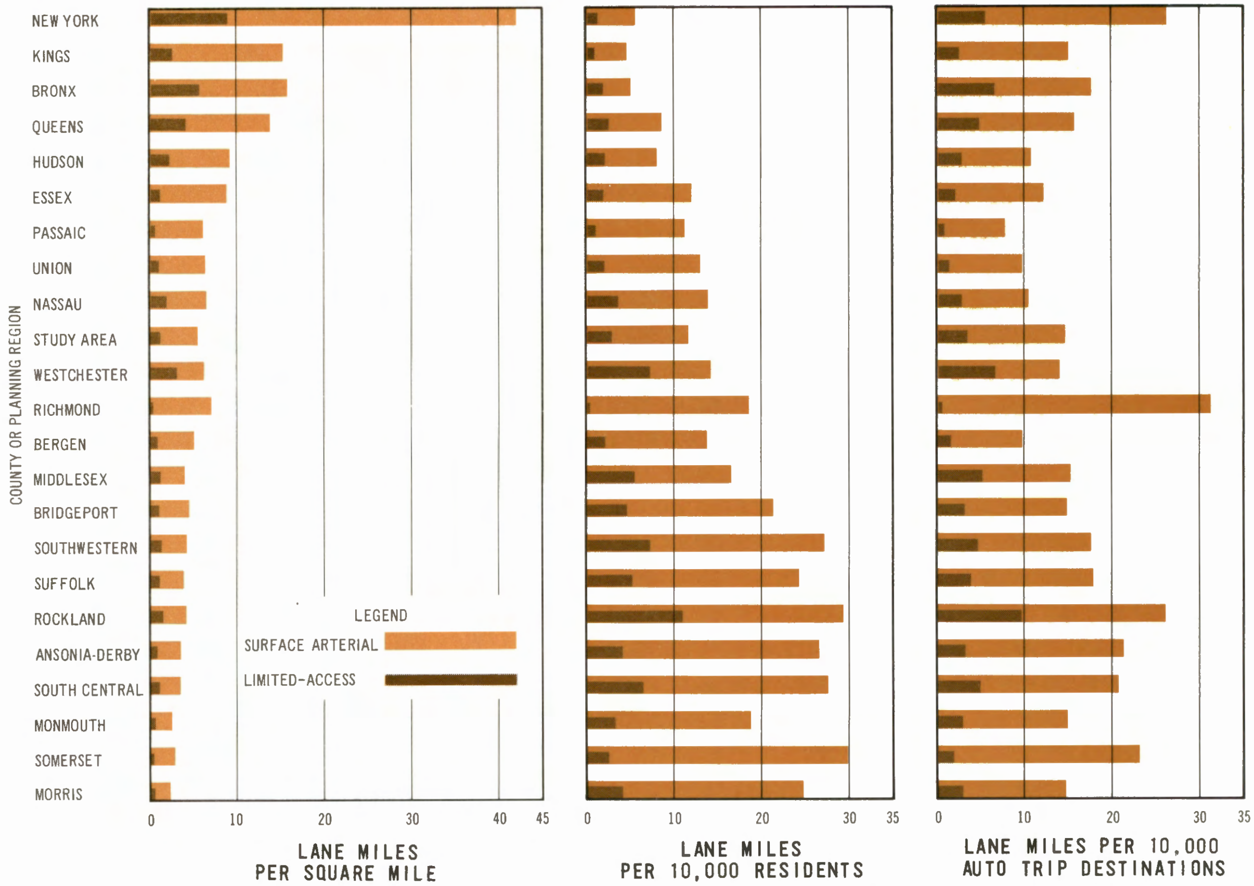


areas. In dense ones, most travel demands are served by mass transportation modes. Thus, a better index of highway supply sufficiency is the number of lane miles per auto destination.

The supply of limited-access lane miles per auto trip destination varies over a fairly narrow range. Brooklyn (Kings County) and the counties of Hudson, Essex, Passaic, Union and Bergen are in particularly short supply of these facilities. Bronx, Westchester and Rockland counties, on the other hand, are relatively well supplied. Middlesex County also rates fairly high, although its lane mileage is principally accounted for by the New Jersey Turnpike with its widely spaced interchanges.

The supply of arterial lane miles per auto destination also varies over a surprisingly narrow range. Manhattan (New York County) seems to be well supplied; however, if taxi and truck travel were added to the destinations for each county, the island would slip back to its expected comparatively congested value. These truck and taxi trip ends are not yet completely available.

SURFACE ARTERIAL AND LIMITED-ACCESS LANE MILES



Lane miles per destination show a decline from counties with the highest population densities to counties in the middle range. Hudson, Essex, Passaic, Union, Nassau and Bergen are relatively deficient. At the lower densities, there is a more abundant supply of surface arterial lane miles per trip end.

In the counties with higher densities—Nassau and those listed above it—there is an interaction between population density and the demands for highway travel. Auto ownership is lower per capita in these areas, yet street supply per capita is also very low. Even a very small amount of vehicular travel per resident is enough to load heavily the available—and relatively fixed—supply of highway lane mileage.

Trip ends in many of the suburban counties can be expected to increase substantially as presently undeveloped areas are developed. It will be very difficult to achieve the same increase in the supply of highway facilities. Some of the 27,000 miles of local streets now existing will have to be converted to arterial uses; the degree of success of such conversions will vary. Arterial widenings will be continued and, where possible, limited-access facilities will be built. All too often public actions lag behind the pace of private development, resulting in high-cost construction and right-of-way acquisition, as well as the multi-faceted impact such construction has on property owners whose land is contiguous to new roads.

In the following sections of this report, a more specific and geographically detailed look is taken at the use of the existing highway network and the level of service it provides.

TOTAL VEHICLE TRIP DESTINATIONS
INCLUDING TRUCKS AND TAXIS
PER SQUARE MILE

TOTAL VEHICLE MILES TRAVELED
PER SQUARE MILE

Vehicular Travel

Vehicular travel is closely related to urban development. Trip destinations reflect home and work sites and, thus, travel is also a reflection of urban land uses. On a typical weekday, 120 million vehicle miles are traveled on the streets and highways within the Region's intensely developed area.

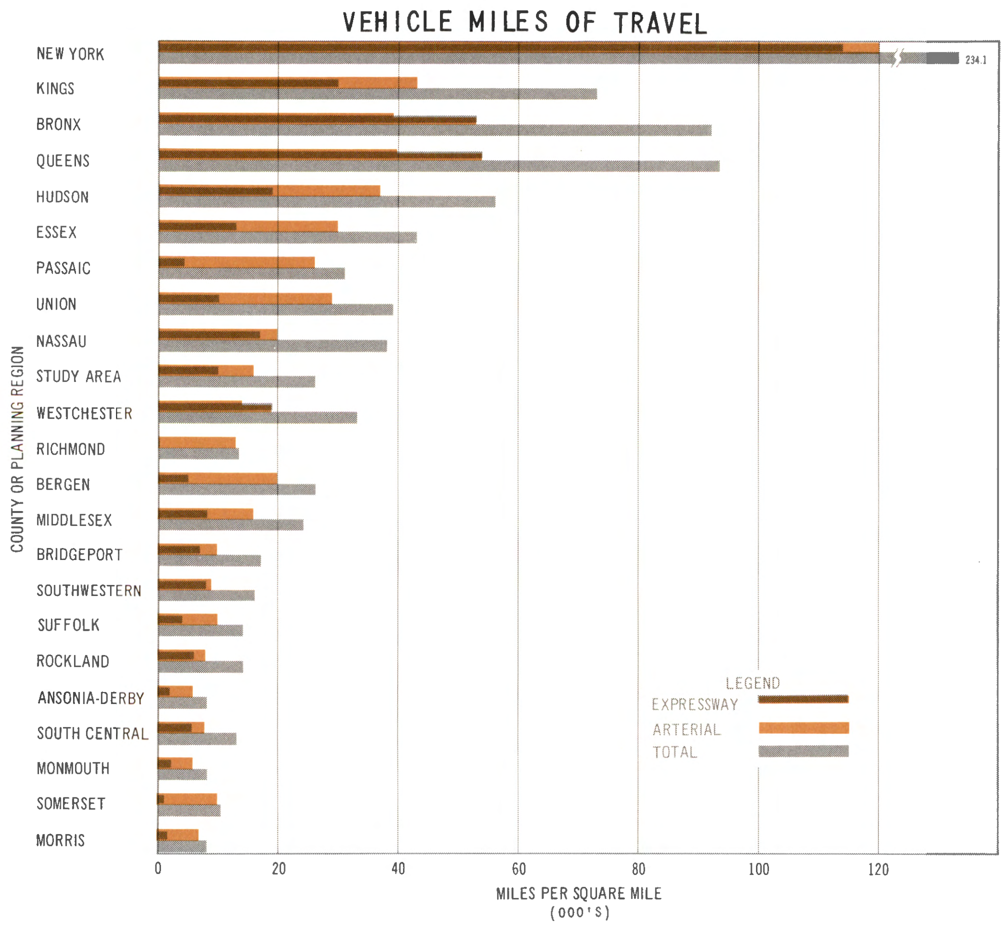
The yardstick of highway use is the number of vehicles served. Vehicle miles of travel (VMT) is the product of multiplying the average number of vehicles on a section of roadway by its length.

TRAVEL CONCENTRATION

The general pattern in the three-dimensional model of vehicle trip destinations is a gradually rising plateau occasionally marked by peaks and valleys. Business districts are clearly discernible by very high concentrations of trip ends at these locations, due largely to the truck and taxi trip ends. (A person-trip destination model, including subway, bus and railroad trips, would even more dramatically show Manhattan and other activity centers.)

A comparison of the two models discloses a markedly similar pattern of total vehicle miles of travel. Points with higher destination densities reflect similar VMT concentrations. However, the difference in the concepts presented can be illustrated by locations which have few destinations but high VMT—such as Randall's Island or the routes across the Hackensack Meadows. Destinations are a measure of activity. VMT reflects both activity and the location of highways accommodating it.

The maximum observed VMT is in a square mile surrounding Rockefeller Center: 398,000 vehicle miles of travel. The average figure for the study area, however, is 33,000 vehicle miles per square mile.



The density of travel on the limited-access and arterial networks in each county is shown in the chart on which the counties are arranged by population density. As this density increases, vehicular travel also goes up. Vehicular travel demand corresponds fairly well with the supply of highways, which can be seen by comparing the illustration of travel density with that of roadway density. A goal of highway planning is maintaining the balance of these two factors—the supply of highway facilities and their level of use.

LOCAL STREET TRAFFIC

On most vehicular trips, the local street network is used only at both ends of the journey. Except for very short trips, most travel is actually done on the higher-class arterial and limited-access highways, on which running speeds and carrying capacities are higher. Although the local street network contains 82 percent of the route mileage in urban areas, it accounts for only 23 percent of the vehicle miles of travel.

The usual build-up toward the center of the urban area is hardly noticeable on the local street VMT model. In denser areas, more of the street system is developed to arterial standards. Thus, while the traffic volumes on all streets increase, the proportion carried on the local street network declines in the denser areas.

LOCAL VEHICLE MILES TRAVELED
PER SQUARE MILE

TRUCKS AND BUSES

The highway system is also used by trucks and buses; at some specific locations, these vehicle types can become the major traffic stream component.

Trucks supply and service homes, stores, factories and construction sites. Therefore, truck traffic is spread throughout the urban area. The model on this page shows its distribution with major concentrations: downtown areas; manufacturing areas, such as the garment district and Newton Creek; and Port Newark and the Brooklyn waterfront. The majority of trucks used within the urban area are single-unit vehicles, since tractor-trailers are used more extensively for long-haul trips.

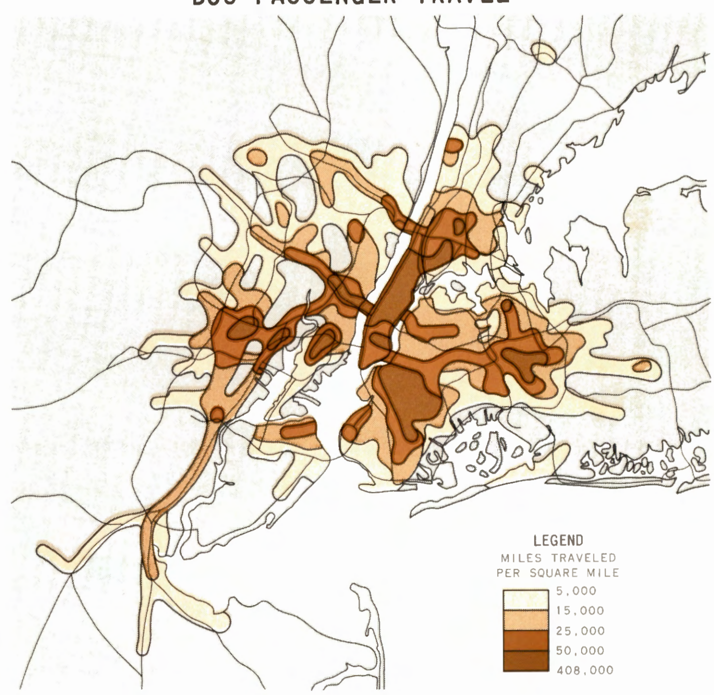
Bus service, which is provided on most of the arterial system is an important means of travel throughout the urban area, as shown on the bus passenger-miles map. For every mile traveled, a bus carrying 40 passengers is providing 40 passenger miles of service. On a typical day, 7820 transit buses are operated on the highway network, averaging 102 miles of travel per bus.

East of the Hudson River, buses are used as feeders to the subway and railroad systems, as well for local travel. The contour map shows this general type of coverage. West of the Hudson, buses are used for local travel around Newark and in Hudson County. But they are also used for long-distance commuting to Newark and Manhattan via N. J. 3, N. J. 4 and the Jersey Turnpike. The elongated corridors representing this travel can be clearly seen. The New Jersey pattern of long-distance bus commuting results from the Lower Manhattan orientation of the railroad system (except for the one direct entry to Penn Station at 33rd Street).

As a measure of network use, vehicle miles of travel is not a complete statement of the network's effectiveness. VMT totals are only indicative of the level of congestion. The relative amount of congestion will be described in the more meaningful terms later in this report.

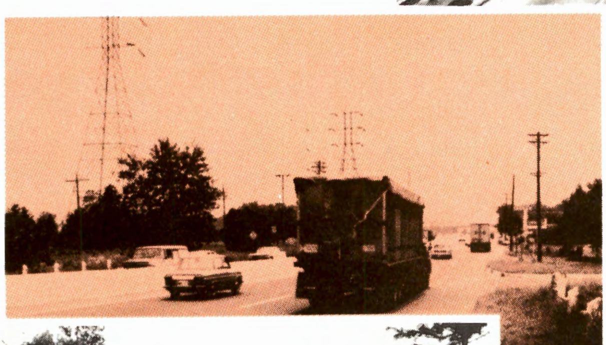
TRUCK TRIP DESTINATIONS
PER SQUARE MILE

BUS PASSENGER TRAVEL

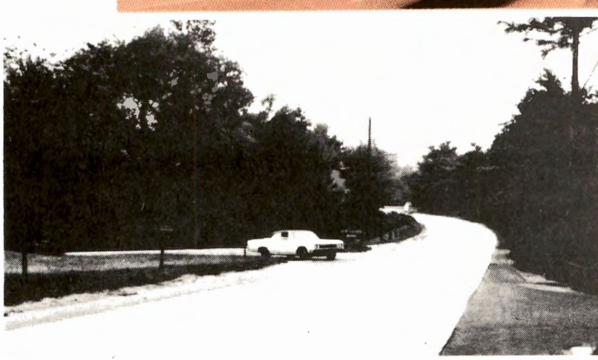


Third Avenue in Manhattan is an urban multilane facility—a wider street with traffic signals and peak-hour parking control. However, this type of roadway is often lined with commercial activity and is subject to pedestrian conflicts.

Urban limited-access expressways, such as the Cross Bronx Expressway, exemplify the advantages of allowing traffic to enter and exit at properly designed points.

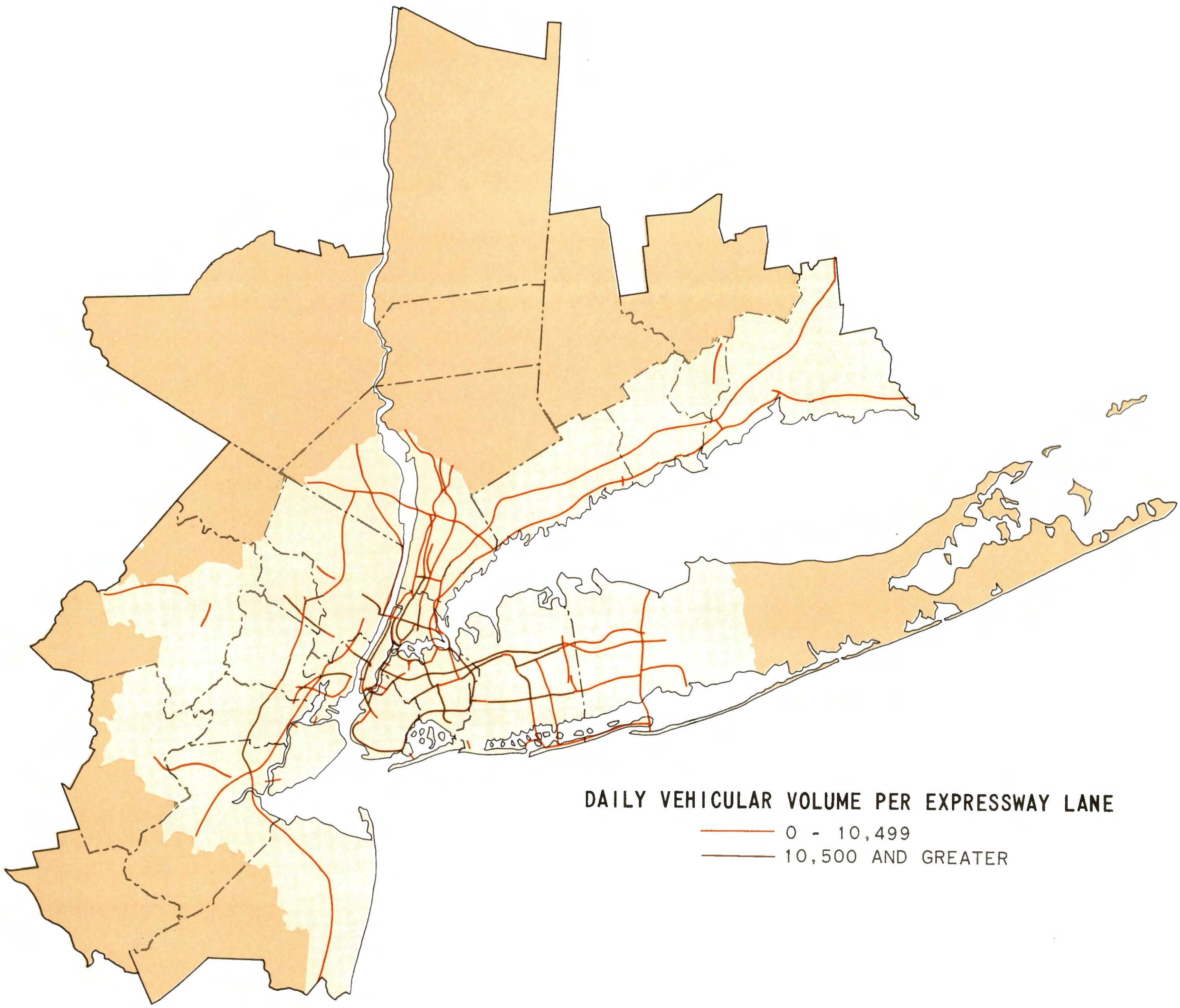


The State of New Jersey has been a leader in developing the maximum carrying capacity of non-limited access highways, such as U. S. 1, illustrated here.



An example of a rural road that is still in proportion to afford low-speed pleasure driving is Round Hill Road (North Greenwich) shown here.

The suburban multilane—such as U. S. 1 (Stamford shown here)—generally provides freer flowing travel than its urban equivalent, but still presents conflicts between land-service and traffic-flow demands.



Traffic Loads on the Highway Network

As previously discussed, the amount of travel in an area is related to the intensity of its development. To a large extent, highway construction–particularly of arterials–is closely related to development density. The magnitude of travel that the highway network must accommodate has been described in terms of vehicle miles of travel. Although such a frame of reference is useful for highway planner and administrator, the motorist is most concerned about the visible congestion he encounters when driving.

In this section, the ability of the highway network to accommodate the vehicular traffic levels that occur is examined. Actual traffic loads are compared to the accepted volumes for a given highway by means of two similar measures: volume per lane and volume/capacity ratio.

TRAFFIC ON LIMITED-ACCESS HIGHWAYS

While it is convenient to summarize the amount of travel in an area in terms of VMT, traffic analysis requires that specific road sections be examined. The accompanying map indicates the traffic load carried on each section of the limited-access network.

In general, radial road traffic volumes increase as the Region's more densely developed areas are approached. Vehicle volumes on circumferential roads are also higher on routes that serve points of intense development. This variation can be most readily observed by following a particular facility from the edge of the urban area in toward the core.

The Long Island Expressway is a good example; its traffic volume is light in Suffolk County, but builds up quickly in Nassau and remains at a very high level through Queens. Similarly, the Connecticut Turnpike passes close to the heart of each city along the coast of Long Island Sound; as it approaches each of these urban areas, traffic volume gains are noticeable. But some distance inland, the Merritt Parkway accommodates traffic volumes that are far lower and stable.

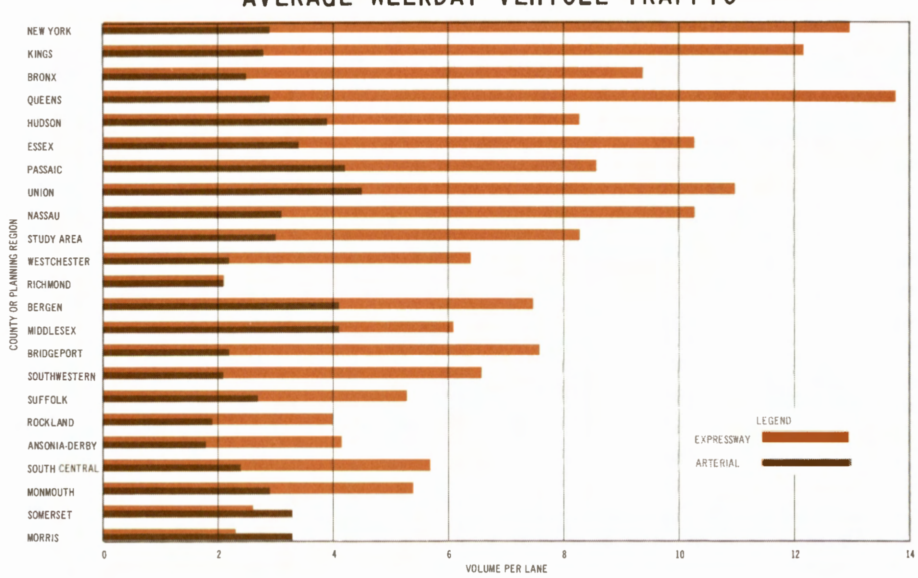
If two limited-access facilities virtually run side by side, but one is parkway and the other expressway, there is a significant difference between traffic volumes on the two roadways. Such situations occur in Nassau and Westchester counties and in the Bronx. Higher traffic volumes in these cases are experienced on the expressway, partially because it is built to higher standards, is newer and affords better connections to other important facilities. However, another traffic-generating factor is the expressway's accommodation of commercial traffic. If an expressway parallels a parkway, it naturally carries an above-normal number of trucks.

VOLUME PER LANE

Utilization of the highway network in various parts of the metropolitan area can be compared on the basis of average volumes per lane. This can be directly observed by counting daily traffic and noting the number of lanes accommodating the traffic stream. In order to reflect rush period conditions, the daily volumes are divided by the width that was actually used during the rush periods.

The average daily volume per lane for limited-access and arterial highways in each of the counties for which data were collected is depicted. On limited-access facilities, the lane volumes generally decline as the population density declines. The major exceptions to this overall pattern are seen in Hudson, Passaic, Bronx and Westchester counties. Both Bronx and Westchester have a very extensive network of limited-access highways, many of which are close to one another. This condition usually acts to reduce the volume on one highway of a given pair. The limited-access facilities in Hudson and Passaic counties are prin-

AVERAGE WEEKDAY VEHICLE TRAFFIC



cipally toll roads that tend to serve longer distance traffic rather than the local variety.

The average use of arterials is fairly constant, with the highest volumes in the counties in the middle of the density scale. This is particularly evident in New Jersey.

Highway capacity studies, which are discussed more fully elsewhere in this report, provide a summary of the daily traffic volumes that highways can accommodate without serious congestion and delays:

THE CONCEPT OF CAPACITY

Every driver who uses a heavily traveled expressway at certain times of the day knows that as the facility's traffic concentration builds up, his travel speed drops and that the traffic flow in which he finds himself can become very erratic. A minor road incident can trigger a stop-and-start situation.

Under a given set of conditions, there is a maximum number of vehicles that can move over a road each minute. Based on numerous

DAILY HIGHWAY VOLUME

STANDARDS	VOLUME PER LANE	
	Limited-Access*	Arterial**
Moderate to Heavy Utilization	7,500-13,499	1,500-4,499
Over Capacity	13,500+	4,500+

*TWELVE-FOOT LANE
**TEN-FOOT LANE

Each highway section was compared to these standards, and the percentage of arterial and limited-access roadways falling in each class was found for each county. The percentage of VMT in each class was also determined. A summary of these findings is presented on page 14.

Regular listeners to traffic reports on the radio are accustomed to hearing about congested conditions on metropolitan area expressways. The predictability of these reports stems from the fact that 32 percent of expressway traffic takes place on 15 percent of over-capacity road mileage, while 40 percent of limited-access travel occurs on moderate to heavily loaded facilities. Manhattan, Brooklyn, Queens and Nassau have the greatest percent of expressway VMT taking place on roadways that are congested. Many counties, including Bronx, Essex, Passaic and Union, have expressway systems that may soon become badly overloaded.

The greater percentage of the area's arterial system is in the heavy-to-overloaded category. Serious congestion is indicated in several New Jersey counties. Since radio traffic reports tend to concentrate on the degree of congestion on the limited-access system, the listener often fails to receive an accurate report of how congested the arterial system becomes daily.

observations made throughout the country, roadway capacity standards have been established, the elements of which include the width of the facility and types and percentages of vehicles using it.[1] The design of the interchanges is also a factor in the capacity of limited-access roadways. Additional factors for arterials include: the percentage of time that signals are green, turning movements, pedestrians' effect on traffic flow, bus stops, and parking regulations and their observance. For instance, a bottleneck at one intersection can cause adjacent intersections to operate below theoretical capacities.

The regular variations in traffic volumes that occur at different times of day are a well-known characteristic of urban life. The percentage of daily traffic occurring during any hour, thus, is quite predictable. Near capacity volumes occur at many locations each morning and evening on the highway network. During midday and at night, traffic flows more smoothly. Since traffic volumes have been measured on a 24-hour basis, the capacity of each section must be stated in the same 24-hour terms to allow a comparison to be made.

[1] See Highway Capacity Manual, 1965, HRB Special Report 87, Highway Research Board, 2101 Constitution Avenue, Washington, D. C. 20418.

PERCENT OF MODERATE-TO-HEAVY AND OVERLOADED HIGHWAY FACILITIES

	Limited-Access Highways				Arterial Highways			
	Percent Route Miles		Percent VMT		Percent Route Miles		Percent VMT	
	Moderate to Heavy	Over Capacity	Moderate to Heavy	Over Capacity	Moderate to Heavy	Over Capacity	Moderate to Heavy	Over Capacity
Manhattan	28	56	27	66	75	9	76	19
Brooklyn	53	43	47	52	71	12	67	26
Bronx	54	11	63	17	65	9	63	26
Queens	40	47	36	59	67	12	67	26
Hudson	31	22	38	36	56	30	41	55
Essex	70	21	65	32	72	20	58	39
Passaic	69	0	80	0	77	19	52	47
Union	72	28	66	34	66	27	42	56
Nassau	30	31	32	58	73	15	72	24
Westchester	32	1	50	2	57	4	71	12
Richmond	0	0	0	0	55	4	76	6
Bergen	22	9	35	20	60	26	40	56
Middlesex	14	10	18	20	62	31	44	54
Bridgeport	36	0	59	0	52	6	72	14
Southwestern	29	0	47	0	45	6	66	17
Suffolk	31	0	53	0	50	17	54	38
Rockland	0	0	0	0	42	5	62	15
Ansonia-Derby	0	0	0	0	37	6	57	16
South Central	13	0	23	0	48	11	59	26
Monmouth	0	0	0	0	57	22	58	34
Somerset	0	0	0	0	45	24	33	58
Morris	0	0	0	0	63	16	60	35
Total	30	15	40	32	59	15	59	34

DESIGN CAPACITIES OF EXPRESSWAYS AND ARTERIALS

(Vehicles per 24 hours)

Street Type	Street Width, Pavement		
	20'	40'	60'
ARTERIAL*			
Downtown Area	6,000	12,300	20,500
Intermediate Area	7,000	13,400	22,000
Rural & Suburban Area	7,500	14,000	23,500
	Number of 12' Lanes		
	4	6	8
EXPRESSWAY			
All Areas	54,000	81,000	108,000

* Assumptions: No peak-hour parking, 50 percent green signal time. 11 percent of daily travel in peak hour and 60-40 directional split.

Generally, about 10 to 11 percent of the daily volume occurs during the peak hour. However, lower percentages on a particular road often indicate congestion—peak demands cannot be accommodated by the roadway. A notable exception to this interpretation is a radial highway through an area that is serviced by rail transit, which is capable of handling a great proportion of peak-hour travel. In this case, peak demands on the radial highway are lessened. If a complementary transit system exists, then peak rates under 10 percent are not necessarily undesirable. Peak percentages greater than 11 percent are most often found in outlying or rural areas.

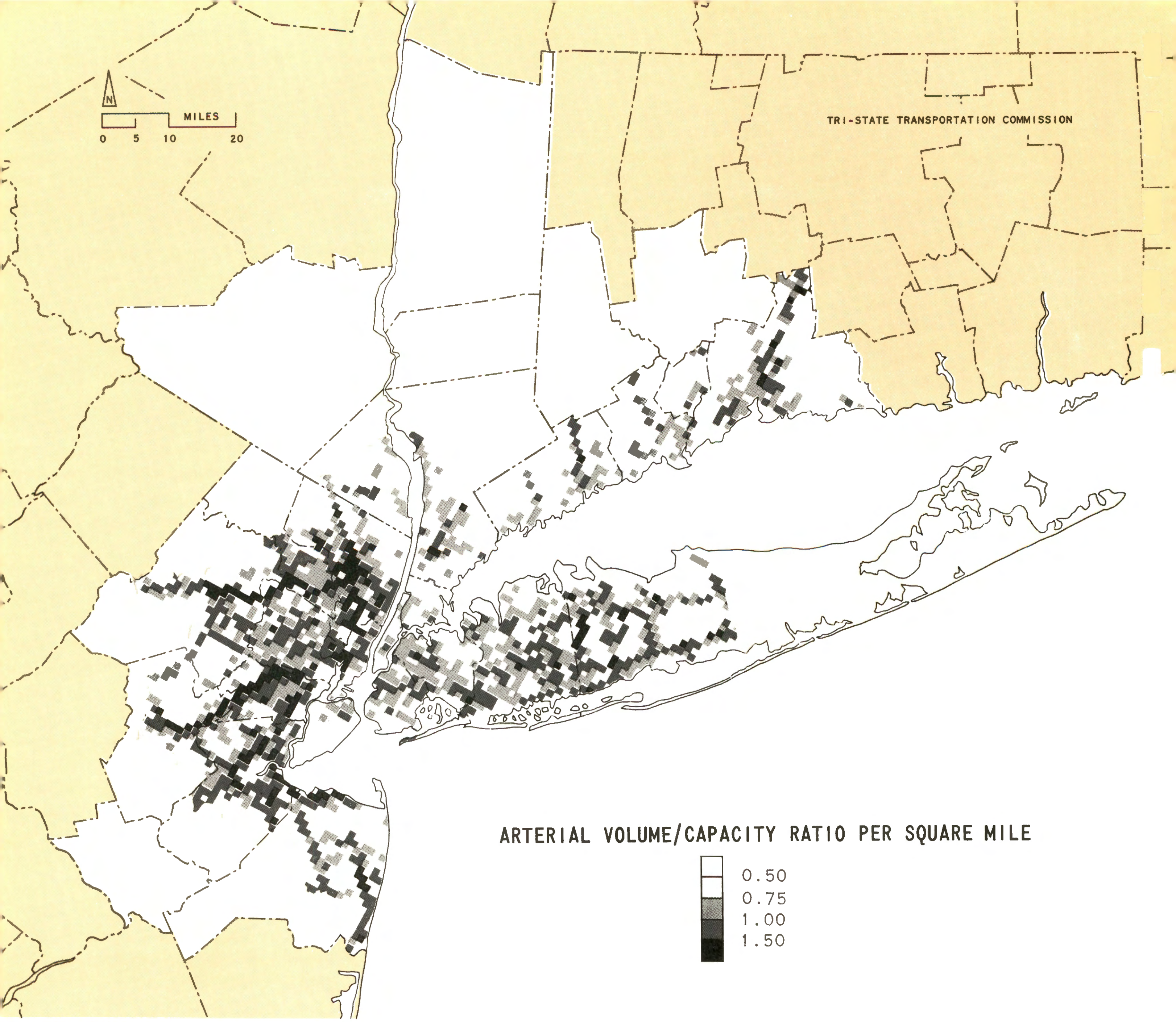
The hourly capacities were converted to daily figures on this average 11-percent basis. The table in this section shows the daily capacity values used for various roadway types and pavement widths. It was assumed that the full pavement width was available for moving traffic during peak periods and that parking would be allowed during lower volume periods.

VOLUME/CAPACITY RATIO

Capacities were calculated for each section of arterial highway and related to its traffic. Vehicle miles of travel and vehicle miles of capacity per square mile were summed, and the volume/capacity ratio was determined. A road with a 0.1 V/C ratio is carrying very light traffic, while a ratio of 1.0 indicates full use. Since demand is not uniform for all roads, an area with a volume/capacity ratio well under 1.0 may still have some overloaded highways.

The map in this section reveals that arterial roadways for much of the area are operating at volume/capacity ratios over 0.5, indicating the extent of mild congestion. Rockland County, the low-density areas in Connecticut between centers of activity and the far reaches of the outlying New Jersey counties are the principal exceptions to this general condition.

Volume/capacity ratios in New York City, including Manhattan, do not seem to be consistently higher than in other parts of suburban New York and New Jersey. This conclusion is not surprising, however, if it is borne in mind that capacity was calculated on the basis of the full pavement width. Until recently, the prevalence of illegal parking and loading and unloading reduced capacity throughout much of the day. It also resulted in added traffic cruising in search of parking space.



Arterials in New Jersey are traveled much more heavily than in other parts of the study area. These roadways generally must accommodate both long and intermediate trips. The limited-access network is not complete, and most of the continuous segments are toll roads—a fact that discourages some potential users. While the major arterials often have been improved with median barriers, jug handles or interchanges with major crossroads, access to abutting properties has not been restricted. It is not unusual for many of the intersections to be grade separated while the road is lined with shopping centers and individual commercial establishments.

Particular areas of high arterial loads in New Jersey are U. S. 22 and U. S. 46 corridors and the Bergen County areas adjacent to Paterson and Clifton. There are serious build-ups in the volume/capacity ratio around many activity centers, including Newark, Jersey City and Elizabeth.

Level of Service

The amount of vehicular travel and the capacity of the highway system to accommodate it in each part of the Region were compared in the previous sections of this report. The ratio of traffic volume to carrying capacity was also reviewed in the light of current operating practices and enforcement. Capacity was then examined as if the entire roadway surface were devoted to moving traffic.

In this section, the level of service is described according to two yardsticks: (1) the amount of travel in each county that is carried on the limited-access system; (2) the average speeds on each type of facility by county.

PERCENT OF TRAVEL ON EXPRESSWAYS

It has been demonstrated on a nationwide scale that vehicular travel on limited-access highways is faster and safer than on arterial roadways. Expressways remove vehicles from local streets where their presence conflicts with pedestrian and land-service activities. Arterial speeds can be raised to a degree by such improvements as better signal coordination and road widenings. But in two areas with similar densities, the one with the greater percentage of expressway travel will register a higher overall vehicular travel speed. The accident rate will be lower, and traffic on both arterials and local streets will flow better because of accommodating a smaller load of the total traffic. Expressways also carry far larger volumes in the same right-of-way width than arterials.

The table listing the percent of vehicular travel carried on the limited-access system of each county shows that Bronx and Queens have the highest percentages, attributable in good part to expressways of fairly recent construction. As previously indicated, the expressways in Queens are much more congested than those in the Bronx. Manhattan has a high proportion of expressways that are also overloaded. The West Side Highway, in particular, was designed using standards that are considered primitive in the light of current construction technology.

At least 20 percent of vehicular travel in suburban New York counties and in Connecticut

PERCENT OF VMT

ON THE LIMITED-ACCESS SYSTEM

County	Percent
Manhattan	43
Brooklyn	30
Bronx	47
Queens	47
Hudson	27
Essex	25
Passaic	10
Union	19
Nassau	36
Westchester	46
Richmond	Less than 01*
Bergen	16
Middlesex	25
Bridgeport	31
Southwestern	36
Suffolk	21
Rockland	35
Ansonia-Derby	18
South Central	28
Monmouth	17
Somerset	Less than 01
Morris	Less than 01
Study Area	30

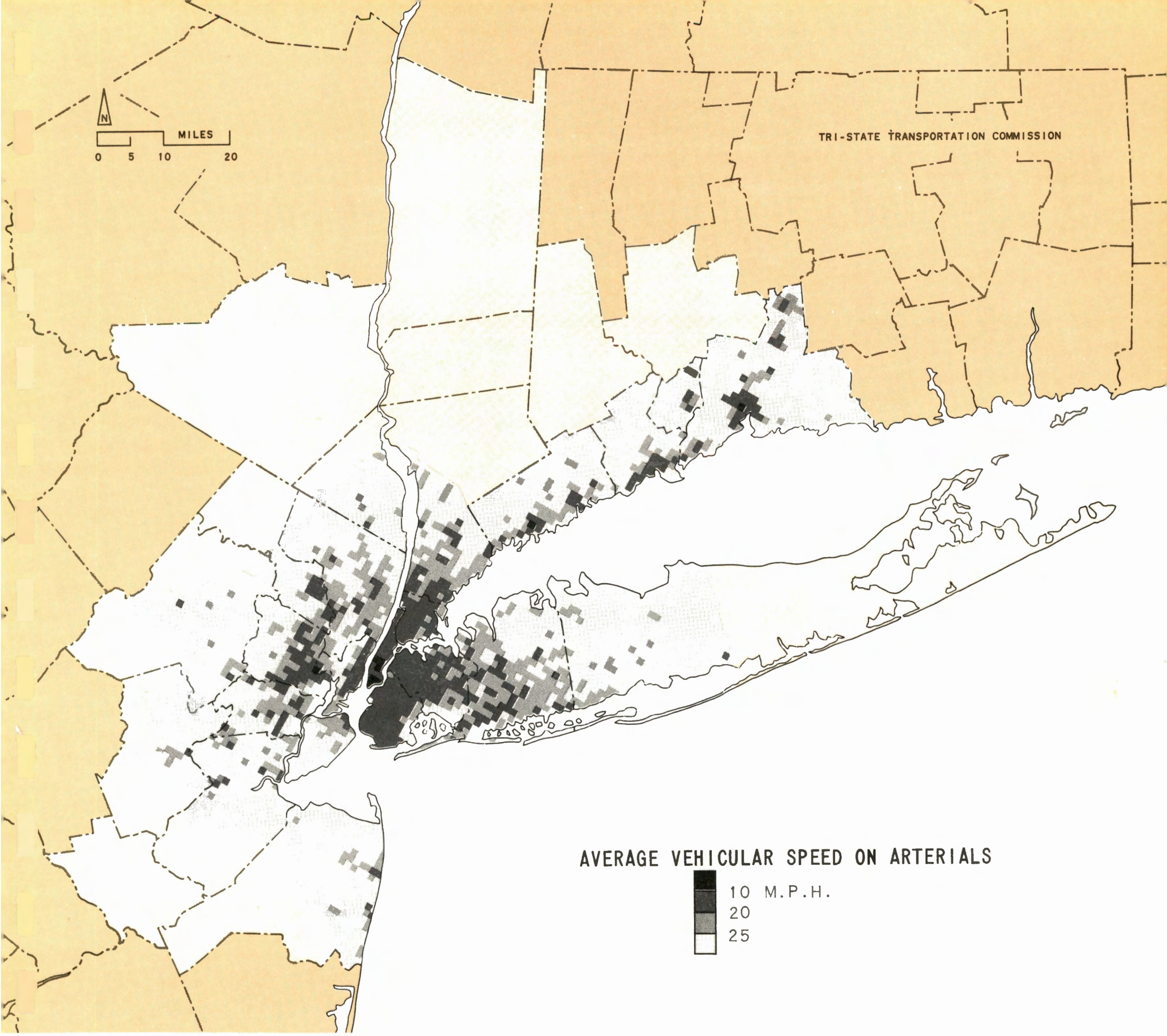
* Staten Island Expressway and Verrazano Narrows Bridge not included.

takes place on the limited-access network, with the exception of Ansonia-Derby, which registers 18 percent. In New Jersey, both Hudson and Essex counties score higher than that but under the 30-percent mark. Hudson County has a high percentage because it is crossed by the New Jersey Turnpike and its Holland Tunnel extension. Essex is also traversed by the turnpike and the Garden State Parkway, as is Union, where the volume is just under 20 percent. The other counties in New Jersey rank low in limited-access-highway travel.

AVERAGE DAILY SPEEDS

The average midday speeds on a sample of study area roads were measured, enabling relationships to be developed among these speeds, highways characteristics and types of areas in which these roads are found. The average midday speed was then calculated for the highway links of the entire network. Many urban transportation studies that have been made indicate that this average *midday* speed is nearly the same as the average *daily* speed; this figure is used as a convenient measure of highway performance. (Although travel is slower during rush hours, this condition, which would ordinarily tend to pull down the average, is canceled by faster travel that occurs during off-peak hours.)

The lower speeds registered in the vicinity of such activity centers as Manhattan, Brooklyn, Newark, Paterson and Bridgeport stand out on the map of average daily speeds on arterials. As development density decreases away from the coastal areas and outward on Long Island, speeds increase. Average daily arterial speeds range from less than 10 mph in the core areas to 30 mph in outlying areas.

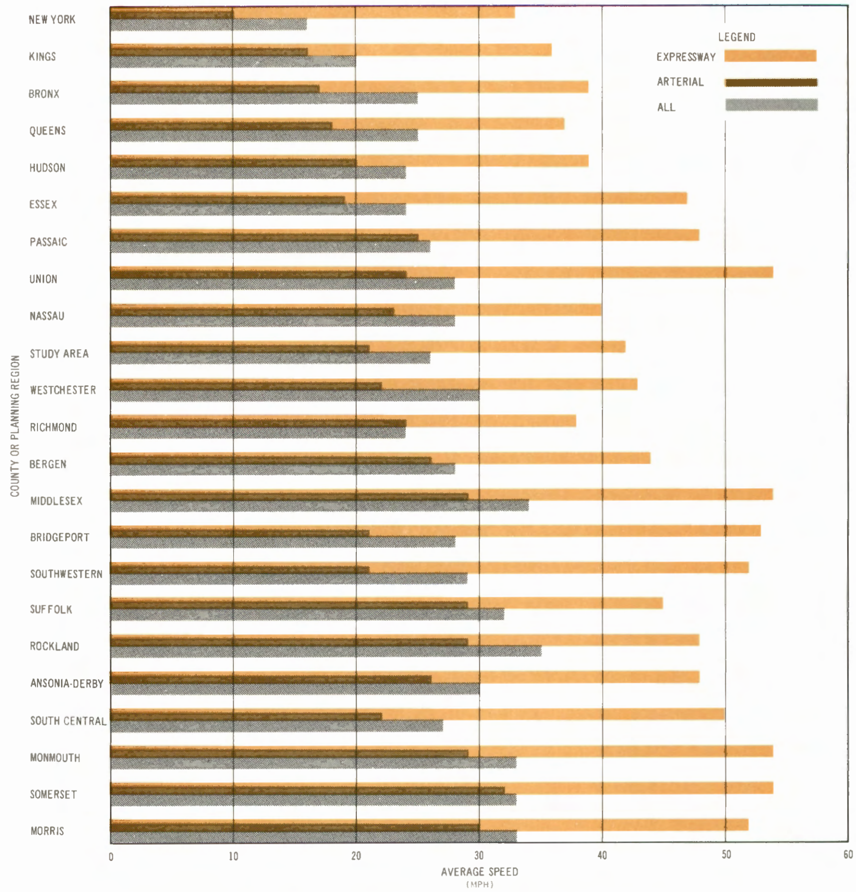


The average speeds by roadway type and area characteristics are presented on page 20.

These arterial speeds, along with limited-access speeds, were summarized to yield county averages. The limited-access speeds increase as density declines, but they are also strongly influenced by the average age of such facilities in a county.

Arterial speeds increase quite regularly as population density lessens. These speeds range from 10 mph in Manhattan to 32 mph in Somerset County. Those counties wherein this trend does not hold true, such as Bridgeport and South Central (New Haven), contain activity centers that pull the speed average downward.

EXPRESSWAY AND ARTERIAL AVERAGE SPEEDS



Lower density produces the same overall speed pattern. However those counties that have greater percentages of vehicular travel on limited-access highways have higher overall speeds than other counties or similar densities. Examples of the latter include Bronx, Queens and Westchester.

As various parts of the Region assume more densely developed configurations, arterial speeds in each will drop. The inevitability of this trend is demonstrated in the chart in this section. A vigorous program of road widenings and traffic engineering service, while capable of decreasing congestion somewhat, cannot obviate the need for a system of modern limited-access highways to maintain—at reasonable levels—overall average speeds.

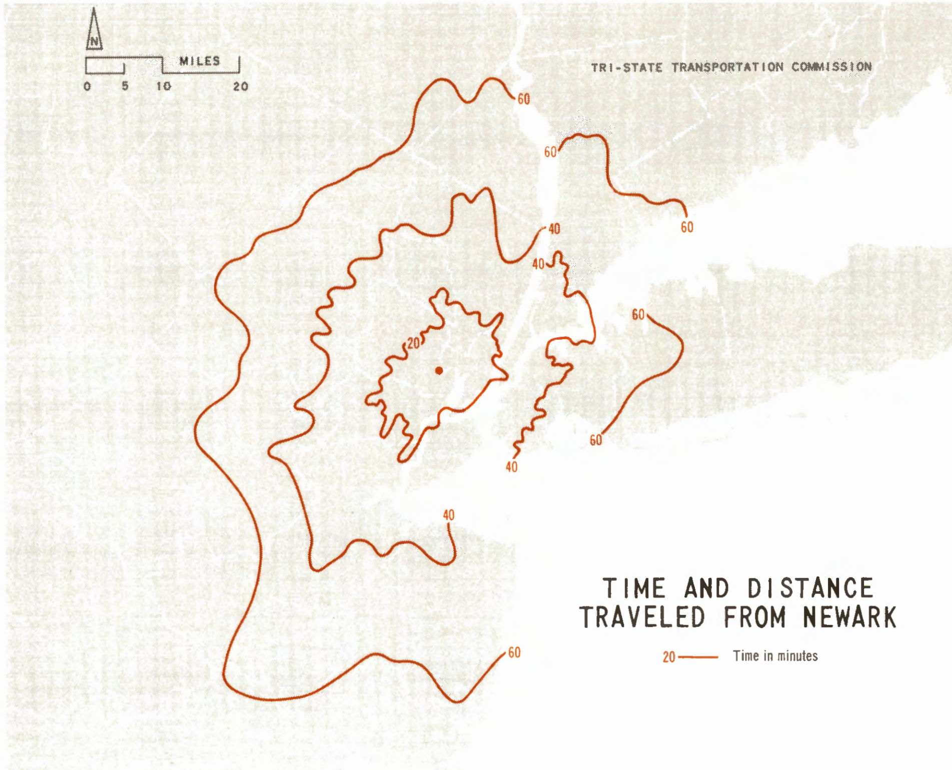
Maps have been prepared that show travel times over the highway network from selected starting points. These time-contour, or isochronal, maps trace how far a driver can travel in each direction in a certain time, making maximum use of the best highway facilities that are available to reach each possible destination.

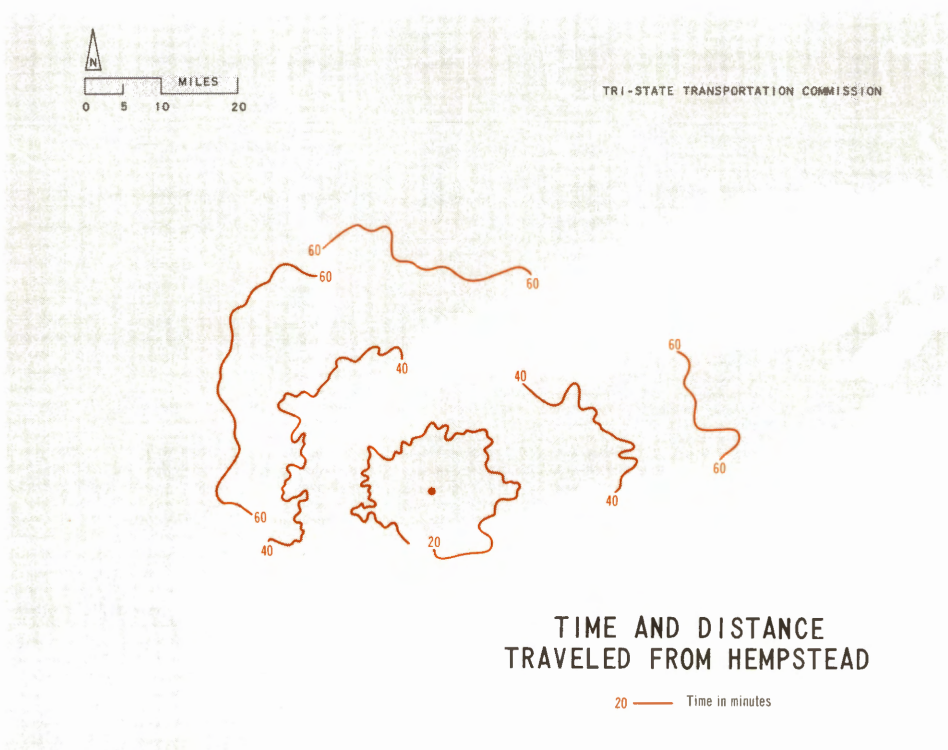
The first of these maps shows the destinations that can be reached in successive 20-minute intervals from mid-Manhattan. The radial expressway system allows approximately equal speed in all directions. The major hindrances are bottlenecks at the approaches to the Hudson and East River crossings. Since there are no limited-access highways through Brooklyn, greater time is necessary to move the same distance there than, for example, in Queens.

In the isochronal map based on downtown Newark, the higher speed of north/south travel, which is served by toll roads, is apparent. Expressways that will improve Newark's east/west access are now under construction.

Time contours from Hempstead are illustrated next. Because this community is situated close to the Southern State and Meadowbrook parkways, motorists leaving it can easily reach all Long Island destinations via the extensive limited-access system, including the outlying southernmost sections of Brooklyn. Speeds to the east toward Suffolk are somewhat higher than speeds inside New York City.

TIME AND DISTANCE TRAVELED FROM MANHATTAN


N
MILES
0 5 10 20
TRI-STATE TRANSPORTATION COMMISSION
60
60
60
40
40
60
20
60
40
40
60
TIME AND DISTANCE
TRAVELED FROM NEWARK
20 Time in minutes


N
MILES
0 5 10 20
TRI-STATE TRANSPORTATION COMMISSION
60
60
60
40
40
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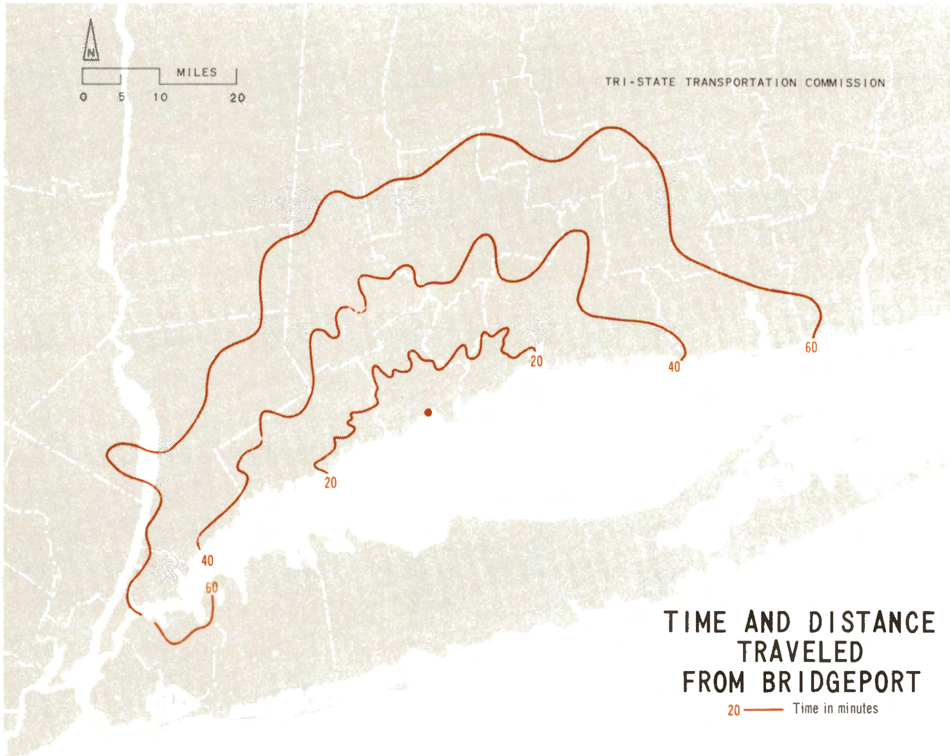
40
60
40
20
TIME AND DISTANCE
TRAVELED FROM HEMPSTEAD
20 Time in minutes



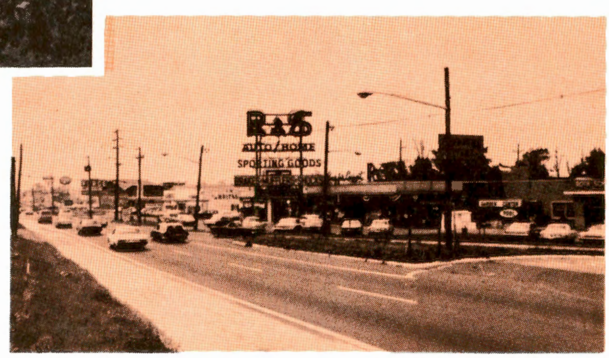
The final map shows time contours based on Bridgeport. Travel time patterns are strongly influenced by the Merritt Parkway and Connecticut Turnpike, since these routes are utilized at the start of most trips inland. Present plans indicate that this pattern of travel and use will be continued, but each major activity center will be provided with a north/south, limited-access facility to form an overall grid.

The inadequacy of the Manhattan approaches of the Queens-Midtown Tunnel shown here, is underscored by the heavy demands on the facility. These conditions cause this East River crossing to be frequently congested.

The Long Island Expressway is the only expressway reaching Manhattan and Brooklyn from the east. Drawing traffic from a wide area, it experiences high volumes of vehicular travel throughout the average day.

At the juncture of N. J. 3 and U. S. 46, five fully loaded westbound lanes of traffic attempt to merge into three lanes, resulting in a daily bottleneck.

U. S. 22 in New Jersey is an example of a roadway on which abutting commercial activity conflicts strongly with the large traffic volumes attempting to use this roadway.



▪ Milestones in the Evolving Highway Network

The following section provides a review of the plans and legislation that have had a considerable impact over the years on the creation of the Tri-State Region's highway system.

1807 PLAN FOR MANHATTAN

By the very early 1800s, Manhattan had grown to a population of 85,000, and its developed area extended from the Battery to Eighth Street on the west side of the island and to Houston Street on the east side. Because the existing street pattern in the lower end of Manhattan was chaotic, a commission was created to prepare a plan for the anticipated growth in the undeveloped areas of the island.

Believing that the principal future traffic flow would be from river to river, the commission mapped a street plan reflecting this assumption. Even though L'Enfant's plan for Washington, replete with diagonal streets and circular intersections, was then enjoying a considerable influence on street planning, the commission opted for a rigid gridiron pattern.

The basics of this plan were blocks 650 to 920 feet long and 200 feet wide, bounded by north/south avenues 100 feet wide and east/west streets 60 feet wide. To accommodate the anticipated cross-island traffic, however, every tenth street was increased to a width of 100 feet. Alleyways were not included.

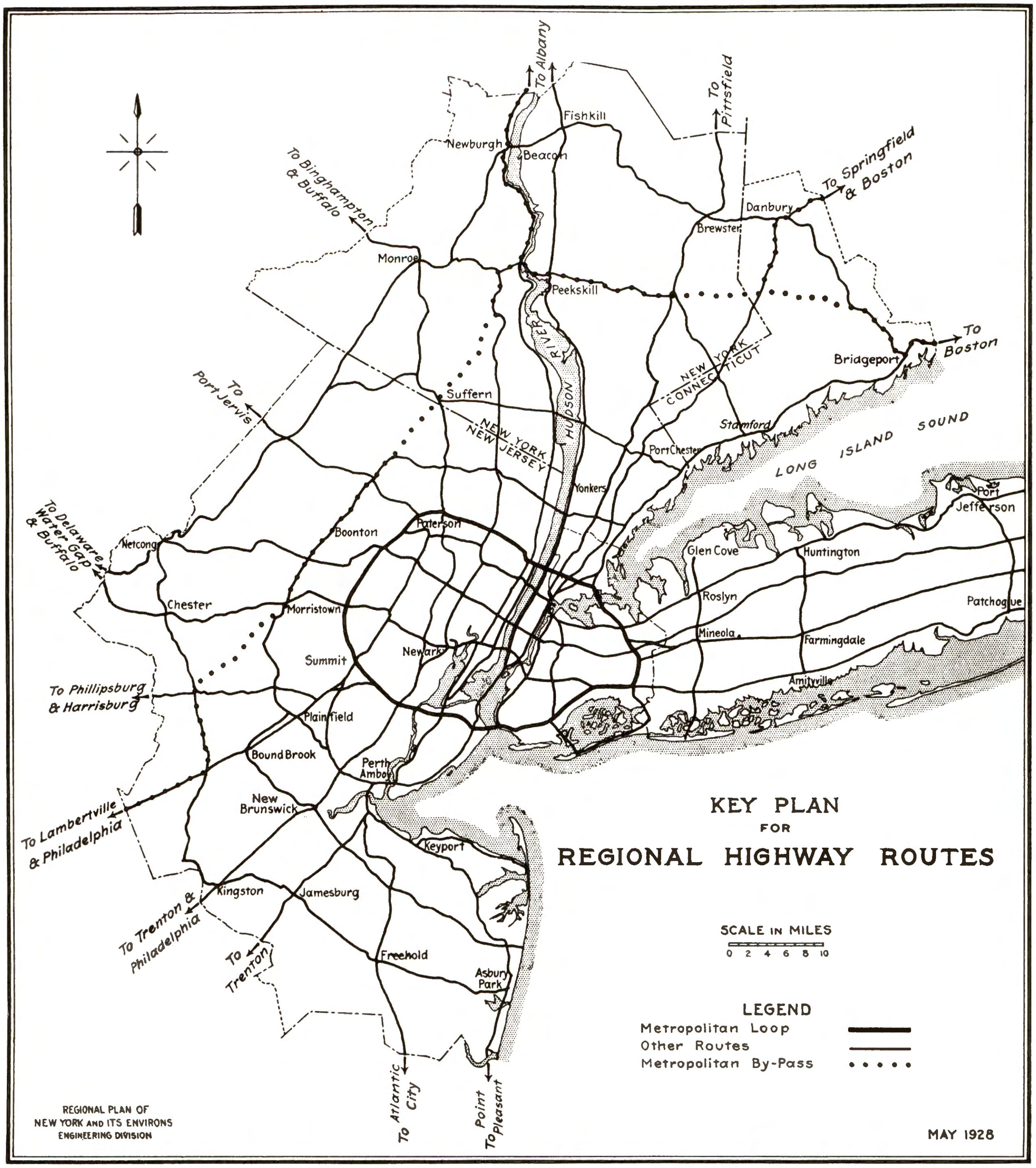
This plan, which allowed maximum street frontage development, had a great impact on urban design throughout the United States.

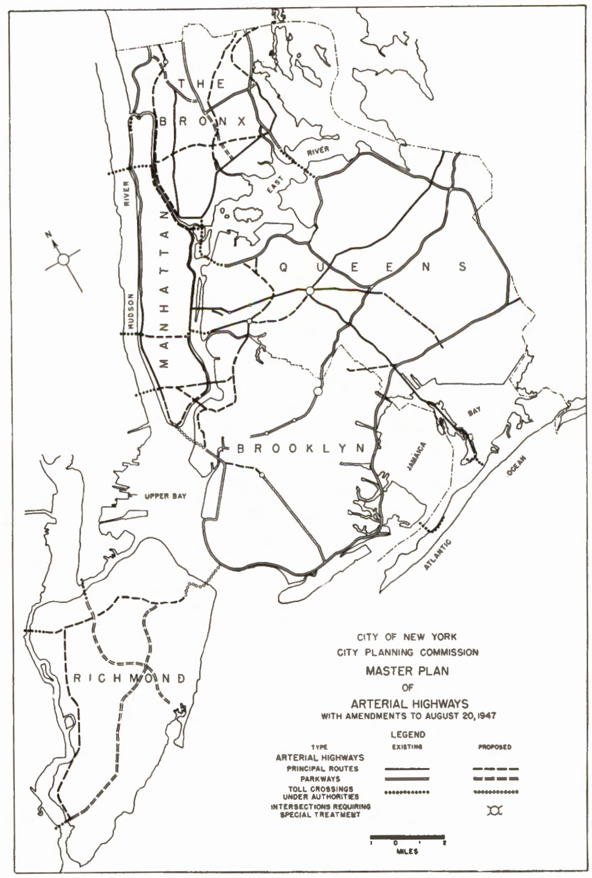
1921 PLAN OF THE PORT OF NEW YORK AUTHORITY

In 1920 a study group—the New York, New Jersey Port and Harbor Development Commission—recommended the creation of an interstate agency that would be charged with developing the port. In response, the following year the Port of New York Authority was created, the first such semi-autonomous agency in the nation.

Drawing considerably on the work accomplished by the commission, the Port Authority issued the first regional transportation plan in 1921; it was primarily concerned with improving rail connections in order to expedite freight movements to the waterfront.

The Port Authority was given the exclusive responsibility for building and operating new vehicular connections between the states of New York and New Jersey. From 1928 to 1931, the Port Authority built three bridges from Staten Island to New Jersey. In 1930, it assumed control of the Holland Tunnel, which had been constructed jointly and opened in 1927 by the two states. The George Washington Bridge followed in 1931 (second deck in 1962), and six years later the Lincoln Tunnel was opened (second and third tubes in 1945 and 1957, respectively).


KEY PLAN
FOR
REGIONAL HIGHWAY ROUTES
SCALE IN MILES
0 2 4 6 8 10
LEGEND
Metropolitan Loop
Other Routes
Metropolitan By-Pass
REGIONAL PLAN OF
NEW YORK AND ITS ENVIRONS
ENGINEERING DIVISION
MAY 1928
To Albany
To Pittsfield
To Springfield & Boston
To Boston
To Binghampton & Buffalo
To Port Jervis
To Delaware Water Gap & Buffalo
To Phillipsburg & Harrisburg
To Lambertville & Philadelphia
To Trenton & Philadelphia
To Trenton
To Atlantic City
To Point Pleasant
Fishkill
Newburgh
Beacon
Danbury
Brewster
Monroe
Peekskill
Bridgeport
Suffern
Stamford
Port Chester
Yonkers
LONG ISLAND SOUND
Port Jefferson
Paterson
Boonton
Netcong
Glen Cove
Huntington
Chester
Morristown
Roslyn
Patchogue
Mineola
Farmingdale
Summit
Newark
Amityville
Plainfield
Bound Brook
Perth Amboy
New Brunswick
Keyport
Kingston
Jamesburg
Freehold
Asbury Park
HUDSON RIVER
NEW YORK
NEW JERSEY
NEW YORK
CONNECTICUT



Source: Harold MacLean Lewis, *Planning the Modern City* (New York: John Wiley, 1957), I, p. 146.

1931 PLAN FOR NEW YORK AND ITS ENVIRONS

The Regional Plan Association was created in 1921 under the sponsorship and support of the Russell Sage Foundation. Ten years later, it published a comprehensive plan for the metropolitan area, including proposals for highway and mass transportation systems. This plan was a milestone for the Tri-State Region and inspired similar efforts elsewhere.

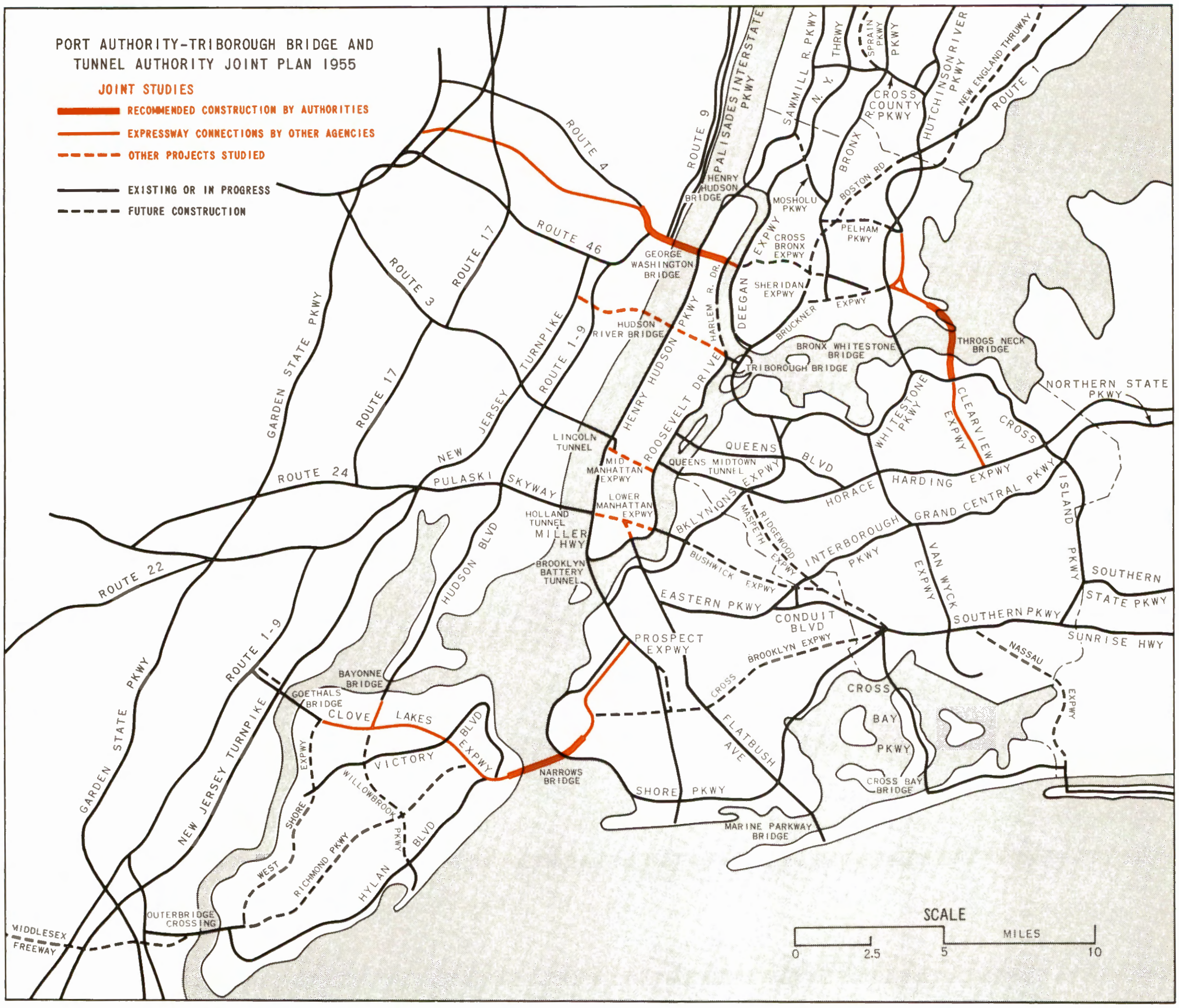
The success of the nation's first limited-access highway—the Bronx River Parkway, which opened in 1921—was reflected in the 1931 plan's recommendation that the new highways be what we now call expressways. Certain roads along shorelines and rivers were to be grade-separated parkways.

The plan's metropolitan ring approximates the locations of the present Garden State Parkway and N. J. 4, the Cross-Bronx Expressway, the Throgs Neck Bridge, the Cross-Island and Belt parkways, the Verrazano Narrows Bridge and the Staten Island Expressway. Routes now known as the Tappan Zee Bridge and Cross-Westchester Expressway and the New England Thruway-Connecticut Turnpike were also recommended. The plan also proposed mid- and lower Manhattan expressways, which are still under consideration.

THE NEW YORK CITY PLANNING COMMISSION'S 1939 AND 1947 PLANS

The New York City Planning Commission prepared a master plan for parkways, expressways and major surface arterials in 1939; an amended plan was released in 1947. These plans mostly showed existing facilities and those under active consideration by other agencies.

The 1947 plan, which is illustrated, proposed northern and southern bypass routes of Manhattan and the mid- and lower Manhattan expressways. The southern portion of the Van Wyck Expressway, the completion of the Long Island Expressway to the Queens-Midtown Tunnel and the Brooklyn-Queens Expressway were also recommended.



1955 TBTA-PONYA PLAN

The Triborough Bridge and Tunnel Authority (TBTA) was created in 1946 by merging three previously independent authorities. The new organization inherited the operation and indebtedness of the Triborough Bridge (opened in 1936), Henry Hudson Bridge (also 1936), Marine Parkway Bridge (1937), Bronx-Whitestone Bridge (1939), Cross Bay Bridge (also 1939) and Queens-Midtown Tunnel (1940). It has built the Brooklyn Battery Tunnel (1950), Throgs Neck Bridge (1961) and Verrazano Narrows Bridge (1964).

TBTA initiated a joint study of arterial facilities in the metropolitan area with the Port of New York Authority (PONYA) in 1954, which culminated in a report that was published in 1955. This study emphasized bypass routes around Manhattan; its principal recommendations have already been carried out by the two authorities in cooperation with the states of New York and New Jersey.

The northern bypass included double-decking the George Washington Bridge and construction of the Alexander Hamilton and Throgs Neck bridges and the Cross-Bronx Expressway. The southern bypass included construction of the Verrazano Narrows Bridge, the Staten Island Expressway and reconstruction of the Gowanus Parkway viaduct.

The study also reviewed proposals for such facilities as the Bushwick Expressway, mid- and lower Manhattan expressways and a Hudson River crossing near 125th Street.

FEDERAL HIGHWAY LEGISLATION

At the turn of the century, no state agencies had been created specifically to plan, construct and maintain a system of roads. These facilities were built by local communities in response to local needs.

The Federal Highway Act of 1916 provided $75 million in aid. To qualify for assistance, states had to have suitable highway departments. While the program was limited to highways for rural areas and towns with a population of less than 2500, it established a precedent for Federal aid for highway construction. By 1917, all states in the Union had established qualifying highway departments.

The Federal Highway Act of 1921 directed what is now the Bureau of Public Roads to establish a nationwide system of numbered highways. About 200,000 miles were included in this primary system.

The Federal Highway Act of 1934 set aside 1.5 percent of the highway funds allocated to each state for the purpose of research and planning. The following year, the first statewide surveys were begun. State highway planning efforts are still largely so financed.

The Federal Highway Act of 1944 extended highway aid to urban areas. It also directed the establishment of the routes to be included in a tentative nationwide interstate system, which was so designated by 1947.

The Federal Highway Act of 1956 authorized construction of the 41,000 mile interstate highway system. The Federal government bears 90 percent of costs rather than the normal 50 percent. The system was planned with a completion date of 1972. Many long-proposed facilities in the metropolitan area were included in the interstate system.

The Federal programs have contributed considerably to the construction of the expressway system in the Tri-State Region.

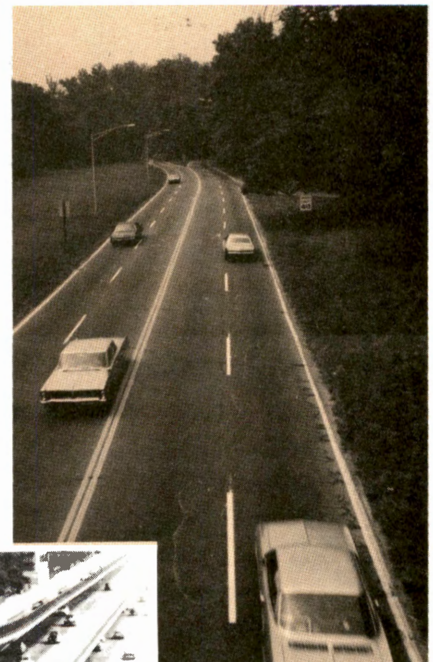
TOLL ROADS

A large segment of the Region's present limited-access highway system was built during the 1950s by toll agencies, which had been organized to help meet the rapidly growing need for high-capacity, high-service facilities. Normal tax revenues could not supply enough of these facilities as well as the many other projects that had been deferred because of World War II.

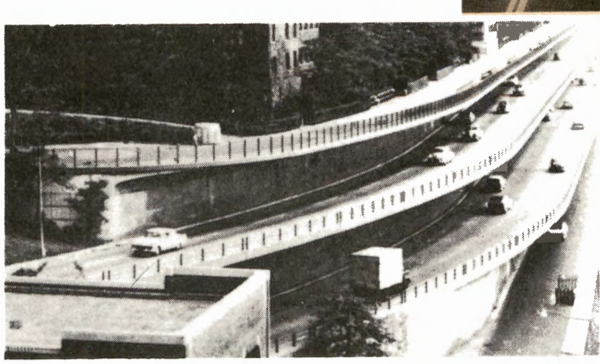
Created in 1950, the New York State Thruway Authority opened parts of its toll road five years later. The New Jersey Turnpike Authority and the New Jersey Highway Authority (Garden State Parkway) both opened parts of their facilities in the early 50s. The Connecticut Turnpike was built by that state's highway department using toll financing.

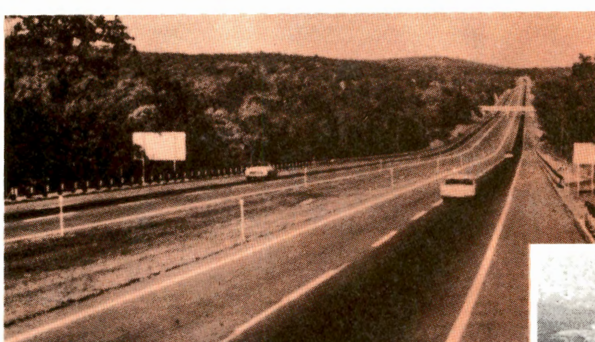
Since this spurt of toll-road construction, subsequent construction has taken place and is continuing on these facilities in the form of widenings, new interchanges and some extensions.

The Bronx River Parkway, the first access-controlled, grade-separated roadway in the nation, was opened in 1921. While still scenic, its design no longer satisfies current width, grade and curve-radius standards.



The Brooklyn-Queens Expressway is a successful example of multiple right-of-way use in an intensely developed area. Shown here is the cantilevered Promenade section of the roadway in Brooklyn Heights.





During the 1950s, separate bond financing resulted in the construction—in high-traffic-demand corridors—of many miles of toll roads, such as the Connecticut Turnpike. Shown here: the section at Madison.

Verrazano Narrows Bridge: Ever since 1929, planners have recommended a Brooklyn-Staten Island crossing at this location. The bridge, completed in 1964 and spanning New York Harbor between the Upper and Lower bays, provides a southern bypass of Manhattan.

Appendix

DATA COLLECTION

The Tri-State Transportation Commission has conducted many surveys to gain an understanding of the nature of travel in the Region and to measure the magnitude of movement patterns. Several of these surveys related directly to the highway system, including physical inventory, travel time study, and arterial and local street traffic counts.

Commission staff members developed the procedures utilized in the highway system project and defined its extent. The fieldwork was usually undertaken by the highway departments of the pertinent states and the obtained data were analyzed by Commission staff members.

PHYSICAL INVENTORY—In cooperation with the state highway departments, the Commission defined the existing limited-access and surface arterial highway system. The intensity of land development was used as a guide in determining which streets were classified as surface arterials. Using the Commission's *Inventory of Highway Facilities—Procedure and Coding Guide*, field observers recorded such components as pavement width, shoulders, degree of access control, number of signals, posted speed limits, and so forth, for designated portions of the highway network.

TRAVEL TIME STUDY—Approximately 20 percent of the inventoried limited-access and surface arterial network was included in this study. The included route sections were selected to provide coverage of various travel directions on all types of facilities. Pre-fieldwork for this study was conducted on the basis of guidelines in *Travel Time Procedure Manual—Technical Operations*.

Each route was driven several times during off-peak and peak periods by trained study teams, the members of which followed instructions contained in *TTPM—Field Operations Manual*. Data, such as the travel time to cross each designated highway section, the number of stops and the presence of parked vehicles were recorded. Subsequent analysis related speed to pavement width, type of facility, area traversed and the number of signals. These analyses were reported in *Technical Bulletins* Vol. II, No. 6 and Vol. III, No. 1.

ARTERIAL-TRAFFIC COUNTING—Existing traffic-counting programs and recently recorded data that were compared to the inventoried limited-access and surface arterial system indicated that about 1550 new counts were necessary. This work was undertaken by state highway departments employing mechanical devices.

All counts were converted to 1963 average weekday values before they were forwarded to Tri-State. These figures form the basis of the VMT travel information contained in this report.

LOCAL STREET TRAFFIC COUNTING—Before the highway system study, little was known about local street network use. Some measure of the system's use was necessary to complete the stock-taking of the entire street and highway network.

Counts were made using a combination of 16- to 24-hour manual "control" station observations and two-hour short counts at local street intersections selected at random. The short counts were expanded to daily volume estimates using control station relationships.

The study area had been subdivided into six strata, according to population density and land use. Twenty control stations and approximately 100 short counts were used in each stratum. A mean volume for each stratum was determined. This was multiplied by the local street length to produce local street VMT.

In the field, vehicle type and turning movements were recorded by 10-minute intervals following the instructions contained in *Local Street Vehicle Miles of Travel Survey Procedure Manual.*

■ ■ ■

Table I

Basic County Data*

	TRIP ENDS PER 100 PERSONS	TRIP END DENSITY (AUTO DRIVER TRIP ENDS/ SQUARE MILE)	AUTO DRIVER TRIP ENDS (000)	PERSONS PER 100 AUTOMOBILES	AUTOMOBILES (000)	POPULATION DENSITY (PERSONS/ SQUARE MILE)	POPULATION**** (000)	LAND AREA (SQUARE MILES)
New York	22	16,041	369	1,131	151	74,056	1,703	23
Kings	30	10,254	790	672	391	34,095	2,625	77
Bronx	27	8,747	376	677	211	32,689	1,406	43
Queens	56	8,742	1,005	407	457	16,194	1,862	115
Hudson	75	8,746	446	424	141	11,707	597	51
Essex	99	7,211	923	335	280	7,309	936	128
Passaic**	141	7,916	562	294	135	5,604	398	71
Union	131	6,633	683	264	198	5,065	522	103
Nassau	132	6,276	1,795	287	475	4,764	1,363	286
Westchester**	110	4,512	790	305	236	4,112	720	175
Richmond	59	2,249	137	386	60	3,795	232	61
Bergen	145	5,171	1,220	266	316	3,571	843	236
Middlesex**	109	2,593	506	280	166	2,368	465	195
Greater Bridgeport***	144	3,036	425	296	99	2,105	295	140
Southwestern Fairfield***	156	2,496	517	252	131	1,599	331	207
Suffolk**	135	2,115	867	291	221	1,567	643	410
Rockland**	112	1,612	171	274	56	1,445	153	106
Ansonia-Derby***	125	1,627	88	263	27	1,305	70	54
South Central***	134	1,684	620	280	164	1,253	461	368
Monmouth**	125	1,476	393	256	123	1,182	314	266
Somerset**	129	1,218	170	248	53	943	132	140
Morris**	147	1,345	342	245	95	912	232	254
Total Urbanized Area	81	3,760	13,195	389	4,186	4,646	16,303	3,509

*COUNTIES LISTED ACCORDING TO DECLINING POPULATION DENSITY

**PORTION WITHIN STUDY AREA

***CONNECTICUT PLANNING AREAS

****BASED UPON TRI-STATE'S HOME INTERVIEW SURVEY

Table II

Route Miles

	AUTO TRIP ENDS PER ROUTE MILE	AUTOMOBILES PER ROUTE MILE	PERSONS PER ROUTE MILE	ROUTE MILES PER SQUARE MILE	ROUTE MILES
Total New York	1,737	709	8,018	9.24	213
Limited Access	10,629	4,338	49,072	1.51	35
Arterial	2,076	847	9,584	7.73	178
Total Kings	2,872	1,421	9,549	3.57	275
Limited Access	23,805	11,780	79,149	0.43	33
Arterial	3,266	1,616	10,859	3.14	242
Total Bronx	2,389	1,339	8,930	3.66	157
Limited Access	9,096	5,098	33,994	0.96	41
Arterial	3,241	1,816	12,111	2.70	116
Total Queens	2,493	1,134	4,619	3.51	403
Limited Access	13,143	5,976	24,347	0.67	76
Arterial	3,077	1,399	5,700	2.84	327
Total Hudson	3,322	1,048	4,447	2.63	134
Limited Access	21,141	6,667	28,298	0.41	21
Arterial	3,941	1,243	5,276	2.22	113
Total Essex	3,077	932	3,119	2.34	300
Limited Access	35,705	10,814	36,193	0.20	26
Arterial	3,368	1,020	3,414	2.14	274
Total Passaic*	4,388	1,057	3,106	1.80	128
Limited Access	77,739	18,728	55.033	0.10	7
Arterial	4,650	1,120	3,292	1.70	121
Total Union	3,688	1,066	2,816	1.80	185
Limited Access	44,305	12,805	33,830	0.15	15
Arterial	4,023	1,163	3,072	1.65	170
Total Nassau	3,375	893	2,562	1.86	532
Limited Access	18,359	4,858	13,936	0.34	98
Arterial	4,135	1,094	3,138	1.52	434
Total Westchester*	1,739	520	1,585	2.59	455
Limited Access	6,892	2,063	6,282	0.65	115
Arterial	2,325	696	2,119	1.94	340
Total Richmond	1,313	574	2,216	1.72	104
Limited Access	127,050	55,545	214,394	0.02	1
Arterial	1,327	580	2,239	1.70	103
Total Bergen	3,170	822	2,189	1.63	385
Limited Access	32,379	8,395	22,359	0.16	38
Arterial	3,514	911	2,426	1.47	347
Total Middlesex*	1,883	619	1,733	1.38	268
Limited Access	11,982	3,940	11,026	0.22	42
Arterial	2,234	735	2,056	1.16	226

Table II continued

Route Miles

	AUTO TRIP ENDS PER ROUTE MILE	AUTOMOBILES PER ROUTE MILE	PERSONS PER ROUTE MILE	ROUTE MILES PER SQUARE MILE	ROUTE MILES
Total Greater Bridgeport	1,708	399	1,184	1.77	249
Limited Access	16,493	3,858	11,435	0.18	26
Arterial	1,905	446	1,321	1.59	223
Total Southwestern Fairfield	1,276	325	818	1.95	405
Limited Access	11,171	2,842	7,158	0.22	46
Arterial	1,441	366	923	1.73	359
Total Suffolk*	1,631	416	1,209	1.29	532
Limited Access	12,919	3,296	9,577	0.16	67
Arterial	1,866	476	1,383	1.13	465
Total Rockland*	819	268	734	1.97	209
Limited Access	5,080	1,661	4,553	0.32	34
Arterial	976	319	875	1.65	175
Total Ansonia-Derby	1,111	339	891	1.46	79
Limited Access	12,349	3,770	9,910	0.13	7
Arterial	1,220	373	979	1.33	72
Total South Central	1,175	312	875	1.43	527
Limited Access	9,217	2,447	6,861	0.18	67
Arterial	1,347	358	1,003	1.25	460
Total Monmouth*	1,806	566	1,446	0.82	218
Limited Access	14,735	4,617	11,800	0.10	27
Arterial	2,058	645	1,648	0.72	191
Total Somerset*	1,150	359	891	1.06	149
Limited Access	37,810	11,879	29,287	0.03	5
Arterial	1,186	370	919	1.03	144
Total Morris*	1,569	435	1,064	0.85	217
Limited Access	20,974	5,809	14,226	0.06	16
Arterial	1,696	470	1,150	0.79	201
Total Urbanized Area	2,155	684	2,662	1.74	6,124
Limited Access	15,648	4,965	19,335	0.24	843
Arterial	2,499	793	3,087	1.50	5,281

*PORTION WITHIN STUDY AREA

Table III

Lane Miles

	AUTO TRIP ENDS PER LANE MILE	AUTOMOBILES PER LANE MILE	PERSONS PER LANE MILE	LANE MILES PER SQUARE MILE	LANE MILES
Total New York	315	129	1,456	50.85	1,170
Limited Access	1,829	746	8,445	8.77	202
Arterial	381	156	1,760	42.08	968
Total Kings	576	285	1,915	17.80	1,371
Limited Access	4,234	2,095	14,077	2.42	187
Arterial	667	330	2,217	15.38	1,184
Total Bronx	412	231	1,539	21.25	914
Limited Access	1,549	868	5,789	5.65	243
Arterial	561	314	2,095	15.60	671
Total Queens	500	227	926	17.49	2,011
Limited Access	2,239	1,018	4,148	3.90	449
Arterial	643	293	1,192	13.59	1,562
Total Hudson	751	237	1,005	11.64	594
Limited Access	3,845	1,213	5,147	2.27	116
Arterial	933	294	1,249	9.37	478
Total Essex	721	218	731	9.99	1,280
Limited Access	5,628	1,704	5,705	1.28	164
Arterial	827	251	839	8.71	1,116
Total Passaic*	1,177	284	833	6.72	478
Limited Access	15,744	3,793	11,145	0.50	36
Arterial	1,272	306	901	6.22	442
Total Union	902	261	689	7.35	758
Limited Access	7,354	2,125	5,615	0.90	93
Arterial	1,028	297	785	6.45	665
Total Nassau	760	201	577	8.26	2,363
Limited Access	3,696	978	2,805	1.70	486
Arterial	956	253	726	6.56	1,877
Total Westchester*	489	146	446	9.23	1,614
Limited Access	1,542	461	1,405	2.93	512
Arterial	717	215	653	6.30	1,102
Total Richmond	317	139	535	7.10	433
Limited Access	31,910	13,951	53,848	0.07	4
Arterial	320	140	540	7.03	429
Total Bergen	914	237	631	5.66	1,335
Limited Access	7,112	1,844	4,911	0.73	172
Arterial	1,049	272	725	4.93	1,163

Table III Continued

Lane Miles

	AUTO TRIP ENDS PER LANE MILE	AUTOMOBILES PER LANE MILE	PERSONS PER LANE MILE	LANE MILES PER SQUARE MILE	LANE MILES
Total Middlesex*	495	163	455	5.24	1,022
Limited Access	2,020	664	1,859	1.28	250
Arterial	655	215	603	3.96	772
Total Greater Bridgeport	560	131	388	5.42	758
Limited Access	3,210	751	2,226	0.95	132
Arterial	679	159	471	4.47	626
Total Southwestern Fairfield	461	117	295	5.42	1,122
Limited Access	2,171	552	1,391	1.15	238
Arterial	585	149	375	4.27	884
Total Suffolk*	463	118	343	4.57	1,873
Limited Access	2,657	678	1,970	0.80	326
Arterial	560	143	415	3.77	1,547
Total Rockland*	280	92	251	5.75	609
Limited Access	1,039	340	931	1.55	164
Arterial	384	125	344	4.20	445
Total Ansonia-Derby	410	125	329	3.97	214
Limited Access	3,125	954	2,507	0.52	28
Arterial	472	144	379	3.45	186
Total South Central	395	105	294	4.26	1,567
Limited Access	2,072	550	1,543	0.81	299
Arterial	488	130	364	3.45	1,268
Total Monmouth*	567	178	454	2.61	693
Limited Access	3,606	1,130	2,888	0.41	109
Arterial	672	211	538	2.20	584
Total Somerset*	404	126	313	3.02	423
Limited Access	5,519	1,721	4,275	0.22	31
Arterial	436	136	337	2.80	392
Total Morris*	518	143	351	2.60	660
Limited Access	3,646	1,010	2,473	0.37	94
Arterial	604	167	409	2.23	566
Total Urbanized Area	567	180	701	6.63	23,262
Limited Access	3,044	966	3,761	1.24	4,335
Arterial	697	221	861	5.39	18,927

*PORTION WITHIN STUDY AREA

Table IV

Vehicle Miles of Travel

ROUTE TYPE	VMT PER SQUARE MILE (000)	VMT PER AUTOMOBILE	VMT PER PERSON	VMT PER AUTO TRIP END	VMT (000)
Total New York	263.1	40.0	3.5	16.4	6,050
Limited Access	113.8	17.3	1.5	7.1	2,616
Arterial	120.3	18.3	1.6	7.5	2,767
Local	29.0	4.4	0.4	1.8	667
Total Kings	98.7	19.4	2.9	9.7	7,606
Limited Access	29.6	5.8	0.9	2.9	2,280
Arterial	43.6	8.6	1.3	4.3	3,360
Local	25.5	5.0	0.7	2.5	1,966
Total Bronx	111.9	22.8	3.4	12.8	4,813
Limited Access	53.0	10.8	1.6	6.1	2,280
Arterial	38.6	7.9	1.2	4.4	1,659
Local	20.3	4.1	0.6	2.3	874
Total Queens	115.4	29.0	7.1	13.2	13,275
Limited Access	53.8	13.5	3.3	6.2	6,190
Arterial	39.3	9.9	2.4	4.5	4,524
Local	22.3	5.6	1.4	2.5	2,561
Total Hudson	70.4	25.5	6.0	8.0	3,587
Limited Access	19.0	6.9	1.6	2.2	967
Arterial	37.0	13.4	3.2	4.2	1,886
Local	14.4	5.2	1.2	1.6	734
Total Essex	53.7	24.5	7.3	7.4	6,884
Limited Access	13.2	6.0	1.8	1.8	1,692
Arterial	29.6	13.5	4.0	4.1	3,795
Local	10.9	5.0	1.5	1.5	1,397
Total Passaic*	41.7	22.0	7.4	5.3	2,962
Limited Access	4.3	2.3	0.8	0.6	306
Arterial	26.4	13.9	4.7	3.3	1,876
Local	11.0	5.8	1.9	1.4	780
Total Union	51.9	27.0	10.2	7.8	5,345
Limited Access	9.9	5.2	2.0	1.5	1,022
Arterial	29.0	15.1	5.7	4.4	2,985
Local	13.0	6.7	2.5	1.9	1,338
Total Nassau	48.8	29.4	10.2	7.8	13,942
Limited Access	17.4	10.5	3.7	2.8	4,980
Arterial	20.1	12.1	4.2	3.2	5,741
Local	11.3	6.8	2.3	1.8	3,221
Total Westchester	41.2	30.6	10.0	9.1	7,215
Limited Access	18.8	14.0	4.6	4.2	3,295
Arterial	14.0	10.4	3.4	3.1	2,445
Local	8.4	6.2	2.0	1.8	1,475
Total Richmond	23.0	23.4	6.0	10.3	1,405
Limited Access	0.1	0.1	.0	0.1	8
Arterial	13.7	13.9	3.6	6.1	836
Local	9.2	9.4	2.4	4.1	561
Total Bergen	33.8	25.2	9.4	6.5	7,973
Limited Access	5.5	4.1	1.5	1.1	1,293
Arterial	20.0	15.0	5.6	3.9	4,731
Local	8.3	6.1	2.3	1.5	1,949

Table IV Continued

Vehicle Miles of Travel

ROUTE TYPE	VMT PER SQUARE MILE (000)	VMT PER AUTOMOBILE	VMT PER PERSON	VMT PER AUTO TRIP END	VMT (000)
Total Middlesex*	31.0	36.3	13.0	11.9	6,038
Limited Access	7.9	9.2	3.3	3.0	1,534
Arterial	16.1	18.9	6.8	6.2	3,144
Local	7.0	8.2	2.9	2.7	1,360
Total Greater Bridgeport	22.8	32.3	10.8	7.6	3,199
Limited Access	7.1	10.1	3.4	2.4	1,001
Arterial	9.6	13.6	4.6	3.2	1,347
Local	6.1	8.6	2.8	2.0	851
Total Southwestern Fairfield	20.8	32.9	13.0	8.3	4,317
Limited Access	7.5	11.9	4.7	3.0	1,563
Arterial	8.8	13.8	5.5	3.5	1,813
Local	4.5	7.2	2.8	1.8	941
Total Suffolk*	20.5	38.1	13.1	9.7	8,418
Limited Access	4.2	7.9	2.7	2.0	1,738
Arterial	10.0	18.6	6.4	4.7	4,112
Local	6.3	11.6	4.0	3.0	2,568
Total Ansonia-Derby	11.9	23.8	9.1	7.3	642
Limited Access	2.1	4.3	1.6	1.3	115
Arterial	6.3	12.5	4.8	3.9	338
Local	3.5	7.0	2.7	2.1	189
Total Rockland	17.9	33.9	12.4	11.1	1,897
Limited Access	6.2	11.8	4.3	3.9	658
Arterial	7.9	15.0	5.5	4.9	840
Local	3.8	7.1	2.6	2.3	399
Total South Central	16.4	36.8	13.0	9.7	6,033
Limited Access	4.6	10.4	3.7	2.7	1,702
Arterial	8.2	18.3	6.4	4.9	3,003
Local	3.6	8.1	2.9	2.1	1,328
Total Mommouth*	13.2	28.4	11.2	8.9	3,505
Limited Access	2.2	4.8	1.9	1.5	592
Arterial	6.4	13.7	5.4	4.3	1,691
Local	4.6	9.9	3.9	3.1	1,222
Total Somerset*	13.3	35.2	14.1	11.0	1,864
Limited Access	0.6	1.5	0.6	0.5	80
Arterial	9.3	24.7	9.9	7.7	1,309
Local	3.4	9.0	3.6	2.8	475
Total Morris*	11.7	31.3	12.8	8.6	2,971
Limited Access	0.9	2.3	0.9	0.6	218
Arterial	7.4	19.8	8.1	5.5	1,878
Local	3.4	9.2	3.8	2.5	875
Total Urbanized Area	34.2	28.6	7.3	9.1	119,940
Limited Access	10.3	8.6	2.2	2.7	36,130
Arterial	16.0	13.4	3.4	4.3	56,080
Local	7.9	6.6	1.7	2.1	27,730

*PORTION WITHIN STUDY AREA

Table V

Average Daily Volume Per Lane (00)
Area Type

ROUTE TYPE	COUNTY AVERAGE	CENTRAL BUSINESS DISTRICT AND OFFICE BUILDINGS	URBAN: RESIDENTIAL, COMMERCIAL, AND INDUSTRIAL	INTERMEDIATE RESIDENTIAL	RURAL: OPEN AND SUBURBAN
Total New York	46	83	37	–	–
Limited Access	130	143	116	–	–
Arterial	29	39	27	–	–
Total Kings	42	37	45	35	–
Limited Access	122	–	116	141	–
Arterial	28	37	31	25	–
Total Bronx	45	–	37	78	–
Limited Access	94	–	107	83	–
Arterial	25	–	25	35	–
Total Queens	55	40	49	52	63
Limited Access	138	–	142	135	138
Arterial	29	40	33	26	25
Total Hudson	48	31	50	31	46
Limited Access	83	–	82	–	91
Arterial	39	31	41	31	38
Total Essex	43	40	43	24	56
Limited Access	103	–	87	–	120
Arterial	34	40	37	24	36
Total Passaic*	46	18	44	33	51
Limited Access	86	–	–	–	86
Arterial	42	18	44	33	44
Total Union	53	27	54	34	57
Limited Access	110	–	88	–	130
Arterial	45	27	50	34	42
Total Nassau	45	–	34	29	61
Limited Access	103	–	138	56	102
Arterial	31	–	33	29	30
Total Westchester*	36	27	38	45	34
Limited Access	64	–	76	86	59
Arterial	22	27	27	27	20
Total Richmond	19	–	30	22	17
Limited Access	19	–	–	–	19
Arterial	19	–	30	22	17

Table V Continued

Average Daily Volume Per Lane (00)
Area Type

ROUTE TYPE	COUNTY AVERAGE	CENTRAL BUSINESS DISTRICT AND OFFICE BUILDINGS	URBAN: RESIDENTIAL, COMMERCIAL, AND INDUSTRIAL	INTERMEDIATE RESIDENTIAL	RURAL: OPEN AND SUBURBAN
Total Bergen	45	–	53	41	41
Limited Access	75	–	66	–	80
Arterial	41	–	51	41	33
Total Middlesex*	46	41	40	28	51
Limited Access	61	–	85	–	61
Arterial	41	41	39	28	44
Total Greater Bridgeport	31	29	34	50	28
Limited Access	76	–	108	106	63
Arterial	22	29	25	25	19
Total Southwestern Fairfield	30	32	33	61	28
Limited Access	66	–	77	97	62
Arterial	21	32	30	26	18
Total Suffolk*	31	–	42	31	29
Limited Access	53	–	–	–	53
Arterial	27	–	42	31	22
Total Rockland*	25	–	31	–	24
Limited Access	40	–	42	–	40
Arterial	19	–	31	–	17
Total Ansonia-Derby	21	–	26	32	20
Limited Access	41	–	47	–	40
Arterial	18	–	23	32	17
Total South Central	30	31	37	28	27
Limited Access	57	–	71	60	54
Arterial	24	31	34	27	18
Total Monmouth*	33	–	36	18	33
Limited Access	54	–	–	–	54
Arterial	29	–	36	18	28
Total Somerset*	33	–	47	28	29
Limited Access	26	–	–	–	26
Arterial	33	–	47	28	29
Total Morris*	32	–	43	51	28
Limited Access	23	–	–	–	23
Arterial	33	–	43	51	29
Total Urbanized Area	40	60	42	39	37
Limited Acess	83	143	101	111	71
Arterial	30	36	35	28	25

*PORTION WITHIN STUDY AREA

Table VI

Average Speed (MPH)
Area Type

ROUTE TYPE	COUNTY AVERAGE	CENTRAL BUSINESS DISTRICT AND OFFICE BUILDING	URBAN: RESIDENTIAL, COMMERCIAL AND INDUSTRIAL	INTERMEDIATE RESIDENTIAL	RURAL: OPEN AND SUBURBAN
Total New York	16	17	15	–	–
Limited Access	33	30	36	–	–
Arterial	10	7	11	–	–
Total Kings	20	8	20	21	–
Limited Access	36	–	35	37	–
Arterial	16	8	15	17	–
Total Bronx	25	–	22	38	–
Limited Access	39	–	39	39	–
Arterial	17	–	17	23	–
Total Queens	25	10	20	27	34
Limited Access	37	–	33	38	37
Arterial	18	10	16	18	27
Total Hudson	24	12	24	19	26
Limited Access	39	–	41	–	23
Arterial	20	12	20	19	27
Total Essex	24	12	21	19	37
Limited Access	47	–	46	–	52
Arterial	19	12	18	19	29
Total Passaic*	26	9	21	22	35
Limited Access	48	–	–	–	48
Arterial	25	9	21	22	32
Total Union	28	14	25	21	35
Limited Access	54	–	52	–	55
Arterial	24	14	22	21	29
Total Nassau	28	–	21	21	36
Limited Access	40	–	37	38	41
Arterial	23	–	21	21	28
Total Westchester*	30	11	25	28	35
Limited Access	43	–	45	38	44
Arterial	22	11	18	21	26
Total Richmond	24	–	21	21	28
Limited Access	38	–	–	–	38
Arterial	24	–	21	21	28
Total Bergen	28	–	26	22	32
Limited Access	44	–	41	–	46
Arterial	26	–	25	22	28

Table VI continued

Average Speed (MPH)
Area Type

ROUTE TYPE	COUNTY AVERAGE	CENTRAL BUSINESS DISTRICT AND OFFICE BUILDINGS	URBAN: RESIDENTIAL, COMMERCIAL AND INDUSTRIAL	INTERMEDIATE RESIDENTIAL	RURAL: OPEN AND SUBURBAN
Total Middlesex*	34	15	27	22	41
Limited Access	54	–	54	–	54
Arterial	29	15	26	22	34
Total Greater Bridgeport	26	8	21	33	34
Limited Access	53	–	55	56	52
Arterial	21	8	16	18	27
Total Southwestern Fairfield	29	9	18	35	35
Limited Access	52	–	52	55	52
Arterial	21	9	16	15	26
Total Suffolk*	32	–	28	26	35
Limited Access	45	–	–	–	45
Arterial	29	–	28	26	30
Total Rockland*	35	–	27	–	36
Limited Access	48	–	45	–	48
Arterial	29	–	26	–	29
Total Ansonia-Derby	30	–	18	23	34
Limited Access	48	–	43	–	49
Arterial	26	–	15	23	31
Total South Central	27	8	21	21	37
Limited Access	50	45	44	52	51
Arterial	22	8	19	20	29
Total Monmouth*	33	–	23	24	38
Limited Access	54	–	–	–	54
Arterial	29	–	23	24	33
Total Somerset*	33	–	28	23	37
Limited Access	54	–	–	–	54
Arterial	32	–	28	23	36
Total Morris*	32	–	27	33	33
Limited Access	52	–	–	–	52
Arterial	30	–	27	33	31
Total Urbanized Area	26	14	21	25	35
Limited Access	42	30	39	39	45
Arterial	21	9	18	20	29

*PORTION WITHIN STUDY AREA

Table VII

Route Miles by Volume/Lane and Route Type

AVERAGE DAILY VOLUME PER LANE RANGE	ROUTE TYPE			
	EXPRESSWAY	TWO-WAY DIVIDED	TWO-WAY UNDIVIDED	ONE-WAY
0 - 749	5	14	444	13
750 - 1,499	10	41	801	57
1,500 - 2,999	82	143	1,689	120
3,000 - 4,499	121	123	992	53
4,500 - 5,999	153	78	370	13
6,000 - 7,499	90	45	112	5
7,500 - 8,999	86	37	40	3
9,000 - 10,499	74	25	15	2
10,500 - 11,999	52	19	5	-
12,000 - 13,499	42	10	2	-
13,500 - 14,999	42	5	-	-
15,000 - 16,499	30	3	-	-
Over 16,500	56	-	-	-
Total Urbanized Area	843	543	4,470	266

Table VIII

Vehicle Miles of Travel (000) by Volume/Lane and Route Type

AVERAGE DAILY VOLUME PER LANE RANGE	ROUTE TYPE			
	EXPRESSWAY	TWO-WAY DIVIDED	TWO-WAY UNDIVIDED	ONE-WAY
1,500 - 2,999	15	38	578	28
3,000 - 4,499	57	265	2,810	210
4,500 - 5,999	958	2,071	13,531	1,012
6,000 - 7,499	2,603	2,703	12,810	901
7,500 - 88,999	3,834	2,215	5,746	287
9,000 - 10,499	3,034	1,608	2,218	150
10,500 - 11,999	3,818	1,598	824	93
12,000 - 13,499	4,246	1,198	445	70
13,500 - 14,999	3,360	1,182	224	-
15,000 - 16,499	3,048	650	149	-
Over - 16,500	3,132	319	-	-
0 - 749	2,499	248	-	-
750 - 1,499	6,053	-	-	-
Total Urbanized Area	36,131	13,995	39,335	2,751

This report was prepared by the highway planning unit under the direction of Edward F. Sullivan, Chief of Travel Analysis. It was written by Albert H. Woehrle, Jr., manager, Kozmas Balkus, transportation engineer, and J. David Jordan, transportation analyst.