Impact of Industrial Development on Traffic Generation in Rural Areas of North Carolina

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• THE CHANGING character of rural North Carolina in recent years has produced new problems for rural traffic planners. Increasing industrial employment of rural dwellers and a general rise in vehicle ownership by such persons have brought new functions and added new traffic to rural secondary roads. Routes that once carried primarily farm-to-market traffic now have a large percentage of industrial work trips. It is the task of the traffic planner of today to evaluate and predict traffic trends in order to plan adequately for future road needs.

To understand the importance of the home-to-work trip, one need only imagine how many people work in North Carolina and how these people get to work. The State Highway Commission in North Carolina has complete responsibility for the maintenance and improvement of 13,000 miles of primary highway and 57,000 miles of secondary road that provide service to nearly 3 million rural inhabitants. Travel on North Carolina highways has nearly tripled during the past 15 years and now totals approximately 17 billion vehicle-miles per year. The home-to-work or work-to-home trip amounts to approximately 27 percent of the trips made and 38 percent of the mileage traveled by the rural inhabitants of North Carolina.

There are significant reasons for the extensive system of secondary roads in North Carolina. Economically, the State has always been dependent on agriculture. Only in recent years has industrial development begun to make inroads into the economic structure of the State.

During the past decade nearly 2,000 new industries began operation in North Carolina and the expanded use and ownership of the automobile have provided the major mode of travel for extensive growth and development of residential, commercial, and industrial areas.

Even though North Carolina has become more and more industrialized and the cities have continued to expand, the majority of the State remains rural. In 1950, 66 percent of the State's population was classified by the Bureau of the Census as rural, compared with 51 percent in the South and 36 percent for the nation. The rural population in North Carolina is growing almost as fast as the urban population, inasmuch as so many nonfarm families are electing to live in the uncrowded rural areas surrounding the major cities. During 1958, when a total of 180 new industries began operation in the State, 26 percent of these industries located in rural areas.

The demand for new and improved roads in rural areas is increasing faster than the roads can be built. Because the rural population is much more dispersed than the urban population, more individual persons tend to drive to work, putting many additional vehicles on the roads during the peak traffic hours. The superimposed graph of the growth in industrial employment and motor vehicles in Figure 1 shows the paralleling growth of industrialization and the number of motor vehicles. Also, one-third of the State's population residing in rural areas now consists of nonfarmers. Figure 2 shows the general economic and geographical areas of the State.

In June 1958 the Department of Engineering Research at North Carolina State College began work on a statewide rural traffic generation study with the following objectives: (a) to investigate and interpret the characteristics of traffic generated in open rural areas of North Carolina and (b) to investigate and analyze the basic characteristics of traffic generated by manufacturing industries and the relative importance of variables affecting work trips in North Carolina. The project was sponsored

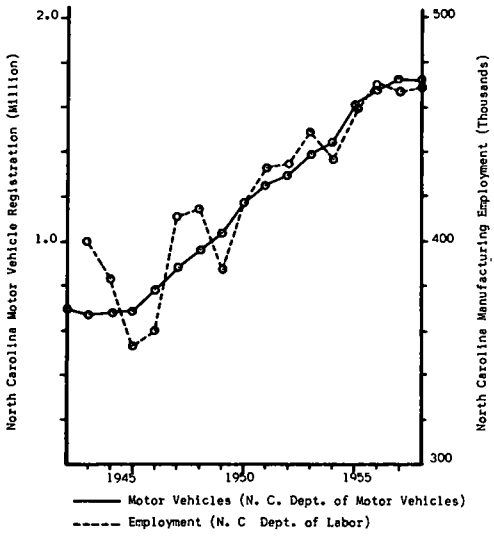

Figure 1. Growth in motor vehicle registration and manufacturing employment.

jointly by the North Carolina State Highway Commission and the U. S. Bureau of Public Roads.

Following a small pilot study from which techniques were determined and refined, a statewide personal interview survey of the occupants of 5,300 rural dwelling units was conducted. Data pertaining to location, date, type of access road, residents, number of vehicles, number of licensed drivers, length of residence, vocation of family, and daily trips by mode, purpose, driver, and length were collected. To facilitate the random selection of dwelling units, highway planning survey maps for the entire State, consisting of 100 counties, were superimposed with ½-mile squares. Each grid square that included a segment of road in a rural area was numbered consecutively in serpentine order. Using only the open rural areas outside city and town limits, a table of random numbers was used to select four samples for each 200 numbered grid squares (Fig. 3). Interviews were conducted in each county during both the summer months and the winter months.

Concurrent with the home interview survey, procedures were developed by which the work trip characteristics of over 44,000 employees of 257 different manufacturing firms were collected. Data pertaining to resident address, living area, race, sex, distance, and mode of travel were collected by providing special forms to each firm for each employee to complete. The firms consisted of twenty types or classifications of industry and eight sizes of industry.

With the combination of data from both the home origins and the industrial work destinations, a multitude of correlations for the travel of rural dwellers were easily obtained with the assistance of punch cards and computer analysis. Tabulated results and plotted relationships filled hundreds of pages; however, a few of the most important relationships are summarized as follows.

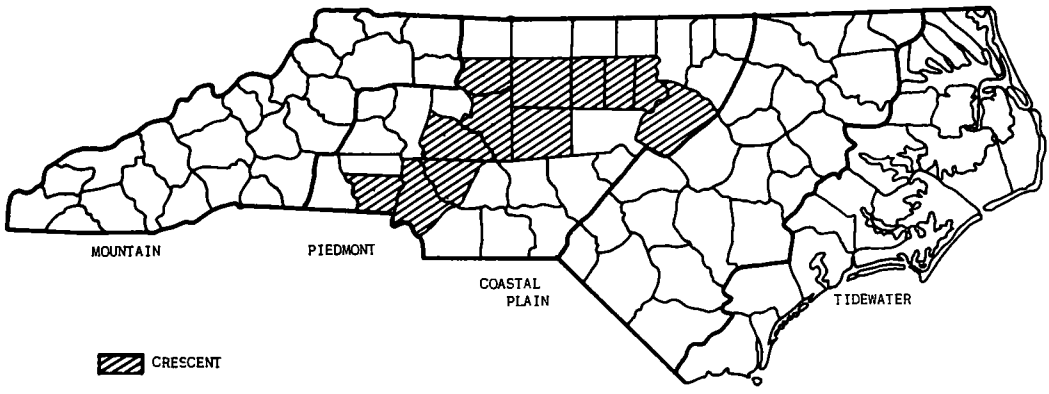

Figure 2. General economic and geographical areas in North Carolina.

Study results indicated that family vocation and race were definitely related to family travel (Table 1). The part-time farm vocational group was the most active in averaging 4.3 trips and 32.8 mi per day. Families that worked only in business or industry were second with 3.5 trips and 28.2 mi per day. In respect to race, white families with 3.6 trips and 25.6 mi per day traveled more than nonwhite families that averaged only 1.5 trips and 9.5 mi per day.

The average length of trip for the entire study was 7.1 mi (Fig. 4). Medical trips were the longest type at 14 mi, whereas shopping trips were shortest, averaging only 3.4 mi in length. Work trips, which accounted for 27.3 percent of the total trips made, averaged 10 mi in length (Fig. 5).

The over-all average numbers of trips and miles per dwelling unit per day were 3.1 and 22.1, respectively.

There seemed to be very little variation in average travel values from one area of the State to another. As previously indicated, however, there was considerable variation between vocations and races. Work trips accounted for a larger percentage of trips in the more industrialized Crescent and Piedmont areas of the State than in the Coastal Plain or Tidewater. In general, shopping trips claimed a large percentage in all areas (22.2 percent statewide).

TABLE 1

TRAVEL AND HOUSEHOLD RATIOS FOR EACH VOCATION GROUP IN EACH AREA OF STATE

State Area	Group	Pers. per DU	Veh. per DU	Trips per DU	Miles per DU	Pers. per Veh.	Trips per Veh.	Miles per Veh.
Tidewater	Farm	4.0	1.1	3.0	18.4	3.6	2.7	16.6
	Part-farm	4.3	1.3	3.8	27.0	3.3	3.0	20.9
	Ind.-bus.	4.5	1.0	2.8	22.5	4.5	2.8	22.9
	Non-work	2.4	0.4	0.8	4.0	5.8	1.9	9.6
	Total	4.1	1.1	2.9	20.2	3.9	2.8	19.1
Coastal Plain	Farm	5 0	1.0	2.7	14.6	5.3	2.9	15.4
	Part-farm	5.0	1.5	4.3	34.5	3.3	2.9	22.9
	Ind.-bus.	4.4	1.2	3.3	27.3	3.8	2.9	23.5
	Non-work	2 8	0.2	0.4	3.3	12.3	1.9	14.7
	Total	4.8	1.1	3.1	21.1	4.4	2.9	19.3
Piedmont	Farm	3.9	1.0	2.4	11.9	4.0	2.4	12.0
	Part-farm	4.6	1.6	4.6	32.4	2.8	2.8	19.8
	Ind.-bus.	4.1	1.3	3.7	28.9	3.1	2.8	21.8
	Non-work	2.4	0.4	0.7	4.5	5.8	1.7	11.1
	Total	4.1	1 3	3.4	23.4	3.2	2.7	18.7
Mountain	Farm	3.6	0.9	1.9	12.2	4.2	2.2	14.2
	Part-farm	4.7	1.5	3.5	31.8	3.1	2.4	21.2
	Ind.-bus.	4.2	1.3	3.2	28.9	3.2	2.4	21.6
	Non-work	2.3	0.3	0.7	4.7	7.1	2.1	14.4
	Total	3.9	1.1	2.6	21.8	3.5	2.3	19.4
Crescent	Farm	3.5	1.1	2.7	12.4	3.2	2.5	11.5
	Part-farm	4.5	1.6	4.6	33.0	2.7	2.8	20.1
	Ind.-bus.	4.1	1 4	3.6	29.4	3.0	2.7	21.5
	Non-work	2.3	0.6	0.7	2.6	4.1	1.2	4.8
	Total	4.0	1.3	3.6	25.4	3.0	2.7	19.1
Statewide	Farm	4.4	1.0	2.5	14.8	4.5	2.6	14.3
	Part-farm	4.7	1.6	4.3	32.8	3.1	2.8	21.2
	Ind.-bus.	4.2	1.3	3.5	28.2	3.3	2.7	22.2
	Non-work	2.4	0.4	0.6	4.3	6.8	1.9	12.1
Total		4.3	1 2	3.1	22.1	3.7	2.7	19.1

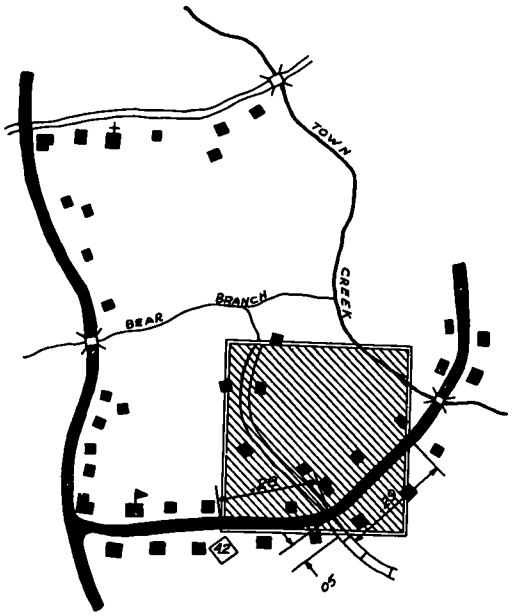

Figure 3. A typical interview section prepared for field use.

Vehicle ownership was largest in the Mountain area, where 88.8 percent of the households interviewed owned one or more motor vehicles. Vehicle ownership was also large in the Crescent (86.6 percent) and the Piedmont (80.0 percent) and was smallest in the Coastal Plain (70.0 percent). Over 92 percent of the part-time farm families owned motor vehicles, as compared to only 68.6 percent for families whose sole occupation was farming. Approximately 78 percent of all families interviewed owned motor vehicles.

Other results of the study revealed that each household interviewed had an average of 1.45 drivers.

Approximately 55 percent of the 5,294 households interviewed in this study had members of the family living at home who worked in business or industry. About two-thirds of these non-farm workers drove to work, whereas 26 percent rode as passengers with someone else driving.

Analyses indicate there is little variation in trip characteristics for rural dwellers in regard to day of the week. However, Monday, Wednesday, and Thursday did experience slightly fewer generated trips per residence than Tuesday and Friday, with all values ranging from 2.91 to 3.48 trips per dwelling unit. There seemed to be some variation in trip generation as to month of the year with values ranging from 2.28 trips per dwelling unit in January to 3.57 trips per dwelling unit in July. This monthly variation is reflected in the seasonal analysis where 2.75 trips per dwelling unit were generated in the winter months and 3.32 trips per dwelling unit were generated in the summer months.

The various agricultural employment classifications seemed to experience considerable differences in trip generation. A low of 0.83 trips per dwelling unit for daywork households and a high of 5.33 trips per dwelling unit for dairy industry households were noted from the collected data. The other classifications had corresponding values generally well dispersed in the upper levels of this range.

There appeared to be no significant difference in trip generation as related to road classification. The data show 3.06 trips per dwelling unit recorded for all paved roads as compared with 3.12 trips per dwelling unit for all unpaved roads. In part, this may be related to the fact that data were gathered only during periods of good weather. However, data were gathered only for the preceding day and therefore there was no assurance that good weather prevailed on that day.

As might be expected, there was definite indication that as the number of licensed drivers residing at a dwelling unit increased there was corresponding increase in the number of trips generated. The values varied from 2.50 trips per dwelling unit for one resident driver to 8.00 trips per dwelling unit for six resident drivers. Also, as the number of drivers increased the number of trips per driver decreased. Values ranging from 2.50 trips per driver for one resident driver households to 1.33 trips per driver for six resident driver households were observed.

An examination of the effect of the number of registered vehicles per residence indicated a similar situation. The trips generated per dwelling unit increased from 3.14 for those residences with one vehicle to 12.00 for those with six vehicles. However, there was a corresponding increase in the number of trips per driver for the same residences with values of 2.13 and 2.77, respectively, being observed.

From the industrial employee data, it was determined that 39.6 percent of all manu-

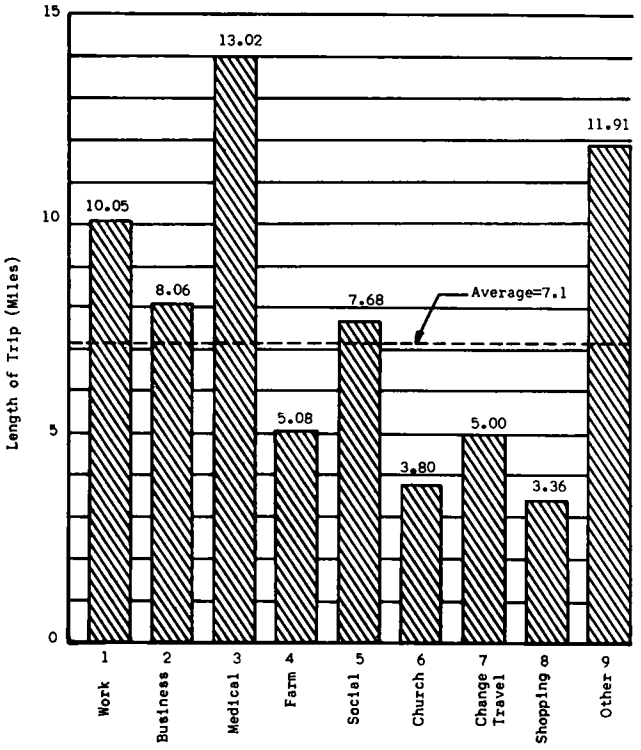

Figure 4. Average length of trip, classified according to purpose, for entire State.

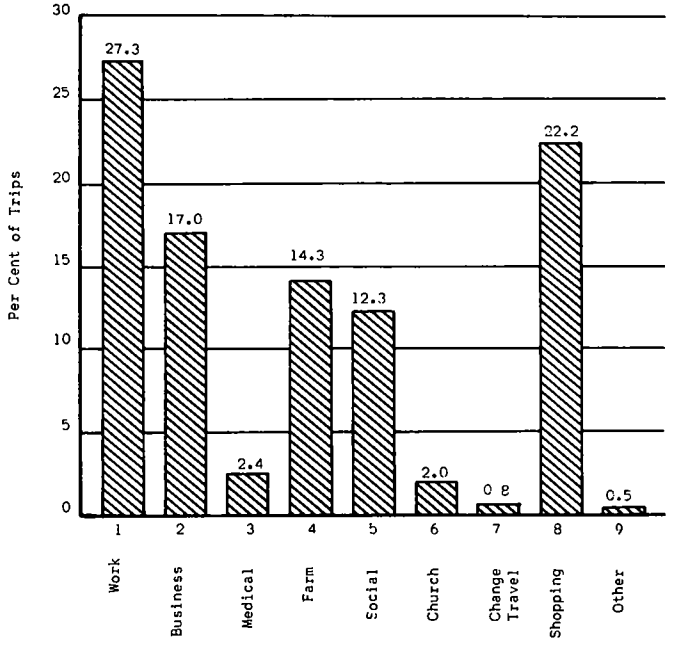

Figure 5. Percentage distribution of trips, classified according to purpose, for entire State.

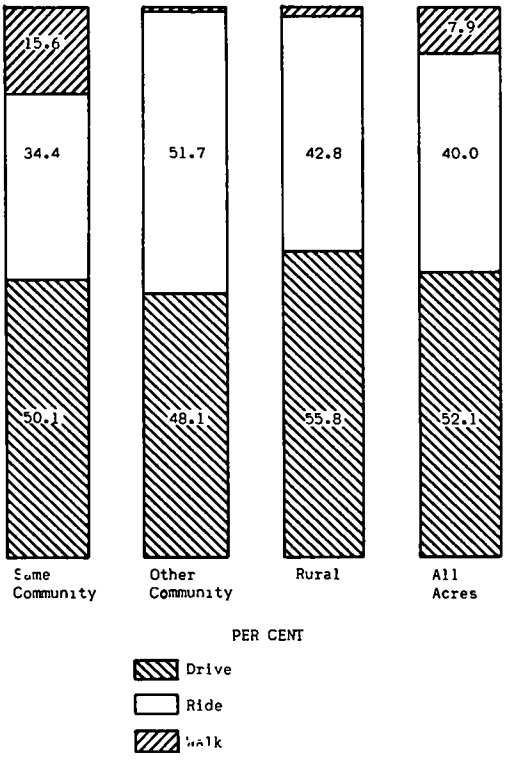

Figure 6. Living area vs mode of travel of employees.

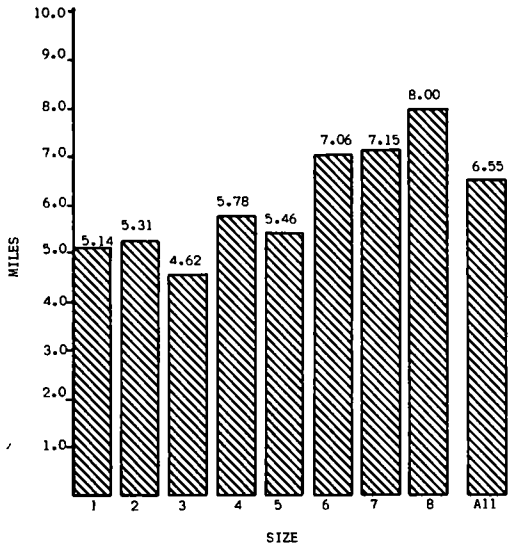

Figure 8. Average length of work trip for all employees vs size of industry.

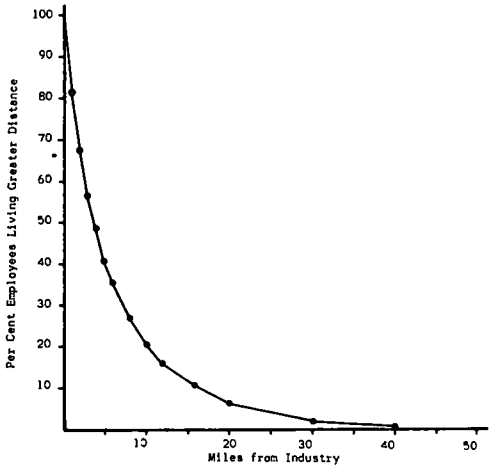

Figure 7. Distance of employee residence from place of employment.

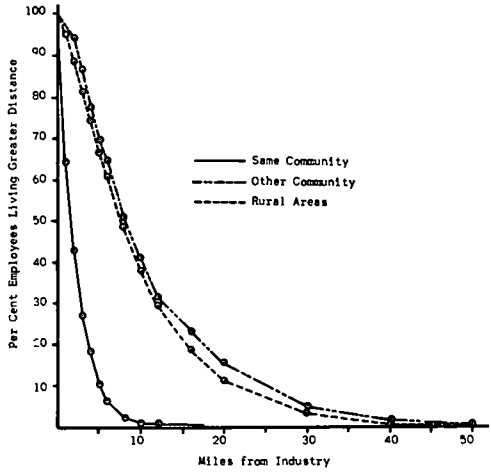

Figure 9. Distance of employee residence from place of employment, by living area.

facturing employees sampled lived in rural areas, and, correspondingly, 60.4 percent lived in urban areas. Of the 60.4 percent urban employees, 46.8 percent lived in the same community as the industry, and 13.6 percent lived in urban communities other than the town in which they worked. The percentage of male employees for all industries sampled was 64.8

Over one-half (52.1 percent) of the employees drove to work, 40.0 percent

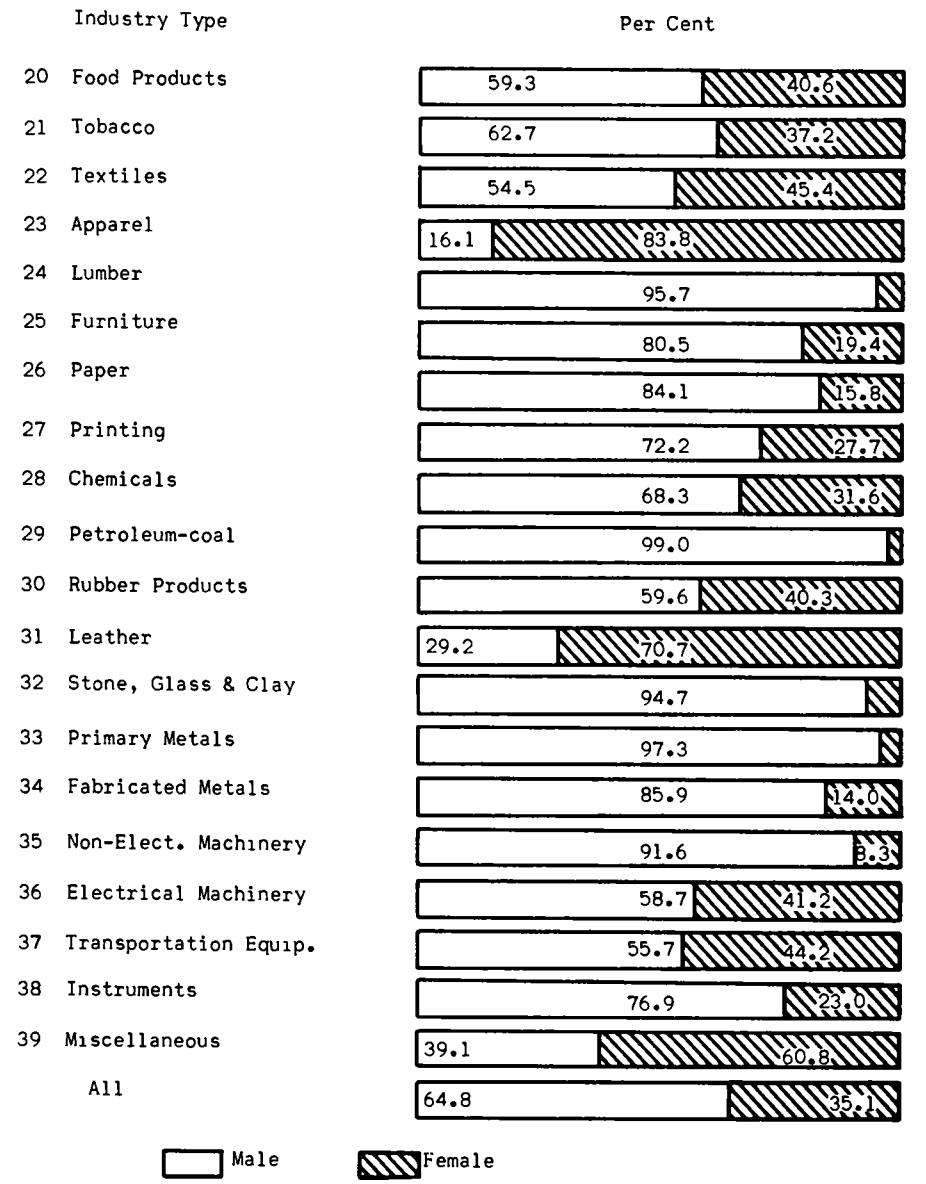

Figure 10. Sex of employees vs type of industry.

rode to work, and only 7.9 percent walked (Fig. 6). The large percentage of employees driving to work indicates the importance of the automobile in the manufacturing employment of North Carolina.

The average distance that manufacturing employees lived from their work was 6.55 mi (Fig. 7). It was determined that over 50.0 percent of all manufacturing employees sampled lived within 4 mi of where they worked, and only 20.0 percent lived more than 10 mi from their employment. The average distance employees walked to work was 0.60 mi; average driver distance was 6.28 mi; and average rider distance, excluding driver, was 8.10 mi.

There seemed to be some difference in the travel and employee characteristics of industries as related to the area of the State in which the industry was located (Fig. 8). This difference in travel characteristics is manifest in the employee distribution curves for each area and the persons per vehicle curves for each area. Also, some difference may be noted in regard to employee characteristics such as race and living area (Fig. 9). However, no appreciable difference was noticed in the sex ratio for each area (Fig. 10).

The collected data also indicated a difference in employee distribution and persons per vehicle between rural and urban companies. Employees of urban companies tend to live closer to the industry than those of rural companies (Fig. 11). Also, rural companies had an over-all average of 1.92 persons per vehicle as compared with 1.59 persons per vehicle for urban companies. Data indicated a decided difference in the living area of employees and a considerably lesser difference in the race and sex of employees (Figs. 12, 13).

Results of an attempt to relate travel and employee characteristics to population of the city in which an industry is located indicated a wide range of difference in distribution curves, persons per vehicle curves, race ratios, sex ratios, and living area ratios. With the exception of the latter, however, these differences did not indicate a trend related to population, but a rather erratic pattern. However, trends were in-

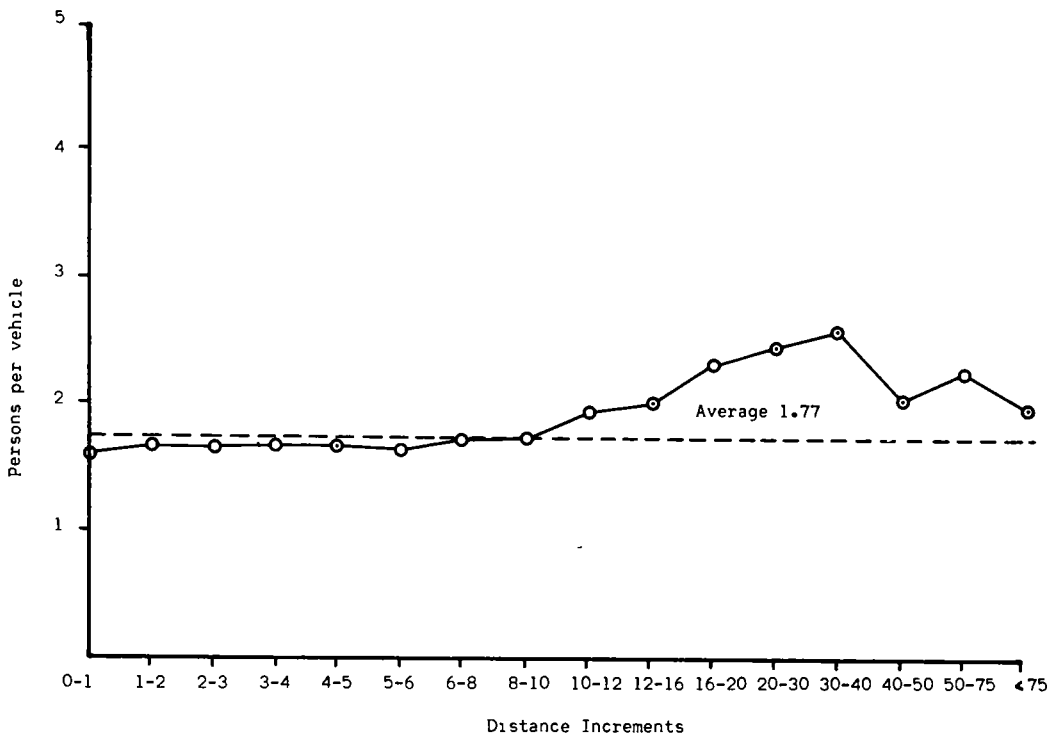

Figure 11. Persons per vehicle vs home-to-work distances for all industries.

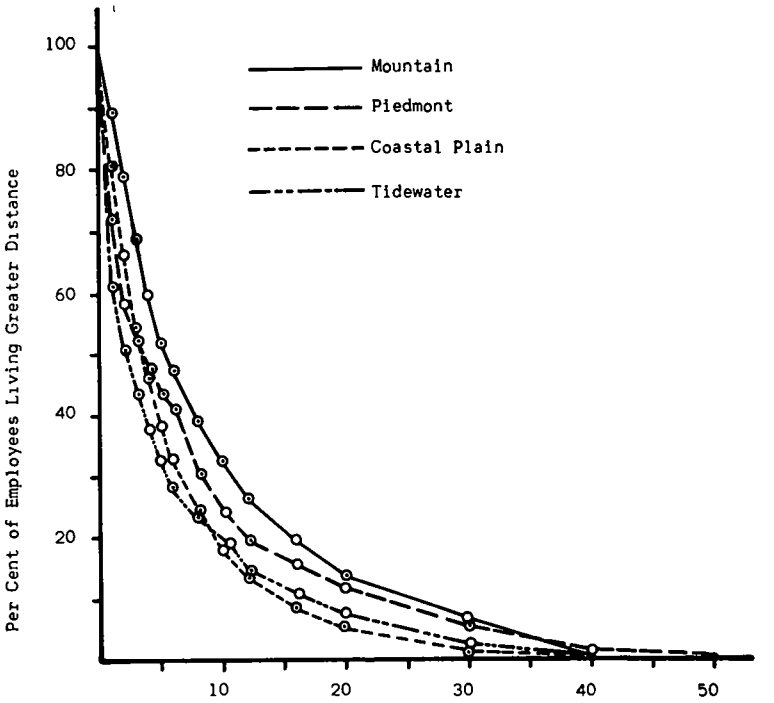

Figure 12. Percent employees living greater distance for areas of State.

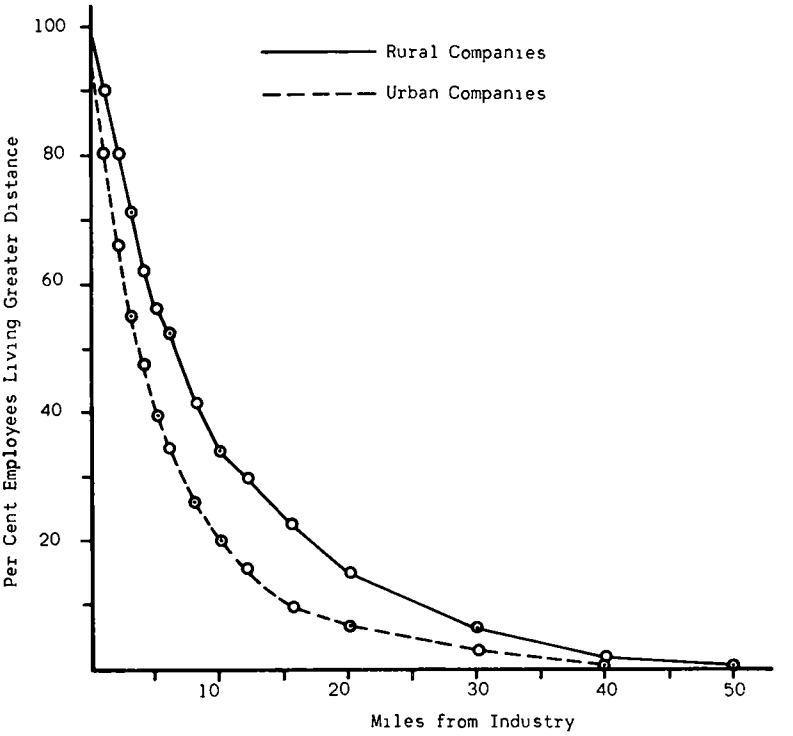

Figure 13. Percent employees living greater distance for urban and rural companies.

dicated for the living area ratios with more employees tending to reside in the same community as the industry as population increased. Correspondingly, rural residence decreased with population increase.

A third phase of the project is now being directed toward the development of predictors of the travel characteristics of the employees of North Carolina industries. The characteristics being investigated are (a) the mileage distribution of residence of employees from their place of work and (b) the percentage of employees that drive their personal automobile to work. These characteristics, when predicted, can be combined to obtain an indication of the amount of traffic generated by an industry.

An initial inspection of the industrial-interview-mileage-distribution data indicated that an exponential distribution could possibly serve as the predictor of mileage distribution of employees from an industry.

The exponential distribution was used to predict the percentages of employees from each mileage increment for each of the twenty types of industries, for each of the eight sizes of industries, and for each of a group of individual industries. The results showed that the distribution generally served as a fair approximation of the actual mileage distribution. There were, however, in several instances, significant differences between the predicted and actual mileage distributions. These differences were more pronounced when working with an individual industry than with groups of industries and also were more significant in the 0- to-1 mileage increment.

An effort is now being made to modify the exponential distribution in order to reduce these discrepancies. The new distribution will have the same basic form as the exponential, but will include at least one other parameter involving some quantitative measure of the industries' locations with respect to population or density of population.

The work on the development of the predictor of the average number of drivers in an industry is just commencing. The initial work has been attempting to determine those industrial characteristics (size, type, etc.) that significantly affect the number of employees driving to work. Ater these characteristics have been isolated, it will then be possible to determine the final form of the predictor.