Characteristics of Motor Vehicle Ownership and Use

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Recent research, especially studies conducted by the U. S. Bureau of Public Roads and the State highway departments for the Highway Cost Allocation Study directed by Section 210 of the Federal Highway Revenue Act of 1956, has developed much new information and new analyses and interpretations of old data, to add to the knowledge about the characteristics of motor vehicle ownership and use. Although this new information answers many questions, it raises others and opens up new areas of speculation for researchers interested in this subject.

This paper presents some of this new material, indicates wherein it answers some questions and raises others; and, wherever possible compares these findings with comparable information obtained by other means, and with the findings of earlier studies of the same general character. Suggestions for further research are offered.

Among the specific characteristics of motor vehicle ownership and use considered are density of vehicle ownership; characteristics of vehicle operators; characteristics of automobile travel, such as amount, purposes, and place of travel; and rates of vehicle fuel consumption.

• THE RAPID CHANGES that have taken place in the approximately 15 years that have elapsed since the close of World War II have brought the highway administrator many problems, some of which he had never encountered before. Fortunately, however, this period has also brought with it developments in highway research and planning that provide him with more and better tools than he ever had before in the form of new data, and new analyses thereof, in the fields of basic economics, sociology, and population; information about the characteristics of motor vehicle ownership and use; and related material. During this period practically every State has had at least one more or less comprehensive long-range highway needs study, and there have been several Federally instigated studies, notably those required by the provisions of the Federal Aid Highway Acts of 1954 and 1956, and by Section 210 of the Federal Highway Revenue Act of 1956.

Some of this recent research, especially those studies conducted cooperatively by the U. S. Bureau of Public Roads and the State highway departments for the Highway Cost Allocation Study required by Section 210 of the Highway Revenue Act of 1956, has developed much new information, portions of which seem to throw into question certain assumptions and hypotheses that highway researchers had grown to accept almost without question. In this connection one thinks especially of past ideas about the magnitude of average annual travel by passenger automo-

biles and their average rates of motor fuel consumption.

Although this new information gleaned in recent years answers many questions, it raises others and opens up new areas of speculation for researchers interested in these general subjects, especially those in Federal, State, and local governments, in colleges and universities, and in industry. It is the purpose of this paper to present some of this material, not from the standpoint of adding to the store of information, but rather from that of raising questions about the continuing validity of assumptions made in the past, with the aim of stimulating thought and, perhaps, new investigation along these lines.

CHANGES IN POPULATION CHARACTERISTICS AND ECONOMIC STATUS

Between 1950 and 1960 the 48 contiguous States and the District of Columbia experienced the greatest numerical population growth in their history, and the greatest percentage increase since the decennial Census of 1910. However, the changes in population distribution that have taken place in the past 10 years are seemingly far more significant than is the change in total population.

Prior to 1920 more than one-half the population of these contiguous jurisdictions resided in areas classified as "rural territory" under Census Bureau definitions. In 1920 the population was almost equally divided between rural territory and urban territory, 49 percent residing in the rural areas, and 51 percent in urban areas. Between 1920 and 1950, the percentage of total population residing in urban territory under the "old definition" increased from 51 to 59 percent.

At the time of the 1950 Census a new definition of urban territory was adopted by the Census Bureau under which the urban population was increased from 59 to 64 percent of the total. Preliminary indications are that under this definition about 70 percent of the population of these jurisdictions lived in urban territory in 1960. Thus, the preliminary returns of the 1960 Census of Population show that 21.3 million of the population increase of 28 millon took place in 189 metropolitan areas, and that 17.1 million of the metropolitan-area increase occurred outside of the central cities. This is just another way of saying that during the past decade, there has been a great acceleration of growth in the suburban areas.

In the 168 urban areas recognized by the Census Bureau as metropolitan areas in 1950, the growth in the suburbs between 1940 and 1950 was 9 million inhabitants, whereas between 1950 and 1960 both actual and relative growth in the central cities slackened. Growth in the suburban fringe in 189 areas now officially recognized was 17 million, representing a 47 percent increase, or 6 times the rate of growth of either the central cities or of territory outside the metropolitan areas.

Implications of Population Shifts

These matters and their implications for highway planners and administrators have been considered elsewhere. They are mentioned here only because of their significant bearing upon present and future characteristics of motor vehicle ownership and use.

It is pointed out by Kanwit and Todd (*1*) that the present growth in suburban areas made possible by the ever-increasing extent of automobile ownership has dominated recent population movements and that there is no apparent indication of either a reversal or a decrease in this trend. It was brought out by Cherniack (*2*) that automobile ownership increases in approximately an inverse relation-

ship with decreases in population density. This means that if the rate of increase of suburban population continues in future years according to the trend it has followed in recent years, with a continuing accompanying decline in central-city populations, the total motor vehicle population is likely to continue to increase at a more rapid rate than the human population, providing there are no economic, technological, or sociological brakes applied to this trend in automobile ownership.

Improvement in Economic Status

Most people are sometimes inclined to doubt whether they are actually any better off today than they were, say, 15 years ago. Actually, according to the 1960 figures published by the Department of Commerce (*3*, Table 400, p. 305) per capita disposable personal income was reported as $1,744 in 1959 in constant dollars as compared with $1,514 in 1945. These figures mean that in 1959 the average resident of the United States had $230 more of constant dollar purchasing power than he had in 1945, because the term "disposable personal income" refers to net income available to individuals for personal consumption or other nontax expenditures after the deduction of taxes, etc., assessed against them as individuals. Thus, the average citizen had appreciably more money to spend, if he chose, on motor vehicles and their operations in 1959 than he did in 1945.

It appears that Mr. Average Citizen is doing just that. A recent release by the Bureau of Public Roads (*4*) indicates that in the past seven years the lowest annual percentage increase in motor vehicle registrations was 1.7 percent in 1958. A preliminary estimate of the increase of 1960 registrations over 1959 was 2,371,000 vehicles, or 3.3 percent.

CHANGING CHARACTERISTICS OF MOTOR VEHICLE OWNERSHIP

Registration Trends Follow Predictions

This trend is closely in line with that predicted by the highway departments of the 48 contiguous States and the District of Columbia in 1957 when, at the request of the Bureau of Public Roads, they made forecasts of future registrations for use in the Highway Cost Allocation Study. The States then expected that total motor vehicle registrations would reach somewhat in excess of 74,000,000 vehicles by 1960, of which some 62,500,000 would be passenger cars and some 12,000,000 would be trucks and buses. The preliminary registration totals for 1960 indicated in the Public Roads release (*4*) are 73,600,000 vehicles, composed of 61,300,000 passenger cars and 12,250,000 trucks and buses. Expressed in terms of density of registrations, there were 38.9 vehicles per 100 persons in 1956 and approximately 42.5 in 1960.

In view of the observed close relationship between the trend in actual registrations between 1956 and 1960 and the forecasts made by the States for the Congressional study, it is of interest to note what the further predictions of the States were. They estimated that by 1976 the density of motor vehicle registrations will have reached 49.5 vehicles per 100 persons, for a total of nearly 113,600,000 vehicles, of which approximately 95,000,000 would be passenger cars and 18,700,000 would be trucks and buses. These estimates are reported by Todd (*5*), but it should be remembered that the foregoing are a composite of the estimates prepared by all of these States individually, and that not all of the States have been equally successful in predicting their individual registration trends. However, up to the present, optimistic predictions in

some States have been offset by conservative predictions in others.

Changes in Registration Composition

One factor in the situation which is not evident from the gross figures previously quoted is the changing composition of the total registrations. Although it is expected that the percentage of trucks and buses to total vehicles registered (16.3 percent in 1956 and 16.6 in 1960) will remain about as it is through 1976, it seems on the basis of recent trends that the average operating gross weight of these vehicles will have increased perceptibly by that time.

It is in the area of passenger car registrations that the most pronounced changes are likely to be found in the next few years, however. There has been some importation of motor vehicles into the United States from almost the very beginning of the automobile era, but such vehicles never played an important part in motor vehicle sales or registrations in this country until 1956, when imports jumped to 108,000 vehicles from a level of 57,000 in the previous year. In 1957 the number imported more than doubled, with 259,000 being reported for that year, increasing to 431,000 in 1958 and to 668,000 in 1959 (*3*, Table 736, p. 559). By 1957 the imported car was no longer a rich man's plaything, but had become a source of economical transportation that has become popular for various reasons.

By 1958 domestic automobile producers began to see what appeared to be a revolt on the part of an important segment of the American car-buying public against certain characteristics of the domestically manufactured products. Two "independent" American car makers made an active bid for this market, and in 1958 produced and sold about 200,000 vehicles of such sizes and price ranges that they became known as "American compacts." In 1959 these same makers sold about 500,000 of these vehicles, and were joined late that year by all of the "Big Three" automobile manufacturing firms, which together sold more than 125,000 "compact" vehicles during that year. In all, more than 625,000 American-made compacts were sold during 1959. These accounted for nearly 12.5 percent of the total sales of new American-made automobiles in that year.

(For statistical purposes the Bureau of Public Roads classifies passenger cars into three groups on the basis of shipping weight, over-all length, wheelbase, and horsepower: Standard, compact, and small vehicles. "Compacts" generally fall within the weight range of 2,000 to 3,000 lb, over-all lengths from 156 to 200 in., wheelbase not over 112 in., and brake horsepower not over 130. A "point system" is used to determine whether vehicles that exceed one or more of these limits shall be classified as "standard" or "compact" vehicles.)

Introduction of the American compacts had an immediate effect on the importation of foreign-made automobiles, which in 1960 dropped by almost one-third from the previous high of 668,000 vehicles to somewhere in the neighborhood of 400,000. Recent trade reports have indicated proportionally larger declines in the sales of all but a few of the imported makes. Preliminary estimates indicate that at the end of 1960 dealers in imported automobiles had in the neighborhood of 120,000 vehicles on hand. Unless this situation is cleared up shortly by some means such as drastic price reductions or the introduction of new models, it seems likely that the sales of imported automobiles will continue to decline during the next few years, both numerically and in proportion to total.

Early reports on domestic production during 1960 indicate that ap-

proximately 6.7 millon automobiles were manufactured, of which 1.9 million, or 29.0 percent, were compacts. As a result, although 1960 appears to have set the second highest mark for total domestic automobile production, manufacture of the so-called "standard" 6- and 8-cylinder cars fell from approximately 4.8 million in 1959 to something over 4.6 million in 1960.

This situation has, understandably, become a matter of concern to many, including not only automobile manufacturers and dealers and manufacturers and sellers of motor fuel, tires, and other accessories, but also tax administrators and others concerned about future income for the support of highways. Hufnagel and Magill (*6*) estimated that the proportion of total domestic automobile production accounted for by compacts will increase steadily through 1963, when such vehicles may be expected to account for about 50 percent of total production, and will then level off. They also estimated that from 1960 through 1965 United States automobile production should average approximately 6.25 million vehicles per year, which, in view of recent production and scrappage levels, appears to be reasonable. However, they predicted that by 1965 the level of domestic production would be just under 7 million vehicles, of which about 3.75 million would be the "economy compacts." They also estimated that by 1965, 70 percent, or 51,350,000, of the 72,750,000 vehicles then expected to be registered, would be of the "standard" domestic type, whereas 17,650,000, or 25 percent, would be of the domestic "compact" vehicle types. They estimated that the remaining 3,750,000, or 5 percent of the vehicles registered, would be imports. With as little as is now available to go on in predicting what the future composition of the American passenger car universe will be, these speculative estimates appear to be reasonable.

Changes in Density of Car Ownership

It is sometimes argued that the availability of American compacts and foreign imports will act together to decrease the proportion of households owning no automobiles, and to increase the proportion owning two or more automobiles. This may occur; if it does, it will tend to decrease the dampening effects, especially on fuel consumption and taxation, of a greater number of economy automobiles in future registrations. However, the information available at present is not sufficient to provide any reliable indication of what is going to happen. Data obtained in motor vehicle use studies conducted in 22 States with Bureau of Public Roads cooperation between 1951 and 1957 indicated that 30.1 percent of all the households interviewed in all population groups, rural and urban, reported no automobiles owned. A nationwide automobile use study, conducted by the Bureau of the Census for the Bureau of Public Roads in 1959 (the results of which have not yet been published), indicated that 27.6 percent of 3,845 households studied reported no automobiles owned. The possibility that these two percentages, independently determined, may indicate a trend is shown in figures published by the Automobile Manufacturers Association (*7*), quoting the "Survey of Consumer Finances" of the Federal Reserve Board and the Survey Research Center of the University of Michigan as the sources, indicated that in 1951 65 percent of U. S. families reported owning automobiles, whereas by 1956 this percentage had increased to 73 percent, and to 74 percent by 1959 (*7*, p. 33).

Information summarized from the 22 motor vehicle use studies previously referred to indicated that 58.9

percent of the households interviewed had one automobile, 10.1 percent had two, and 0.9 percent had three or more. The Census automobile use study cited previously reported single-car ownership at 57.5 percent of the households, two-car ownership at 13.6 percent, and ownership of three cars or more at 1.3 percent. To give further substantiation to the apparent increase in multicar ownership, the Automobile Manufacturers Association (*7*, p. 35) cites statistics to indicate that multicar households had increased by 67 percent from 1954 through 1959—from 8.8 of all households in the former year to 13.5 in the latter.

Both the Census auto use study and the AMA publication (*7*) indicate that the rate of multicar ownership is heavier in the households reporting larger incomes, as might be expected. Thus, the Census auto use study findings indicate that households with incomes under $1,000 per year account for 22.7 percent of the households owning no automobiles, only 3.7 percent of those owning one automobile, and only about 1.4 percent of those owning two or more. On the other hand, households with incomes of $10,000 or more account for only 1.2 percent of the nonownership families; 4.9 percent of the one-car families; and 21.1 percent of the multicar families. The AMA publication (*7*, p. 35) also cites statistics to the effect that although only 20.6 percent of the households living in metropolitan area suburbs own more than one automobile, they account for 42.3 percent of the total multicar households.

Effects of Changes in Age Distribution of Population

Although it is commonly expected that the proportion of total population to be found in the often-cited "driving ages" of 15 to 74 years will increase appreciably between 1961 and 1976, it is generally expected that the proportion of drivers to total population will continue to increase even more rapidly for several years. This can be deduced from Figures 1

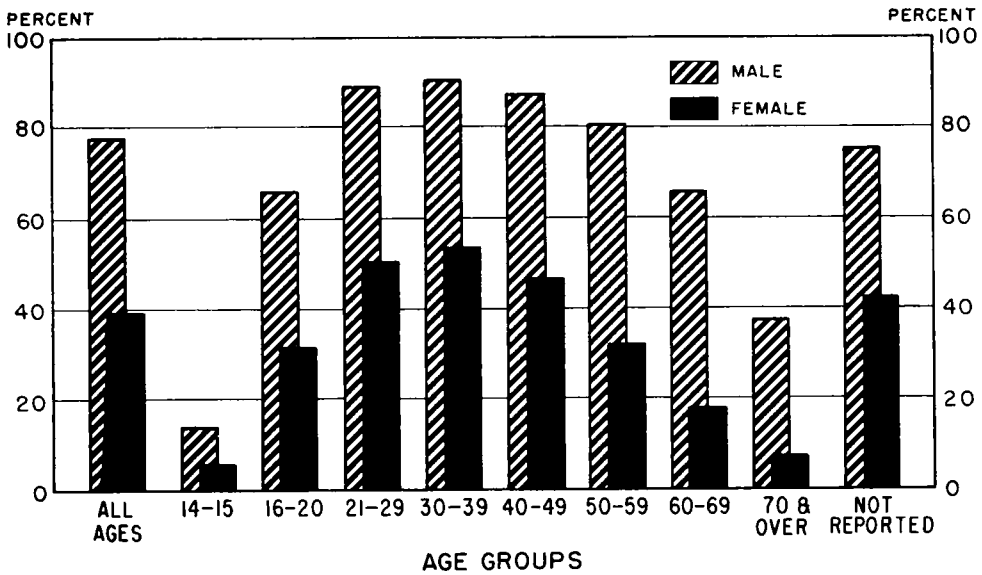

Figure 1. Proportion of total population in each age-sex group licensed as motor vehicle operators, for all places of residence, 19 States.

and 2, which were developed from information obtained in motor vehicle use studies made from 1951 through 1956 in 19 States.

Figure 1 indicates the proportion of males and females in each of several age groupings who were licensed as motor vehicle operators at the time of the study. It may be observed that about 90 percent of the males and more than 50 percent of the females in the 30-39 age group were licensed to drive, and that this was the highest incidence of licensed drivers to total population in any group. Beyond that age group the percentages of persons holding motor vehicle operator licenses declines rather rapidly, especially in the case of the females. However, it has been generally concluded that one reason for this rapid drop in the proportion of persons holding motor vehicle operator licenses in the older age groups is that many of these people, especially the women, never did learn to drive.

In substantiation of this contention, it may be pointed out that nearly 70 percent of the males and about 30 percent of the females in the 16-20 age group, the youngest group permitted to drive in most States, are already licensed as motor vehicle operators. For males this percentage is almost identical with that of the 60-69 age group; for females it is almost identical with that of the 50-59 age group. It is reasonable to believe that by the time they are 30 to 39 years old more than 90 percent of the males and about 60 percent of the females in this group will be licensed to drive.

By then, those who were in the 30-39 age group will have reached the 50-59 age group. It is considered likely that few persons physically capable of driving will have voluntarily surrendered their licenses to do so by that time. Thus, it seems reasonable to believe that over the next 15 to 20 years the number of licensed drivers can be expected to increase materially, even without any corresponding increase in the proportion of persons in those age groups to total population.

Figure 2, which indicates the distribution of licensed motor vehicle operators by age and sex groups as it existed at the time the motor vehicle use studies were made in the 19 States, would be considerably flattened if this situation materializes.

CHARACTERISTICS OF MOTOR VEHICLE USE

Estimates of Travel Volume

In the past it has been possible to estimate the over-all magnitude of motor vehicle travel by several means, none of which is completely satisfactory and some of which are open to serious question on theoretical grounds. For more than 25 years the planning divisions of most of the State highway departments have been making "density" and "classification" counts of traffic on the highways and streets within their boundaries. Because of the excellence of the procedures employed, the length of time that the program has been in effect, and the number of counts made, the estimates of total travel on rural primary highways are generally regarded as being very good indeed. The same can be said for urban extensions of primary highways and other important city arterials in some States, but, unfortunately, not all. However, as one goes down the scale of traffic importance of the various highway systems, the estimates of total travel on each system become less and less reliable, largely because the greatly increased mileages and decreased densities of traffic make it extremely costly *in toto* and on a unit basis to obtain adequate information on these highways and streets.

Estimates of over-all travel within a State can also be obtained from sources, such as motor vehicle use studies and statewide origin and des-

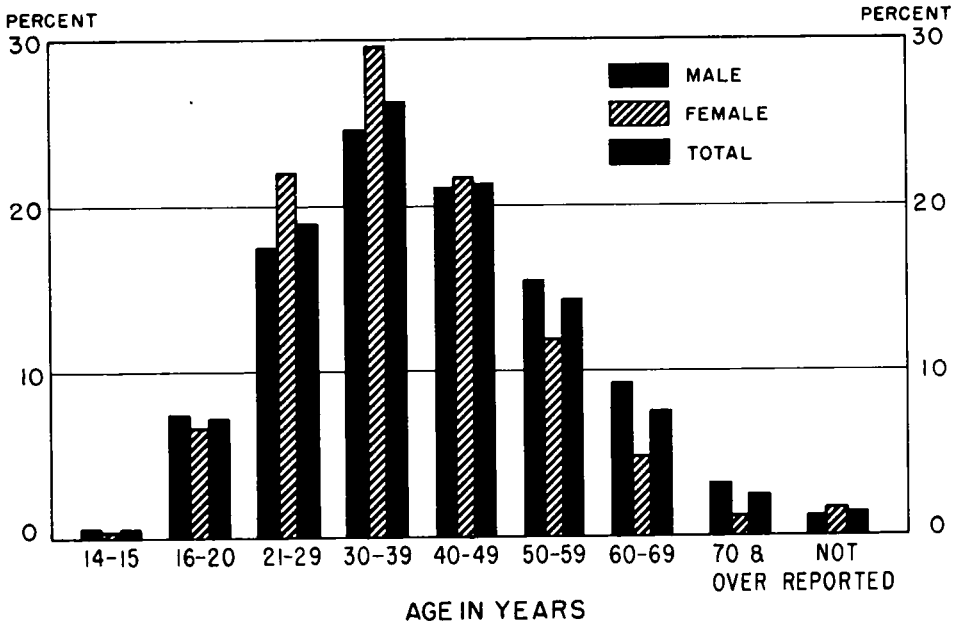

Figure 2. Age distribution of licensed motor vehicle operators for each sex group, for all places of residence, 19 States.

tination studies, which are based on carefully selected interview samples. A third method of estimating total travel that is frequently used is to project total travel within a State as a function of fuel consumption, on the assumption that total highway use of motor fuel is rather accurately known by virtue of the official records kept of taxed gallonage, and that the average rate of fuel consumption for all motor vehicles combined can be accurately estimated. A combination method of estimating travel by systems that is sometimes employed involves estimating total travel in a State on the basis of fuel consumption, then subtracting from it successive estimates of travel on primary and secondary rural and urban highways based upon traffic counts, with the remainder being considered as travel on local or land-service roads and streets.

Estimates of statewide total travel, travel by systems, or travel within specified areas derived by the processes just described have frequently been compared with similar information obtained in motor vehicle use or origin and destination studies. In general, such comparisons have shown the estimates derived from motor vehicle use or origin and destination sources to be considerably below those derived from the other sources, the differences being almost always greatest proportionally on secondary and local roads and streets. Because of incomplete recall on the part of persons interviewed in such interview-type studies as motor vehicle use and origin and destination, a certain amount of understatement—usually considered to be in the neighborhood of 10 to 15 percent—is to be expected. These and other known weaknesses of such sampling studies can be more or less overcome by the application of accepted sta-

tistical procedures. Even when these are applied, however, the adjusted estimates obtained for the secondary and local roads are frequently considerably below the estimates for those systems obtained by the other recognized methods of calculating traffic. This has frequently led to summary dismissal of travel estimates obtained from the interview-type studies.

Recent Studies Have Facilitated Further Analyses

On the other hand, some researchers have begun to question whether estimates of travel on secondary and local roads and streets derived from exceedingly small traffic count samples, or by subtraction from statewide estimates of total travel derived from motor fuel consumption, are, after all, any more reliable than those obtained from the interview-type studies. Within the past decade, especially since passage of the Federal-Aid Highway Act of 1956, all of the States have had one or more occasions to estimate both current and future travel on the various classes of highways and streets within their boundaries—for the Highway Cost Allocation Study, for Statewide long-range highway needs studies, and for day-to-day planning and administrative purposes. Although the methods employed in making these estimates were, in general, those previously used in the individual States in making similar estimates, the new ones were made with greater care, more uniformity, and in more detail than had been customary in the past.

The availability of this information for all States at one time, and covering approximately the same period, provided an ideal opportunity for taking a broad look at the estimates of travel on local or land-service roads and streets than had been possible before. Although differences in the administrative classification among the States of highways and streets introduce difficulties in making meaningful comparisons, such comparisons are believed to be worthwhile.

Calculations of the average daily traffic estimated for local rural roads for the 48 contiguous States (the District of Columbia has no highways classed as rural) were prepared from summaries of recent reports. These revealed the following distribution:

Average Traffic Density (veh/day)	No. of States
1—25	9
26—50	19
51—75	5
76—100	2
101—150	3
151—200	3
201—250	3
251—300	1
301 and over	3

It may be observed that 19 of the States estimated their average daily traffic on local rural roads at between 26 and 50 vehicles per day, whereas 9 estimated such traffic as less than 25 vehicles per day. On the other hand, 13 States estimated average daily traffic on such roads at more than 100 vehicles per day. As might be expected, the most urban States fell within the last category. On the other hand, three States having extensive areas of relatively low population density reported local-road traffic densities of between 100 and 150 vehicles per day.

The extreme range in reported densities was from 3 vehicles per day in Nevada to 666 in New Jersey. Several groups of contiguous States having many similar characteristics (such as the extent of the local road systems, or density of population in rural areas) exhibited unexplained differences in the average densities of traffic reported.

Because travel on local or land-service roads is composed almost ex-

clusively of traffic either originating or terminating on the road sections under consideration, the density of travel on any given section can be expected to be directly related to the number of farms, other dwelling units, commercial establishments, industries, schools, or other places of traffic generation having direct access to it. Therefore, it is hardly likely that land-service roads in sparsely settled rural areas, such as are commonly found in the Midwest and Far West, can be expected to carry very heavy traffic. Another factor that requires consideration is the nature of the local road network existing in any given State. Thus, a State where the rural roads are laid out on the rectangular grid pattern would be likely to exhibit less average traffic density on its local rural roads than would a State where the roads follow the terrain, as is more common in the East, because in the latter case the road mileage per square mile of area is considerably less. Finally, as mentioned previously, differences in road system classification must also be reckoned with. Thus, incorporation of a relatively larger percentage of total road mileage into a secondary or feeder system would tend to reduce the average density of travel on the remaining land-service roads.

A similar analysis of the information reported for local streets in the 48 States and the District of Columbia produced the following results:

Average Traffic Density (veh/day)	No. of States
1— 250	0
251— 500	7
501— 750	11
751—1,000	10
1,001—1,250	5
1,251—1,500	5
1,501—1,750	5
1,751—2,000	3
2,001 and over	3

In this case a much flatter distribution is evident, with 28 of the jurisdictions indicating average travel between 250 and 1,000 vehicles per day. Surprisingly, no State reported information which indicated average daily traffic on local city streets of less than 250 vehicles per day, whereas three indicated average travel on local city streets in excess of 2,000 vehicles per day.

Although there was some evidence of patterns in the distribution—most of the more urban States showed relatively higher densities; most of the predominantly rural States exhibited relatively lower densities — there were enough departures from such a distribution to cast some doubt upon it. This raises a possible question of definition: Were there significant differences in what is classed as a "local" street from one State to another?

Differences among the States in such factors as terrain, population density, land use, and road-system classification are of such magnitude that it cannot be inferred, *per se*, that any of the reported estimates of travel on local rural roads or local city streets referred to above are wrong. However, it is believed that the wide ranges of average densities calculated, and some of the inconsistencies noted among adjoining States, indicate clearly the need for further careful study of this whole matter of estimating travel on local roads and streets.

New Data on Fuel Consumption Characteristics

Closely related to this problem of estimating total motor vehicle travel is that of determining rates of motor fuel consumption on the highways. It has been recognized for several years by most highway researchers that increasing urbanization, the use of automatic transmissions, increasing operating weights of vehicles,

larger engines in passenger cars, and higher average road speeds are tending to increase fuel consumption rates, although they are countered somewhat by greater engine and fuel efficiency. The Bureau of Public Roads has given recognition to this trend in a series of published tables showing classified estimates of travel by motor vehicles in the United States for calendar years from 1954 up to the present. Thus, for the 1954 table the average inverse rate of fuel consumption for passenger cars and taxicabs was taken at 14.58 miles per gallon, for all buses combined at 5.84 mpg, for trucks and combinations at 8.44 mpg, and for all vehicles combined at 12.69 mpg. For 1959, comparable averages used were 14.30, 5.27, 7.96, and 12.43, respectively. For the third progress report of the Highway Cost Allocation Study, a miles-per-gallon figure of 15.1, derived from motor vehicle use study sources, was used for all private passenger cars (excluding taxicabs and commercially operated passenger cars) (*8*).

The Highway Cost Allocation Study staff was not satisfied with information it had available about passenger car rates of fuel consumption. There was a general feeling that changes brought about by the trends previously noted, augmented by the introduction of large numbers of small imported cars and the impact of the new American compact automobiles, which was just beginning to be felt, rendered undesirable a continued use for forecast purposes of averages based on data obtained in the past. Accordingly, arrangements were made with several of the State highway departments, widely distributed throughout the 48 contiguous States, to obtain fuel consumption data on the operation of private passenger cars owned by highway department employees. Some Bureau of Public Roads field employees also participated. These studies were begun in the late fall and early winter of 1959-1960, and are continuing up to the present in some instances. It is recognized that this sample of vehicle owners may be somewhat lacking in representativeness of the automobile-owning population, because it includes neither extreme of the income distribution scale. However, the approximately 16,000 records tabulated appear to include a good cross-section of rural and urban drivers, and of vehicle makes and year models.

Although no formal report has yet been prepared on these studies, preliminary analyses have been made of some of the data received. Reports on 3,576 automobiles operated during the winter of 1959-1960 indicated an average rate of fuel consumption of 12.9 miles per gallon; reports on 3,755 vehicles operated in the spring of 1960 indicated an average of 13.6 mpg; and reports on 990 vehicles operated in the summer of 1960 yielded an average of 14.5 mpg. Each of these summaries involves vehicles from several States. A preliminary report from one State on operations during the autumn of 1959 indicated that 205 vehicles averaged 13.0 mpg. It is still too early to make any accurate estimate of what the average rate of fuel consumption for an entire year will be, but it seems, on the basis of the returns received to date, that the average miles-per-gallon (inverse) rate will be appreciably lower than that recently being used.

A summary of fuel consumption rates by type of passenger car prepared by the Illinois Division of Highways from fuel consumption study data is of interest. Information on 49 foreign-made vehicles operated during the winter of 1959-1960 and 39 operated in the spring of 1960 indicated average fuel consumption rates of 25.1 and 26.4 mpg, respectively. Furthermore, reports on the operation of 57 American compacts

during the winter season and 67 during the spring season produced average fuel consumption rates of 17.3 and 18.5 mpg, respectively. Reports on 2,159 "other American" cars operated during the winter season and 1,973 operated during the spring season resulted in fuel consumption rates of 13.1 and 13.6 mpg, respectively. The consolidated fuel consumption figures for all vehicles in the two samples were 13.4 mpg for the winter season and 13.9 mpg for the spring season. It must be recognized, of course, that the percentage of American compacts to total in this sample (approximately 3 percent) is considerably less than will probably be found in the registration universe in the very near future; this certainly will have some effect in reducing fuel consumption (that is, increasing the miles-per-gallon rate). Information submitted up to the present by other States participating in the fuel consumption studies generally corresponds closely to the results obtained in Illinois.

In these studies an attempt also was made to determine the probable effect of restricted driving (that is, driving in areas where speed limits were restricted and traffic congestion was likely to be encountered) on rates of fuel consumption. The preliminary findings of the Illinois study are illuminating in this respect. The over-all average for all of the passenger cars in the study was approximately 13.7 mpg. For 183 vehicles operated under conditions where less than 10 percent of the driving was in restricted areas, the average rate of fuel consumption was 15.0 mpg. On the other hand, for 210 vehicles operated under conditions where from 90 to 100 percent of the travel was under restricted driving conditions, the average rate of fuel consumption was 12.3 mpg. A consistent trend in rates of fuel consumption was evident for vehicles operating at the various levels of restriction between these two extremes. Information obtained in other States shows similar trends.

Other analyses of the fuel consumption study data now in progress give strong support to the following conclusions:

1. Under conditions of normal operation and maintenance the age of an automobile alone appears to have little effect on its fuel consumption rate.

2. Under average operating conditions a passenger car equipped with an automatic transmission will consume gasoline at a rate appreciably greater than will a similar vehicle equipped with a manual transmission. Thus, about 5,300 reports on standard light American passenger cars equipped with manual transmissions indicated an average fuel consumption rate of 15.4 mpg, whereas 4,600 reports on similar vehicles equipped with automatic transmissions indicated an average fuel consumption rate of 13.9 mpg.

3. A trend toward larger engines in the "compact" automobiles will considerably erode their fuel economy advantage over the "standard" light passenger cars. Thus, reports on 141 compact automobiles equipped with 6-cylinder engines and automatic transmission indicated an average fuel consumption rate of 17.9 mpg, whereas 886 comparably equipped standard light automobiles yielded an average rate of 14.7 mpg. However, 36 reports on compacts equipped with 8-cylinder engines and automatic transmissions averaged only 14.3 mpg, while 2,951 standard light passenger cars comparably equipped averaged 13.7 mpg.

CHANGING CHARACTER OF MOTOR VEHICLES

Since the close of World War II the shape, size, weight, and horsepower of American automobles have changed dramatically. Changes have also taken place in buses, trucks, and truck tractors, but not as spectacularly. All of these changes have had their effects on the highway plant, both physically and financially. The past effects have been evaluated; the question is, what of the future?

The possible effects of future changes in bus, truck, and truck tractor design have not seemed to cause undue concern among highway engineers and administrators, probably because technological changes have occurred rather slowly and maximum vehicle size and weight are regulated closely in most States. Furthermore, the market for these vehicles has not exhibited the "faddish" tendencies that have characterized the passenger car market in recent years.

Table 1 may give some light on what may be expected in the near future in American automobiles. From such data it may be possible to draw conclusions about what effects these trends in automobile design can be expected to have on highway user tax revenues, as follows:

1. The "standard" light passenger cars of 1940 and 1950 were in many respects far more similar to today's "compacts" than to their modern "counterparts."

2. In the past manufacturers frequently offered smaller, lighter, or stripped-down automobiles to make their lines more competitive in price, or economy, or both, with other makes. (Examples were the Ford 6, Nash Lafayette, Hudson 6 Traveler, and Studebaker Champion.) Although today's compacts appear to have captured the public fancy more than most of those cars did, the introduction of such vehicles is really not unique.

3. When the compacts were introduced much stress was laid on the economy of their operation. The tendency in 1961 seems to be toward de-emphasis of the economy aspects. In several instances either horsepower was increased over the 1960 models or new more powerful engines were made available (for example, Comet, Rambler Classic 6, Studebaker Lark 6). Furthermore, except for the Dodge Lancer all of the new compacts introduced in 1961 have new, relatively large engines with higher horsepower, and evident capabilities for horsepower increases.

It seems doubtful that compact automobiles will reach nearly 40 percent of 1961 American passenger car production, as predicted by Hufnagel and Magill (*6*, p. 5). However, should this occur, the presence in this total of several thousand of the new "luxury" compacts, coupled with a decline in the sales of certain "economy" compacts, may not produce the adverse effects on fuel consumption and fuel tax revenues expected immediately in some quarters. Cope (*9*) said:

> . . . by making certain assumptions, we have concluded that for each 10 percent of the total number of automobiles registered that are compact/economy cars, motor fuel tax revenues will be decreased by perhaps 2 percent. This means that when or if compact/economy vehicles constitute 30 percent of the automobiles in use, total motor fuel consumption will be . . . 6 percent less than it would have been had all the cars in use been "standard" vehicles.

Such is not likely to occur before 1965 or 1966; in the meantime, drastic changes could occur in the character of vehicles in use. Highway economists and financial planners should not fail to collect and analyze quickly and carefully the data needed to keep them informed of what is happening in these areas.

TABLE 1

SPECIFICATIONS[a] OF SELECTED STANDARD-SIZE LIGHT AND AMERICAN COMPACT AUTOMOBILES; 1940, 1950, 1960 AND 1961

Automobile			Length[b] (in.)	Wheelbase[b] (in.)	Height[b] (in.)	Width[b] (in.)	Shipping Weight (lb)	Cylinders	Brake Horsepower	Displacement (cu in.)
Class	Make	Year								
Std. size, light 4-door sedan	Chevrolet	1940	192	113	67	—	2,960	6	85	216
		1950	198	115	66	74	3,120	6	92	217
		1960	211	119	56	81	3,545	6[c]	135[c]	236[c]
		1961	210	119	56	78	3,505	6[c]	135[c]	236[c]
	Ford	1940	191	112	67	—	2,850[d]	8[e]	85[e]	221[e]
		1950	197	114	65	73	3,030	8	100	239
		1960	214	119	55	82	3,556	8[f]	185[f]	292[f]
		1961	210	119	55	80	3,683	8[g]	175[g]	292[g]
	Plymouth	1940	194	117	68	—	2,924	6	84	201
		1950	193	119	—	74	3,062	6	97	218
		1960	209	118	55	79	3,520	6[h]	145[h]	225[h]
		1961	209	118	55	80	3,465	6[i]	145[i]	225[i]
	Nash	1940	199	117	70	—	3,275	6	99	235
		1950	201	112	63	78	2,965	6	85	184
	Studebaker	1940	189	110	65	—	2,365	6	78	164
	Champion	1950	197	113	61	70	2,750	6	85	170
American Compact	Comet	1960	195	114	55	70	2,432	6	90	144
		1961	195	114	55	70	2,411[d]	6	85	144
							2,600[d]	6	101	170
	Corvair	1960	180	108	51	67	2,375	6	80	140
		1961	180	108	52	67	2,355	6	80	145
	Ford Falcon	1960	181	110	54	70	2,288	6	90	144
		1961	182	110	54	71	2,289	6	85	144
	Rambler American	1960	178	100	57	73	2,469	6	90	196
		1961	173	100	56	70	2,520	6	90	196
	Rambler Classic	1960	190	108	57	72	2,948	6	90	196
							3,282	8	200	250
		1961	190	108	57	72	2,950	6	127	196
							3,290	8	200	250
	Studebaker Lark	1960	175	108	58	71	2,605	6	90	170
							2,924	8	180	259
		1961	175	108	56	71	2,665	6	112	170
							2,941	8	180	259
	Plymouth Valiant	1960	184	106	53	70	2,635	6	101	170
		1961	184	106	53	70	2,590	6	101	170
	Buick Special	1961	188	112	53	71	2,632	8	155	215
	Dodge Lancer	1961	189	106	53	72	2,595	6	101	170
	Oldsmobile F-85	1961	188	112	53	72	2,695	8	155	215
	Pontiac Tempest	1961	189	112	54	72	2,800	4	110	194

[a] Sources: 1940—*Motor*, Annual Show Number (Oct. 1939); 1950—*Automotive Industries*, Statistical Issue (Mar. 15, 1950); 1960—*Automotive News*, 1960 Almanac (Apr. 25, 1960); 1961—*Motor Magazine* (July 1961).
[b] All dimensions given to nearest inch.
[c] 8-cyl. engines at 170 and 250 BHP also available, with displacements of 283 and 348 cu in., respectively.
[d] Approximate.
[e] 6-cyl. 60-hp engine also available with 136-cu in. displacement.
[f] 6-cyl. 145-hp engine and two higher-powered 8-cyl. engines also available.
[g] 6-cyl. 135-hp engine with 223-cu in. displacement, and larger higher-powered 8-cyl. engines also available.
[h] 8-cyl. 230-hp engine also available with 318-cu in. displacement.
[i] Two V-8 engines available at 230 and 305 hp with displacements of 318 and 361 cu in., respectively.

IMPLICATIONS OF CHANGING TRENDS IN CHARACTERISTICS OF VEHICLE OWNERSHIP AND USE

It seems abundantly clear from the material discussed in this paper that the present is no time to rest in investigation of characteristics of motor vehicle ownership and use. Changing conditions in the age composition and geographic distribution of population, changes in economic status, changes in the character of the vehicles using the highways, and changes in the manner in which these vehicles are operated, all work together to bring into question the previously held concepts of what the characteristics of motor vehicle ownership and use are. Studies made between 1935 and 1940 and studies made shortly after the close of World War II showed remarkably similar conditions. But changes which have occurred in the last ten years—and particularly changes now occurring—appear to throw into question all of our previous knowledge of the subject.

Areas that should be investigated further include the travel habits of multicar households with the aim of obtaining answers to such questions as: For what purpose are the various cars used? By whom are they driven? and What is the annual mileage per vehicle and the total miles for the household? It may be found that because of the increasing number of multicar households it may become desirable to make further investigations into motor vehicle travel per capita, rather than concentrating on travel per vehicle as has been done mainly in the past. In years gone by the studies of travel per capita have not been particularly rewarding. However, with the changes in the characteristics of motor vehicle ownership and use that are now taking place, it may be found that such averages will be more indicative than those based on vehicles alone.

Further attention also should be given to the characteristics of ownership and use of motor vehicles in the larger urbanized areas, especially the suburban areas of the largest cities.

The types of study now in use may be sufficient, perhaps with some modification, to obtain the further information required by the physical and financial planning of the highway systems. However, careful study should be given to the possibilities of developing newer, better, and perhaps cheaper ways of obtaining such data.

Such knowledge has far more than academic value. It is important that better be done now than has ever been done before in estimating future traffic loads so that the highways will be better designed to meet the demands of the years ahead. Furthermore, types of vehicles using the highways, the extent of their use, and the rate at which they will consume motor fuel, are going to be important factors not only to the industries which produce vehicles, tires, parts, and fuel, but also to the government agencies responsible for the administration of the highway function. Changes in rates of fuel consumption and in total travel, for example, can produce important changes in the income from taxes imposed on the highway use of motor fuel. Furthermore, changes in the average weight of vehicles using the highways can produce important effects on income from vehicle registration taxes, especially in certain States.

Thus, it becomes essential that highway planners and administrators be particularly careful in the years immediately ahead to avoid continued use of incorrect or outdated information; that they use extreme care in making forecasts of the future demands for highways and highway services that may be based on similar information; and that they institute new research, possibly along

lines currently contemplated or suggested herein, that will produce accurate and up-to-date information in these most critical areas.

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