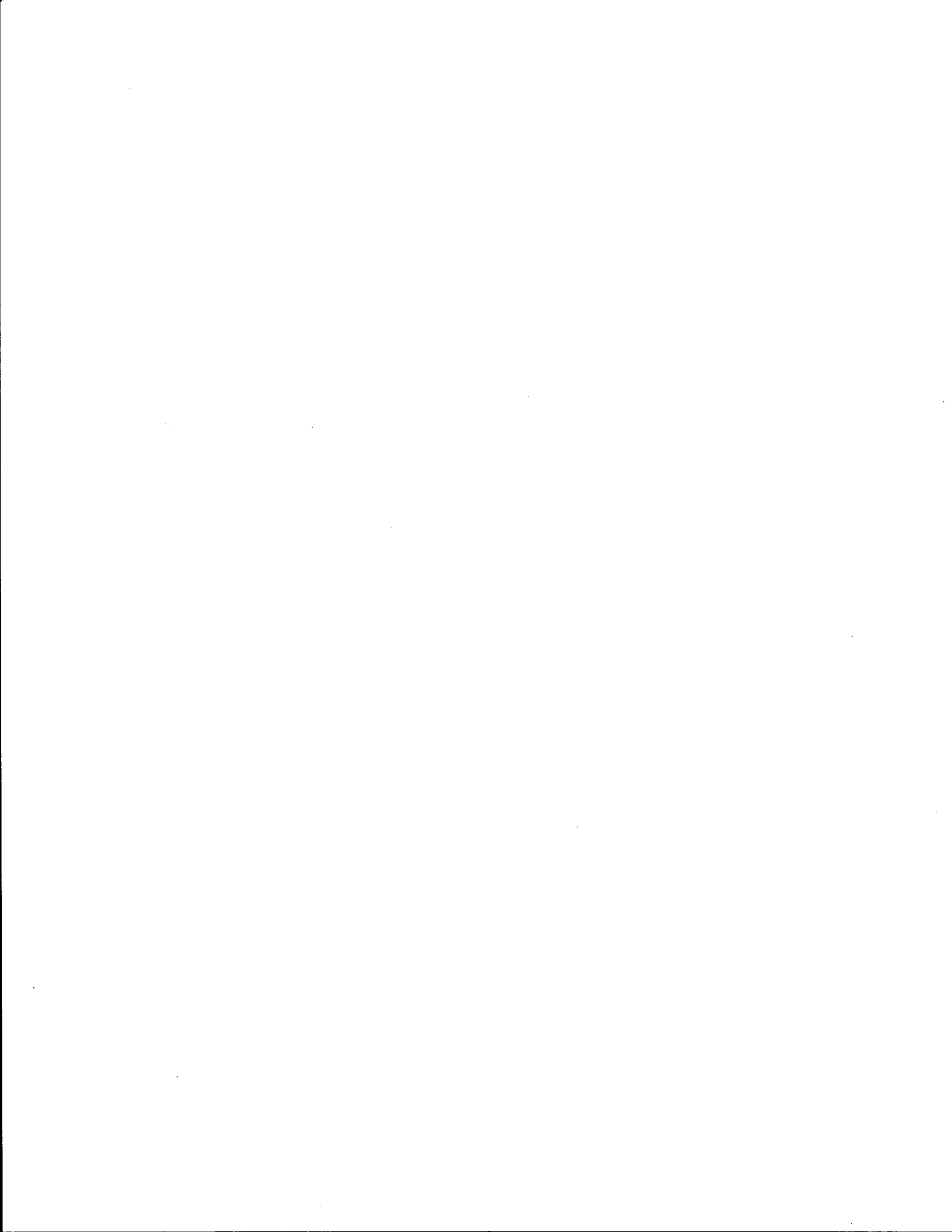


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16. Abstract In an effort to identify current travel characteristics and the changes that have occurred, in 1990 the Texas Department of Transportation (TxDOT) approved funding for travel surveys in San Antonio, Amarillo, Brownsville, Tyler, and Sherman-Denison. These surveys were designed to update models used to estimate travel demands and the impact of those demands on air quality and energy consumption. The models in use prior to initiating the surveys, with two exceptions, were based on information gathered in origin-destination surveys conducted in the late 1960's and early 1970's. The information obtained in these surveys is critical for monitoring changes in travel characteristics and for projecting travel demands in the future. This report presents an overview of the major surveys done in 1990 and, where possible, the surveys done in the Dallas-Fort Worth area, the Houston-Galveston area, and the Texarkana area. This report also presents a comparison between the travel characteristics observed in the origin-destination surveys conducted in the 1960's and 1970's and the characteristics observed in the most recent surveys.					
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METRIC (SI*) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
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LENGTH

in	Inches	2.54	centimetres	cm
ft	feet	0.3048	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km

AREA

in ²	square inches	645.2	centimetres squared	cm ²
ft ²	square feet	0.0929	metres squared	m ²
yd ²	square yards	0.836	metres squared	m ²
mi ²	square miles	2.59	kilometres squared	km ²
ac	acres	0.395	hectares	ha

MASS (weight)

oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg

VOLUME

fl oz	fluid ounces	29.57	millilitres	mL
gal	gallons	3.785	litres	L
ft ³	cubic feet	0.0328	metres cubed	m ³
yd ³	cubic yards	0.0765	metres cubed	m ³

NOTE: Volumes greater than 1000 L shall be shown in m³.

TEMPERATURE (exact)

°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C
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APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
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LENGTH

mm	millimetres	0.039	inches	in
m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi

AREA

mm ²	millimetres squared	0.0016	square inches	in ²
m ²	metres squared	10.764	square feet	ft ²
km ²	kilometres squared	0.39	square miles	mi ²
ha	hectares (10 000 m ²)	2.53	acres	ac

MASS (weight)

g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (1 000 kg)	1.103	short tons	T

VOLUME

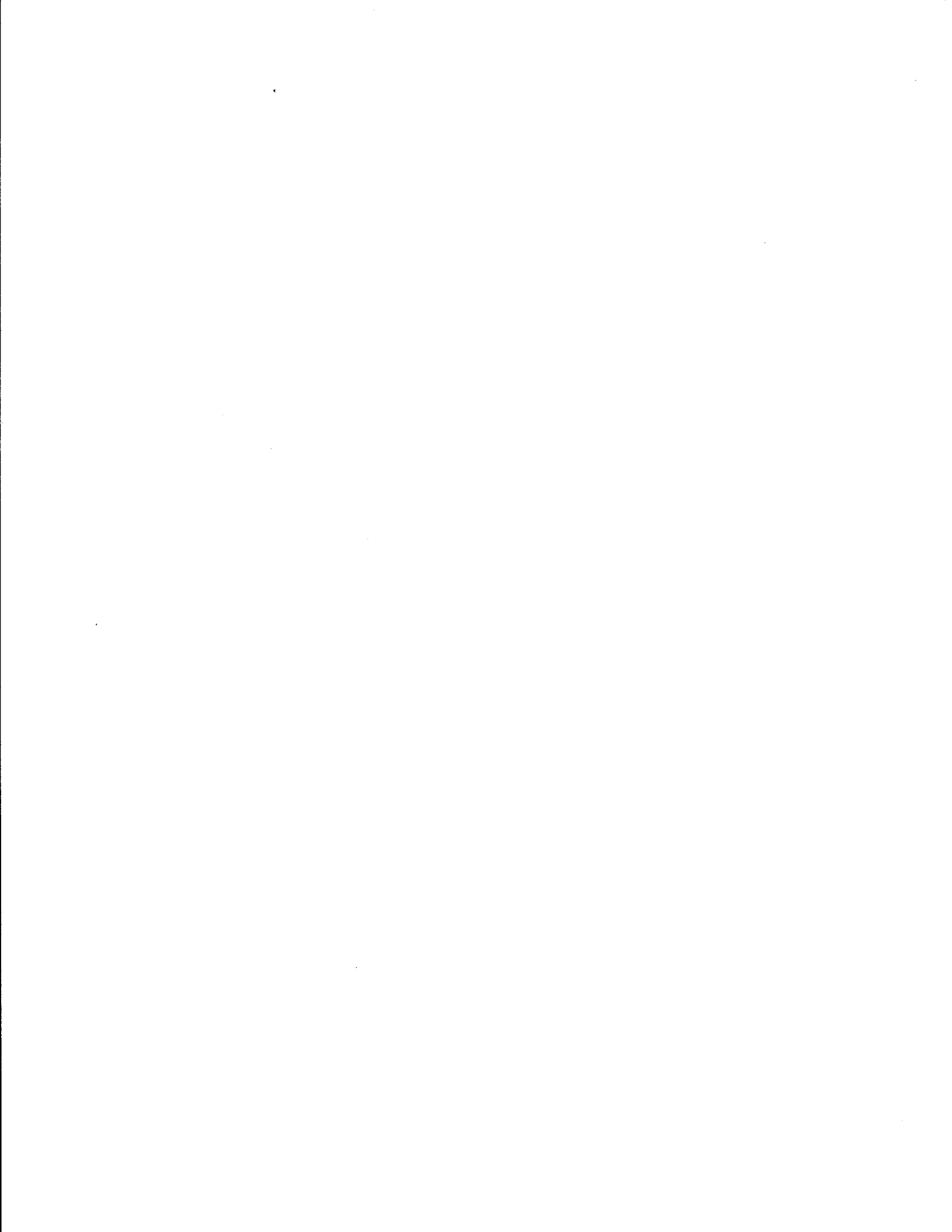
mL	millilitres	0.034	fluid ounces	fl oz
L	litres	0.264	gallons	gal
m ³	metres cubed	35.315	cubic feet	ft ³
m ³	metres cubed	1.308	cubic yards	yd ³

TEMPERATURE (exact)

°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F
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These factors conform to the requirement of FHWA Order 5190.1A.

* SI is the symbol for the International System of Measurements



URBAN TRAVEL IN TEXAS:
AN OVERVIEW OF TRAVEL SURVEYS

by

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Research Engineer

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Executive Overview

Texans, Transportation, and Traffic Trouble

Texans have always been a mobile group. In the early years of the Republic, we did our commuting by horseback. But, "horsepower" took on a different meaning when we embraced the horseless carriage. The wide, open spaces gave way to the open road. And Texans' love affair with the automobile had begun.

This new-fangled transportation brought a new set of needs and challenges: Blacksmiths gave way to service stations; gasoline replaced oats and hay; and dusty cow trails did not make for pleasant driving.

Over the past 30 years, our population — both people and vehicles — has exploded. From 1960 to 1990 the population grew as much as it did in 70 years, from 1890 to 1960. Today we face challenges as great as those pioneer drivers: Where do we put all those drivers and vehicles, and how do we plan for the future?

Help on the Horizon

One of the most reliable means of planning for the driving public's demands for adequate, safe roadways is by conducting transportation surveys. Transportation surveys are critical for monitoring changes in travel characteristics. Surveys provide data to determine where Texas' transportation system is now and what direction we need to take to ensure that the system will meet future needs.

TxDOT's practice has been to conduct five transportation surveys in most urban areas. In the **household survey**, household members keep diaries of the trips made on a particular day; the survey provides household characteristics such as the number of persons in and vehicles available to the household. **Workplace surveys** determine trips per employee. **Special generator surveys** examine the number of trips made to specific activity centers (such as shopping malls or airports). **External station surveys** conducted at locations on the perimeter of the study area determine the number of trips entering and leaving urban areas. **Truck surveys**, which

determine the number of truck trips and average trip length, help forecast the amount of urban travel attributable to trucks.

In the 1960's and 1970's, TxDOT surveyed the state's most populated areas to determine household size, household income, how many vehicles were available to each household, and for what purpose trips were made. Armed with this information, TxDOT planned for expansion, started construction projects, and assured our state of a continuing preeminent position in transportation.

Once Is Not Enough

The information that served so well in the 1960's and 1970's, however, has become obsolete. Recognizing the need to update the 20-year-old data, major travel surveys were conducted in Dallas-Fort Worth and Houston-Galveston in 1984. In 1989 and 1990 TxDOT continued these survey updates in Texarkana, San Antonio, Amarillo, Brownsville, Tyler, and Sherman-Denison.

The new survey data have been used to estimate and forecast transportation requirements and to determine transportation's impact on air quality and energy consumption. By comparing survey results from the 1960's and 1970's with the more recent surveys and by incorporating transportation planning methods developed over many years, TxDOT is able to anticipate, plan, and evaluate transportation improvements.

Lessons Learned

So, what have we learned so far? We know that in Texas, we don't simply grow at a slow, steady pace — we grow by leaps and bounds! The historical data record Texas' phenomenal growth rates. Since 1960 our population has almost doubled from 9.6 million to 17 million. Even more astounding is growth in the number of registered vehicles; that number has almost tripled since 1960 from 4.9 million to 14.5 million in 1990.

By comparing the early transportation surveys with those done more recently, we find that the reasons we use the transportation system and how often we use it has changed dramatically. The surveys indicate that in both large and small urban areas we are driving more miles, making more trips, and operating more and more vehicles. The surveys also show that in all but one area (Brownsville), household size is declining. And fewer people are riding together; the average occupancy per vehicle is slightly more than 1.

One finding is that travel patterns and characteristics in large urban areas (populations greater than 200,000) are different from small urban areas. In comparing Dallas-Fort Worth, Houston-Galveston, and San Antonio 1960 surveys to the 1984 and 1990 surveys, population is shown to have doubled, the number of trips made by the driving public increased more than 2.5 times (from 10 million to 26 million trips), and the daily miles traveled by vehicles in those areas increased more than 4.5 times (from 31 million to 173 million).

The Facts:

In general:

- Households travel more today than they did 20 years ago.
- The number of trips from home to work have increased; trips made from a place other than home have increased as much as 40 percent.
- Since the early surveys were conducted, trips from home to non-work locations have declined.
- Household size is shrinking. In the early surveys the average household size was 3.12 persons per household; in the later surveys, the average size was 2.73. In contrast, however, the number of vehicles available to each household has risen from 1.34 vehicles per household to 1.77. The days of large households sharing a single vehicle are drawing to a close.

In large urban areas (Dallas-Fort Worth, Houston-Galveston, and San Antonio) transportation surveys show:

- The average household size has declined, but the number of trips has increased 13 percent.
- The number of people traveling together in a vehicle has declined 18 percent; this has resulted in a 13 percent increase in driver trips and a 27 percent decrease in passenger trips. In other words, more Texans are driving alone.
- Household members spend an average of 1.5 hours on the road and drive an average of 42 miles a day.

In small urban areas (Texarkana, Amarillo, Brownsville, Tyler, and Sherman-Denison) transportation surveys show:

- Like the large urban areas, average household size has declined and the number of trips has increased 13 percent.
- The number of people making trips together has declined 15 percent resulting in a 13 percent increase in driver trips and a 27 percent decrease in passenger trips. As in the large urban areas, Texans prefer to drive alone.
- Household members spend an average of less than one hour on the road and drive an average of 24 miles a day.

Meeting the Future Head On

There is no indication that Texas drivers intend to make fewer trips in the future. Despite rising fuel costs and traffic congestion, Texans are going to hit the road. Texas has been, is, and always will be a growing and mobile state. For TxDOT to ensure that our transportation system remains current,

transportation surveys must be done regularly and more often.

We must maintain the tremendous investment we have in transportation facilities. If we are to plan effectively for the future, if we are to have any hope of staying ahead of the growth, we must have the facts on where, when, and by how much our driving population is changing.

It is recommended that conducting surveys be a high priority. Surveys should be scheduled and conducted on a regular basis, preferably every 10 years. It is recommended that our largest urban areas — Dallas-Fort Worth and Houston-Galveston — be surveyed again by 1994. It is also recommended that new surveys be conducted in Austin, Longview, and Victoria as soon as possible because of their potential to become air quality nonattainment areas in the near future.

Transportation surveys provide the information to meet our planning needs. The data from previous surveys have proved to be invaluable in forecasting and anticipating demands. As we plan for the future, we face one inevitable truth: Like the weather, nothing — especially transportation needs — ever stays the same in Texas.

The remainder of this report expands on this section and is of a more technical nature.



Introduction

In 1990, the Texas Department of Transportation (TxDOT) approved funding for travel surveys in five urban areas in Texas: San Antonio, Amarillo, Brownsville, Tyler, and Sherman-Denison. TxDOT began a major effort to identify current travel characteristics and the changes that have occurred over time in Texas. These surveys were designed to update models used to estimate travel demands and the impact of those demands on air quality and energy consumption. The models in use prior to initiating the surveys, with two exceptions, were based on information gathered in origin-destination surveys conducted in the 1960's and early 1970's.

Prior to 1990, travel surveys had been done in the Dallas-Fort Worth area, the Houston-Galveston area, and the Texarkana area. While there were some similarities between these surveys, each was significantly different in certain areas considered critical for comparison purposes. The surveys funded by TxDOT in 1990 used the same survey instruments and, with minor exceptions, were consistent in their implementation.

The information obtained in these surveys is critical for monitoring changes in travel characteristics and for projecting travel demands in the future. They provide an insight to the changes that have been and are occurring. The information will improve TxDOT's ability to anticipate and plan future transportation improvements through a broader understanding of the changes in travel characteristics and through the development of better tools for predicting travel.

This report presents an overview of the major surveys done in 1990 and, where possible, the surveys done in the Dallas-Fort Worth area, the Houston-Galveston area, and the Texarkana area. Comparisons were not possible in all aspects of the surveys and, in certain areas of this report, data will be presented for less than eight urban areas. This report also presents a comparison between the travel characteristics observed in the origin-destination surveys conducted in the 1960's and 1970's and the characteristics observed in the most recent surveys.

This report is presented in six sections. The next section discusses the surveys that were done and the basic differences between some of the surveys. Following that section is a brief discussion of the terminology and definitions used in the report. The fourth section presents a summary of the observed travel behavior in the urban areas that were surveyed and includes

discussions of the changes in travel characteristics over time. The fifth section presents some of the major findings from the surveys. The last section presents a summary of the surveys.



Surveys

There were five distinct surveys conducted in most of the urban areas. These consisted of a household travel survey, a workplace survey, a special generator survey, an external travel survey, and a truck survey. These are briefly described in the following paragraphs.

Household Survey

Household travel surveys were conducted in all eight urban areas. Households agreeing to participate in the survey were asked to record on a travel diary the trips made by each person age five and older during a 24-hour period. Characteristics of the household, such as number of persons in the household, number of vehicles available to the household, etc., were also collected. The household information is used to stratify trip rates (i.e., trips per household) for application in trip generation models. These models estimate the number of trips produced by households in an urban area. In total, nearly 12,000 households were surveyed in 1990-91 in the five urban areas. The three prior surveys obtained travel information from a total of nearly 5,000 households. All eight surveys involved nearly 45,000 individuals and compiled information on more than 150,000 trips.

Workplace Survey

Workplace surveys were conducted in all but the Houston-Galveston area. The survey consisted of two parts: one dealt with the employees and one with non-employees. For workplaces agreeing to participate, employees were given travel diaries and asked to record all of their trips on a specific travel day. This information was similar to that collected in the household survey. During the same travel day, non-employees arriving at the workplace were randomly interviewed to determine their trip purpose, mode of travel, vehicle occupancy, etc.

The combined information from the employee and non-employee surveys was used to develop attraction rates (i.e., trips per employee) for workplaces. The workplace surveys conducted in the five urban areas in 1990-91 involved nearly 800 workplaces where nearly 13,000 employees participated in the survey and nearly 65,000 non-employees were surveyed. The two prior workplace surveys in Dallas-Fort Worth and Texarkana involved over 500 workplaces, 22,000 employees and nearly 17,000 non-employees.

Special Generator Survey

Special generator surveys were conducted in Dallas-Fort Worth, San Antonio, Amarillo, and Tyler. These were identical to the workplace survey in terms of methodology but were designed and targeted to specific activity centers which are considered unique in their trip generation characteristics. In the trip generation process (i.e., the first step in the transportation modeling process), the trips being produced and attracted are estimated individually for these types of activity centers. Examples of such centers include regional shopping centers, airports, hospitals/medical centers, etc. In all, 28 special generators were surveyed. These surveys involved over 20,000 employees and non-employees.

External Station Survey

External station surveys were conducted in all of the urban areas except Dallas-Fort Worth and Houston-Galveston. At external stations in the urban areas, vehicles leaving the area were randomly surveyed to determine information on vehicle occupancy, number and type of vehicles, number of trips through the area, and trips beginning in the area and traveling out of the area (non-through trips). This information is used to estimate the number and type of trips entering and exiting urban areas. It is a part of the overall trip generation process for travel demand modeling. In total, over 70,000 surveys were completed at external stations. Results of the evaluation of the external station surveys will be included in a later report.

Truck Survey

Truck surveys were done in all of the urban areas except Dallas-Fort Worth, Houston-Galveston, and Texarkana. These surveys were designed to determine the number of trips made by trucks on a typical day and the average trip length of those trips. This information is useful in predicting the amount of travel in an urban area attributable to trucks. Results of the evaluation of the truck surveys will be included in a later report.



Terminology

Terminology is discussed separately because of the potential for confusion in the subsequent discussions of survey findings. The following terms and their definitions are used:

Trip Purpose

The purpose of a trip. In the analysis of the surveys, three trip purposes were used, home based work (HBW), home based non-work (HBNW), and non-home based (NHB). Home based work trips are trips from home to work or from work to home. Home based non-work trips are all non-work trips beginning or ending at home. Non-home based trips are trips which begin and end at locations other than home.

Person Trips

The number of trips made by persons five years of age or older. These are usually summed for all members of a household and reported as person trips per household. These are also summed by household and divided by the number of persons in the household to compute the person trips per person. Person trips per household is also referred to as the person trip rate.

Vehicle Trips

The number of vehicle trips made by individuals within a household. These are generally reported as vehicle trips per household and/or vehicle trips per person. Vehicle trips per person are computed by summing the number of individual vehicle trips and dividing by the number of persons within a household. Vehicle trips per household is also referred to as the vehicle trip rate.

Vehicle Availability

The number of vehicles available to members of a household for travel purposes.

Vehicle Occupancy

The number of occupants in a vehicle during a vehicle trip.

Trip Length

The length of a trip measured in distance or time.

Mode of Travel

The physical means of transportation. The modes available include vehicle driver, vehicle passenger, transit, school bus, walk, bicycle, taxi, and commercial vehicle.

Productions

The number of trips which are produced by members of a household. They are computed by trip purpose as well as by mode of travel. Production rates refer to the total trips produced divided by the number of households.

Attractions

The number of trips to and from a workplace made by employees and non-employees. They are computed by trip purpose as well as by mode of travel. Attraction rates refer to the total attractions for a workplace divided by the number of employees at the workplace.

Linked Trips

Trips are linked (or combined) into a single trip which reflects what is perceived to be the true purpose of the trip. For example, a person driving a child to a day care center (or school) and then proceeding on to work would have made two unlinked trips, a home based non-work trip and a non-home based trip. These two trips would be "linked" to create one trip, a home based work trip.



Travel Behavior in Texas

In the subsequent sections of this report, various statistics and comparisons will be presented to illustrate the temporal changes and differences between urban areas in terms of travel characteristics. For comparison purposes, as well as consistency, the data presented are for unlinked trips. This distinction is made because in the majority of urban areas, the trip rates used for projecting travel are developed for linked trips. Because some of the surveys did not collect the information necessary to link all trips and the earlier surveys (i.e., 1960's and 1970's) did not link trips when developing trip rates, the decision was made to present the information in this report in terms of unlinked trips. Data are not presented for the external station surveys and the truck surveys. These surveys will be presented in subsequent reports.

Purpose of Travel

The analysis of the travel surveys in Texas has revealed some significant differences in travel characteristics between urban areas and changes in urban travel patterns over the past 20 years. One of the first findings was that

travel patterns and characteristics are different between smaller urban areas and larger urban areas. For this report, a small urban area is one with less than 200,000 population, while a large urban area is one with a population of 200,000 or more.

The average distribution of person trips by trip purpose is shown in Figure 1 for both large and small urban areas. Home based work trips in large urban areas comprised 21 percent of all person trips while in the smaller urban areas, they accounted for 16 percent of the total person trips. The percentage of trips that were home based non-work and non-home based were slightly higher in smaller urban areas than the larger urban areas. A similar relationship was found for vehicle trips as shown

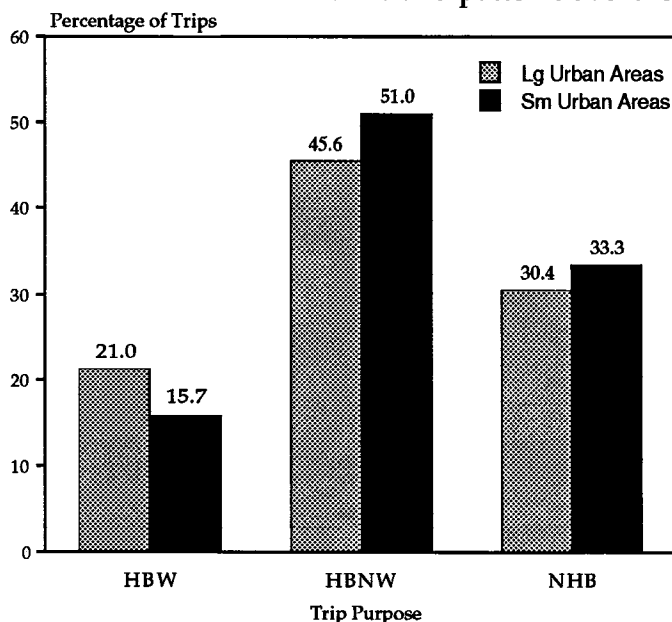


Figure 1. Distribution of Person Trips by Trip Purpose (1990 Travel Surveys)

in Figure 2. In large urban areas, one of every four vehicle trips was a home based work trip. In small urban areas, one of every five vehicle trips was home based work.

In comparing changes in the purpose of travel over time, the most significant change has occurred in a shift of travel to non-home based trips. In the early origin destination surveys, non-home based trips in the large urban areas comprised about 22 percent of the person trips and 25 percent of the vehicle trips. Non-home based trips now comprise over 30 percent of the person trips and 33 percent of the vehicle trips. The percentage of non-home based trips in small urban areas showed increases of less magnitude than for the large urban areas. Both large and small urban areas displayed slight increases in the percentage of home based work trips, significant declines in the percentage of home based non-work trips and significant increases in non-home based trips. The change in the percentage of person trips by trip purpose is shown in Figure 3; the changes for large urban areas are based on data for San Antonio and Dallas-Fort Worth only.

Figures 1 through 3 reveal that households in small urban areas tend to make more non-work related trips than those in larger urban areas. This may be an indication that travel is more difficult (e.g., more congestion) in larger urban areas. All of the urban areas surveyed exhibited slight increases in the percentage of work trips and significant increases in the percentage of non-home based trips. This indicates that more trips are occurring while away from home. For example, there may be a greater tendency to stop and shop on the way home from work to avoid making another trip. This could also be a result of increasing numbers of two-worker households.

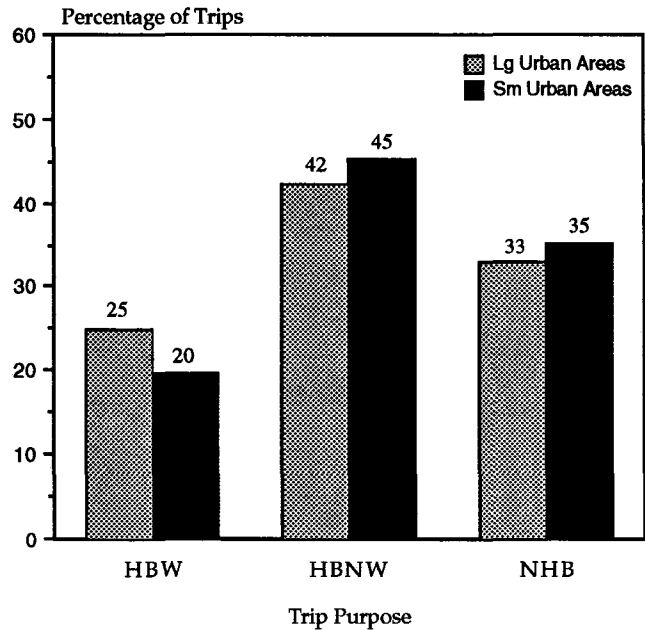
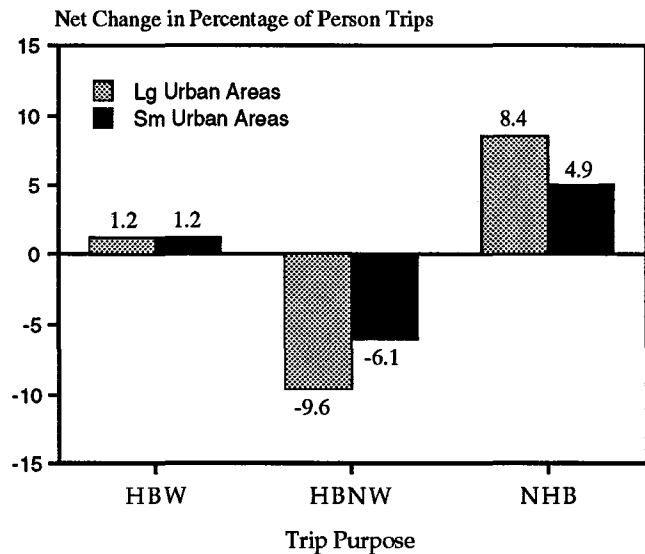


Figure 2. Distribution of Vehicle Trips (1990 Travel Surveys)

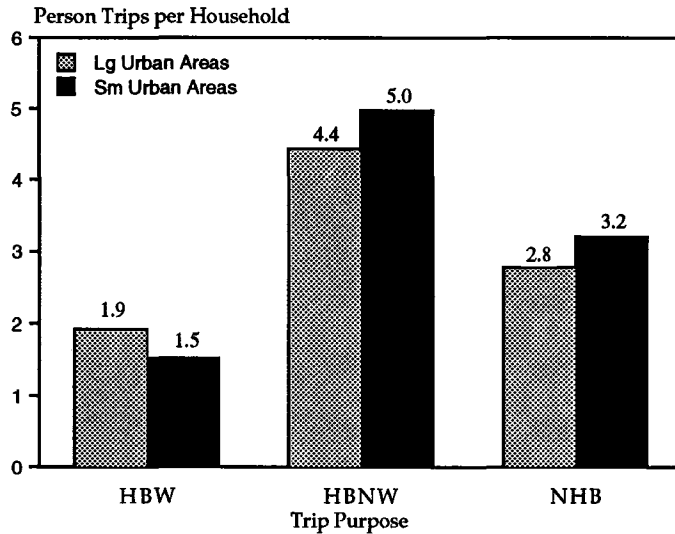


As measured from surveys done in the 1960's and 1970's

Figure 3. Net Change in Percentage of Person Trips by Trip Purpose (1960 - 1990)

Person and Vehicle Trips per Household

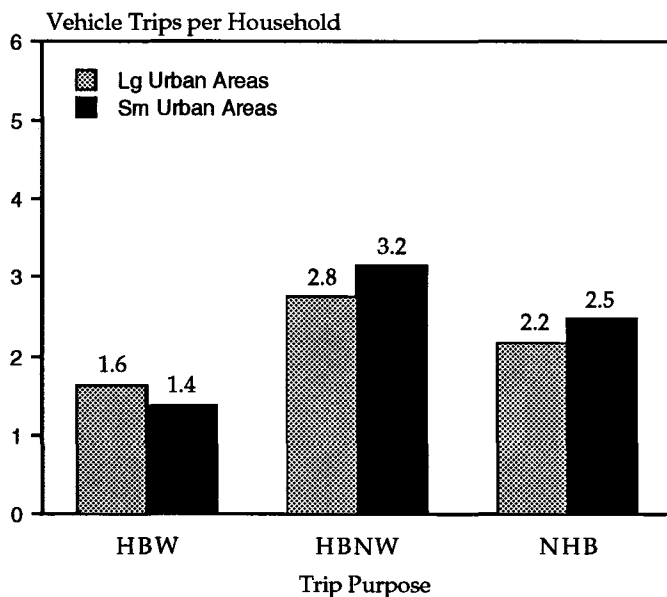
Household trips may be analyzed in several ways. One is to look at the overall expanded average trips per household by trip purpose and another is to stratify the trips per household on the basis of the household's socioeconomic characteristics. This report presents the results from the analysis of the expanded average trips per household by trip purpose. A later report will contain the comparisons and additional detailed analyses of the trip rates stratified by household characteristics.



Large Area Total = 9.12 Trips/Household

Small Area Total = 9.69 Trips/Household

Figure 4. Person Trips per Household (1990)



Large Area Total = 6.54 Trips/Household

Small Area Total = 6.98 Trips/Household

Figure 5. Vehicle Trips per Household (1990)

In the three largest urban areas surveyed, the average person trips per household ranged from 8.71 in Dallas-Fort Worth to 9.45 in Houston-Galveston. The average vehicle trips per household ranged from 6.39 in San Antonio to 6.81 in Houston-Galveston. The overall averages for large urban areas were 9.12 person trips per household and 6.54 vehicle trips per household. Based on data for San Antonio and Dallas-Fort Worth, person trips per household have increased very little while vehicle trips per household have increased over 12 percent. The time frame for these changes is about 20 years.

In the small urban areas, the average person trips per household ranged from a low of 8.66 in Tyler to a high of 11.26 in Brownsville. The average vehicle trips per household ranged from 6.55 in Tyler and Sherman-Denison to 7.41 in Texarkana. The rates for the small urban areas, in nearly all cases, were larger than those for the large urban areas. The overall average for the small urban areas was 9.69 person trips per household and 6.98 vehicle trips per household. Comparing these trip rates with those found in the earlier origin-destination surveys (done in the 1960's and 1970's), the results were mixed; some areas experienced an increase in the trip rates, and others experienced a decline. The average person trip rate showed no change; the increase in the average vehicle trip rate, however, was over 10 percent. Vehicle trip rates have experienced much greater increases over time than person trip rates.

Figures 4 and 5 present the average person and vehicle trips per household by trip purpose for both large and small urban areas.

Figures 6 and 7 exhibit the percentage change in person and vehicle trip rates by trip purpose for large and small urban areas. Households tend to make more home based work trips in the large urban areas and fewer home based non-work and non-home based trips than households in the small urban areas. The same trend was observed in the previous discussion on the distribution of trips by trip purpose.

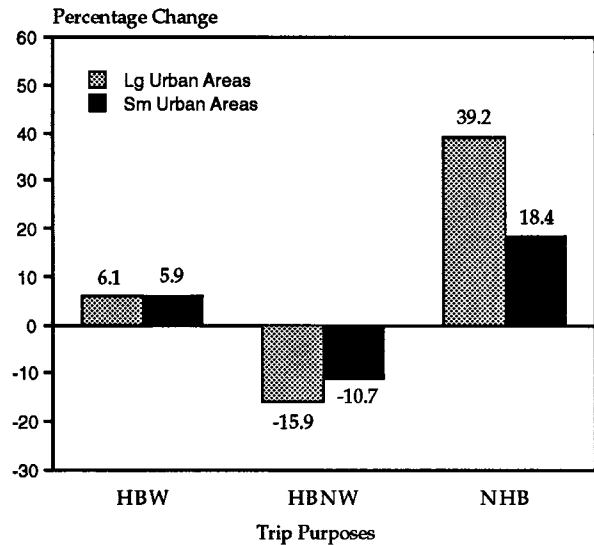
Figures 6 and 7 illustrate both person and vehicle trip rate changes that have occurred since the early origin-destination surveys. Home based work person trips per household have increased about 6 percent in both large and small urban areas. Non-home based person trip rates have increased significantly while home based non-work trip rates have declined. Vehicle trips per household have increased significantly since the early origin-destination surveys (Figure 7).

In summary, overall average person trip rates have remained stable over time while average vehicle trip rates have increased. The major changes that have occurred have been shifts in the trip rates by trip purpose, indicating significant changes in urban travel patterns.

Household Size

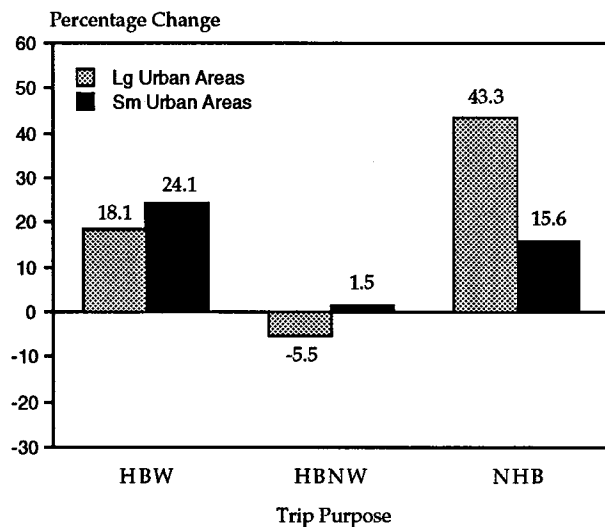
Average household size varied between the urban areas surveyed. It ranged from a low of 2.55 persons per household in Dallas-Fort Worth to a high of 3.73 persons per household in Brownsville. The significance of household size on trip making is illustrated by the fact that in the large urban areas, a household with five or more members averaged just over 16 person trips per day while a two-person household averaged 7.4 person trips per day. The opposite is true when analyzing trips per person, i.e., trips per person decline as the household size increases.

All but one of the eight urban areas exhibited the same trend of declining household size over time. The rate of decline has varied among the urban areas. The change in average household size ranged from an increase of 2.7 percent for Brownsville to a 17.4 percent decline for Dallas-Fort Worth. This declining household size has the effect of increasing the average number of trips per person.



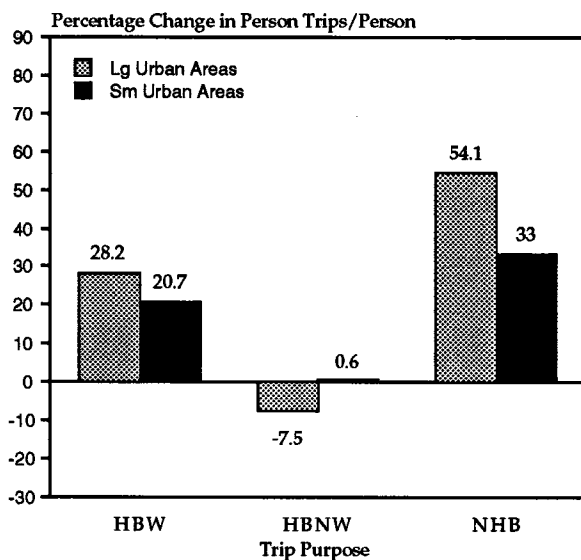
As measured from surveys done in the 1960's and 1970's

Figure 6. Percentage Change in Person Trips per Household by Trip Purpose (1960 - 1990)



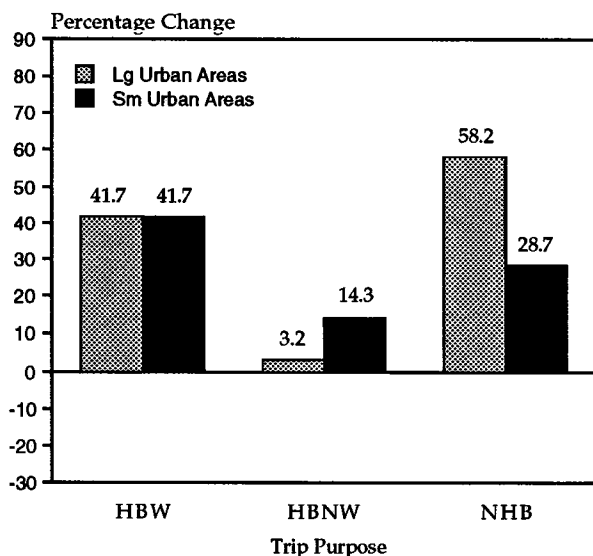
As measured from surveys done in the 1960's and 1970's

Figure 7. Percentage Change in Vehicle Trips per Household by Trip Purpose (1960 - 1990)



Large Area Change in Total = 12.8%
 Small Area Change in Total = 13.0%

Figure 8. Percentage Change in Person Trips per Person by Trip Purpose (1960 - 1990)



Large Area Change in Total = 26.1%
 Small Area Change in Total = 23.9%

Figure 9. Percentage Change in Vehicle Trips per Person by Trip Purpose (1960 - 1990)

Person and Vehicle Trips per Person

The number of person trips per person has increased since the early origin-destination surveys. For large urban areas, the average person trips per person has increased from 2.82 to 3.18, nearly 13 percent. For the small urban areas, the increase has also been nearly 13 percent from 3.16 person trips per person to 3.57. The change in vehicle trips per person has been almost double that of person trips per person: 26 percent for large urban areas and 24 percent for small urban areas. Figures 8 and 9 present the percentage change from the origin-destination surveys in person and vehicle trips per person for both large and small urban areas by trip purpose. Both indicate significant changes in the characteristics of travel since the origin-destination surveys done in the 1960's and 1970's. Much of this may be attributed to changes in household size and the economic characteristics, (e.g., household income, vehicle availability) of the households.

Vehicle Availability

While changes in average household size have affected travel characteristics, other variables have also had an impact. One of these has been the number of vehicles available to households for travel. The average number of vehicles available to a household in large urban areas in the 1960's was 1.38. This increased to an average of 1.79, a change of nearly 30 percent (based on survey statistics for Dallas-Fort Worth and San Antonio only).

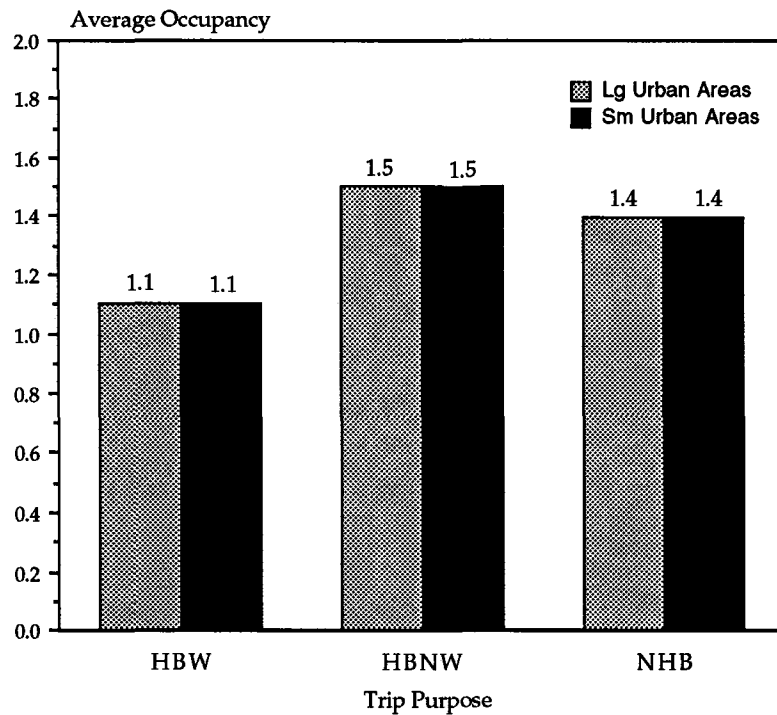
The average vehicles per household in small urban areas has shown an increase of nearly 35 percent from 1.29 to 1.74 vehicles (based on survey statistics for Brownsville, Texarkana, and Amarillo). The greater availability of vehicles for travel has been a factor in the increase in the

number of person and vehicle trips per household.

The increase in vehicle availability is also reflected in the change in the number of households with zero vehicles available. In 1964, about one out

of every 10 households had no vehicles available in the Dallas-Fort Worth area. In San Antonio, the 1969 origin-destination survey indicated one in every eight households had no vehicles available. The 1990 census data indicate that in the Dallas-Fort Worth area, only one in 16 households has no vehicle available. In San Antonio this has dropped to one in 10 households. Data for the small urban areas reflect a similar decline, from about one in every seven households to approximately one in every 10 households. Increasing vehicle availability has contributed to the rise in vehicular travel reflected in Figures 5 and 9.

Figure 10 presents the average reported vehicle occupancy by trip purpose for both large and small urban areas. No significant difference was observed in average vehicle occupancy between large and small urban areas. Average vehicle occupancy has declined by an average of 18 percent in the large urban areas and by 15 percent in the small urban areas. The reported vehicle occupancy averaged 1.35 persons per vehicle in large urban areas and 1.36 persons per vehicle in the small urban areas. In the early origin-destination surveys, these values were respectively 1.65 and 1.60. This reduction in vehicle occupancy translates directly into more vehicular trips.



Based on reported vehicle occupancies

Figure 10. Average Vehicle Occupancy by Trip Purpose (1990)

Travel Mode

Early origin-destination surveys reported that in large urban areas 63 percent of the trips were made by vehicle drivers and 31 percent by vehicle passengers. The percentage of trips made by vehicle drivers has increased to 71 percent, and the percentage by vehicle passengers has declined to 23 percent. These reflect the trend in declining vehicle occupancy and the increase in vehicle trips. Similar trends were noted in the small urban areas where vehicle driver trips have increased from 65 percent to 73 percent of all trips, and vehicle passenger trips have declined from 31 percent to 23 percent. Figures 11 and 12 compare the distribution of trips by mode of travel as observed in the early origin-destination surveys and in the more recent surveys. Of particular interest is the fact that the percentage of trips made as a bus passenger (including school bus passengers) has declined in both large and small urban areas.

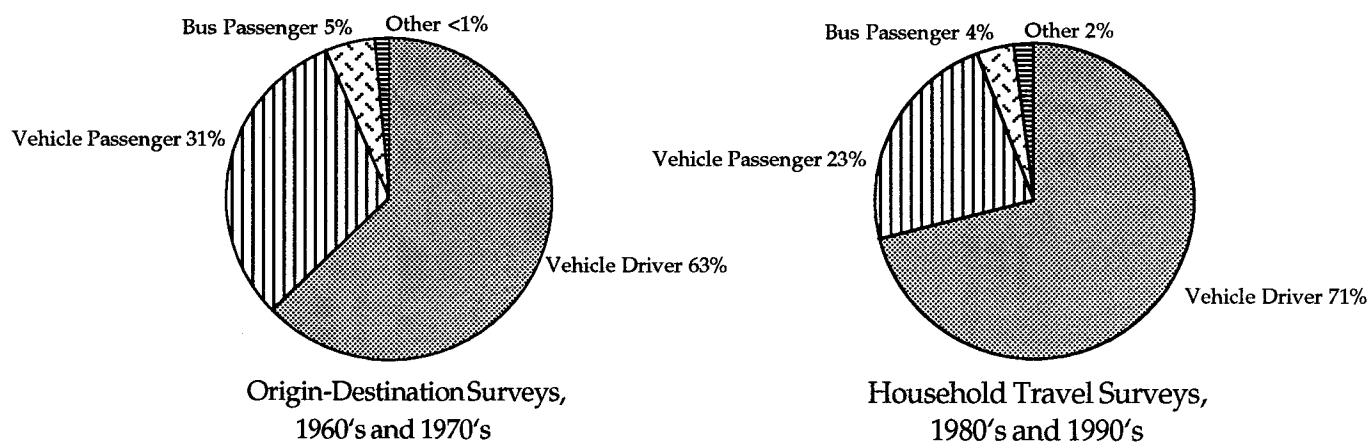


Figure 11. Percentage of Trips by Travel Mode in Large Urban Areas

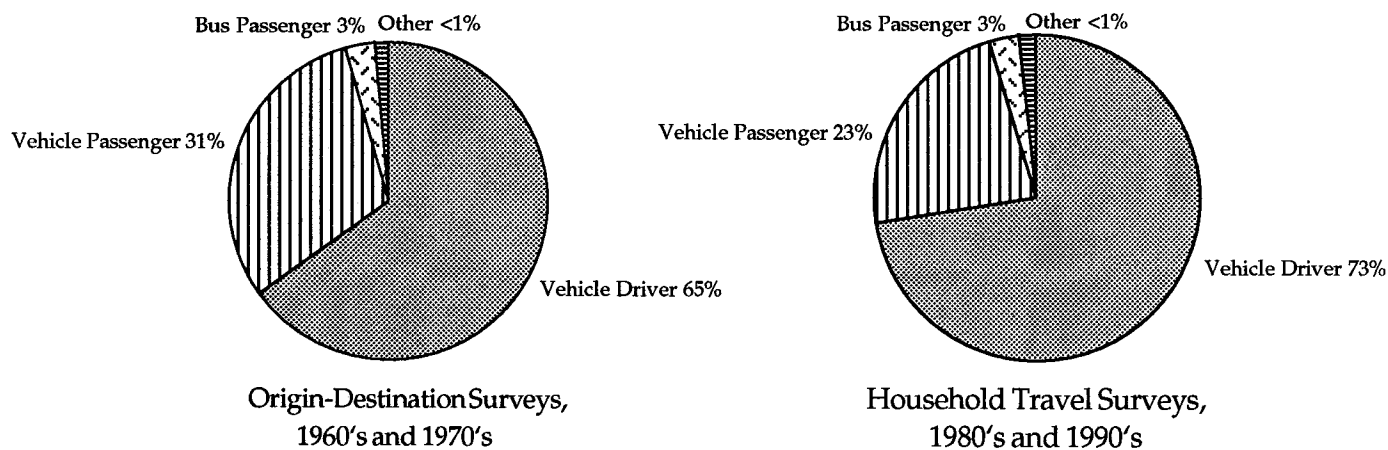


Figure 12. Percentage of Trips by Travel Mode in Small Urban Areas

Temporal Distribution of Travel

An important consideration in evaluating travel is knowing when the travel is occurring. Figures 13 and 14 present the percentage of trips by trip purpose plotted by the time the trips began for large and small urban areas. Both have similar patterns of travel by time of day. The peak periods of travel occur in the mornings between 6 and 8 a.m. and in the evenings between 3 and 5 p.m. The distributions of travel are similar for home based work and non-work trips, while non-home based trips tend to peak during the middle of the day. The morning and evening peaks correspond with the periods of time when traffic congestion is typically the worst. The survey data are representative of typical travel patterns.

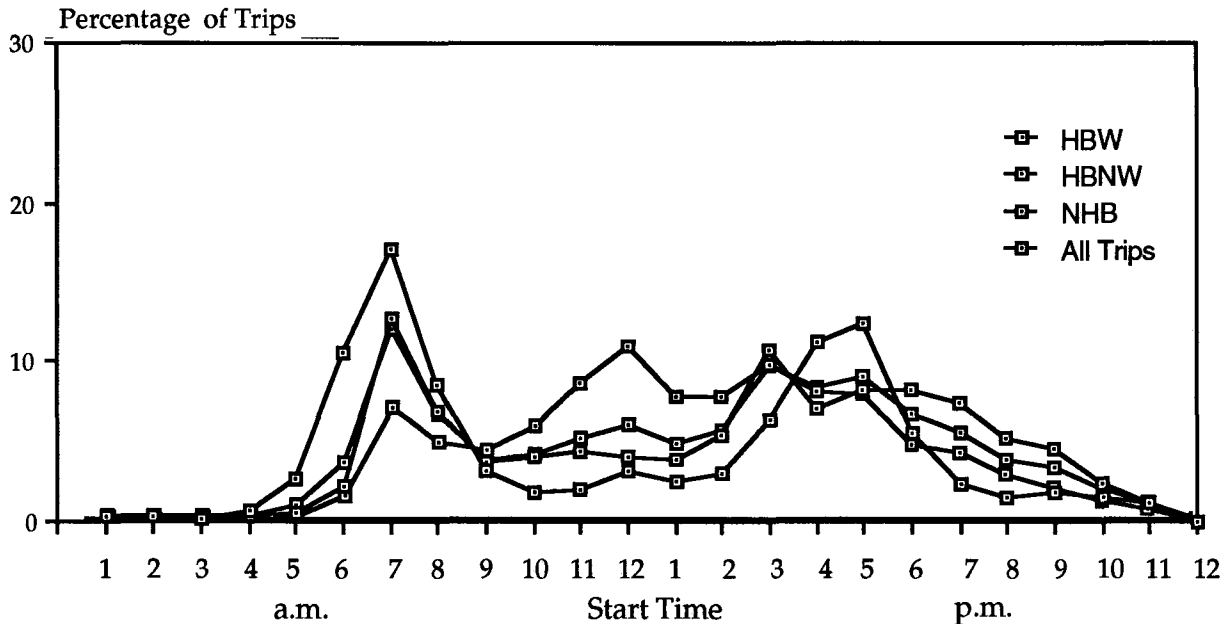


Figure 13. Distribution of Large Urban Area Trips by Start Time

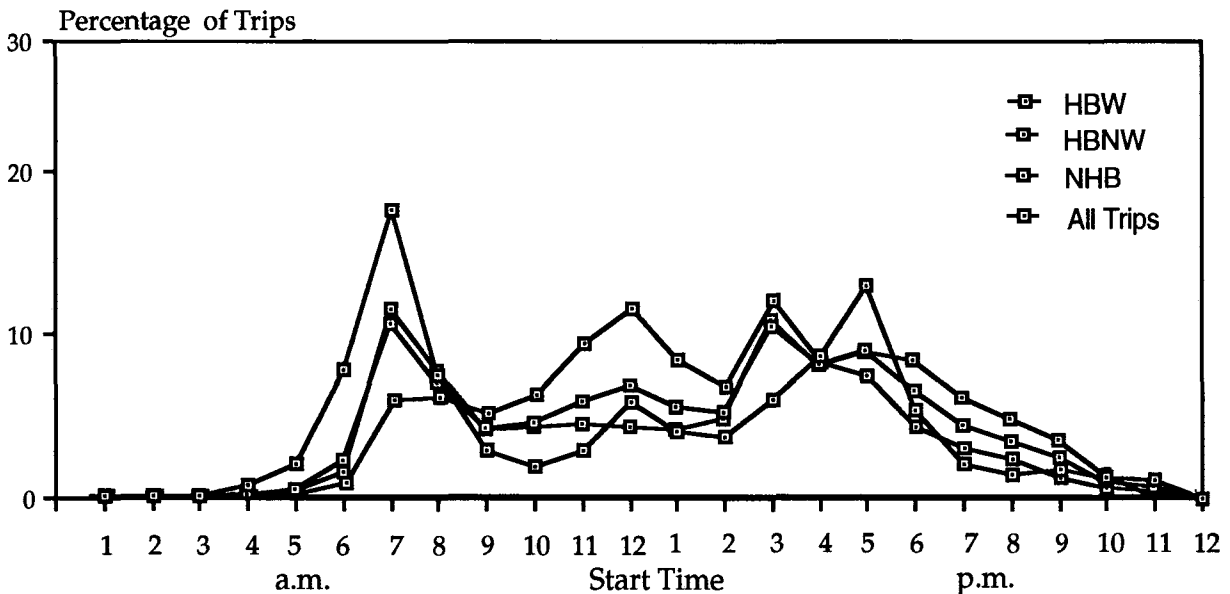
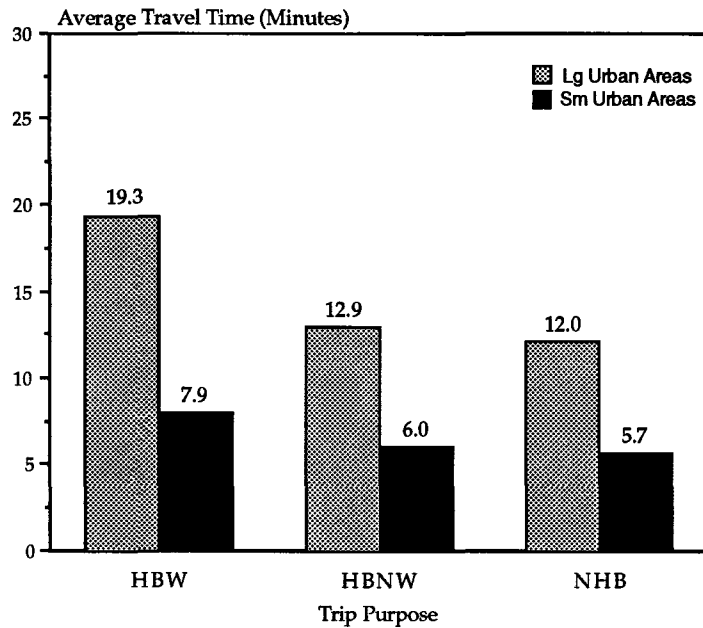


Figure 14. Distribution of Small Urban Area Trips by Start Time



Based on computed travel times from transportation network

Figure 15. Average Travel Time per Vehicle Trip (1990)

Trip Duration and Trip Length

In 1990, the average length of vehicle trips in large urban areas in terms of time was nearly 15 minutes. In small urban areas the average time was just over 6 minutes. The large urban areas included Dallas-Fort Worth and San Antonio; Amarillo, Brownsville, Tyler, and Sherman-Denison were included in the small urban areas analyzed in this section. Figure 15 presents the average time per vehicle trip by trip purpose for both large and small urban areas. Home based work trips are the longest in terms of time for both. Figure 16 presents the change in average travel time by trip purpose as observed since the origin-destination surveys were done in the 1960's and 1970's. Of interest is the

significant increase observed in the large urban areas; very little change was noted in the small urban areas. This may be due to the combination of urban area size, increasing suburbanization, and increasing congestion in the larger urban areas.

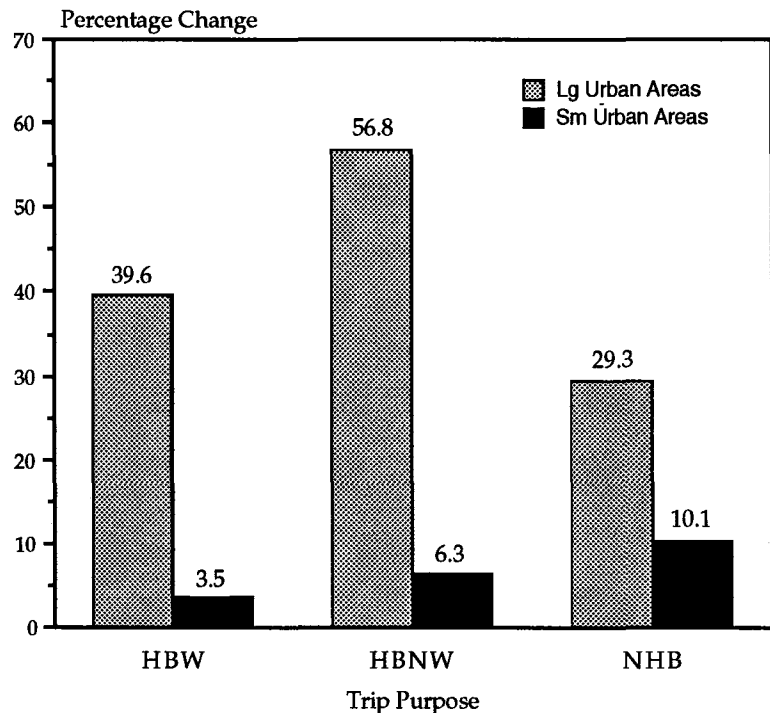


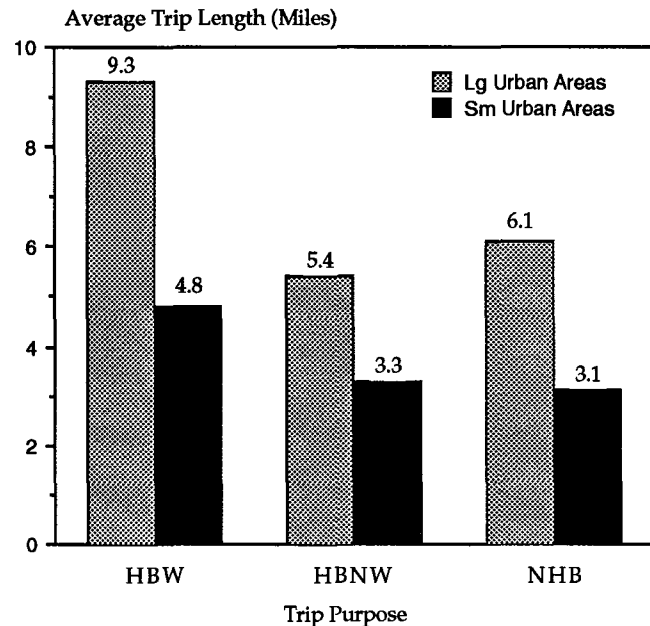
Figure 16. Percentage Change in Average Travel Time (1960 - 1990)

The average length of vehicle trips in large urban areas in terms of distance was 6.5 miles in 1990. In small urban areas, the average distance was 3.5 miles. This difference is probably due largely to the differences in physical size of the areas involved. Figure 17 presents the average trip length in miles by trip purpose for both large and small urban areas. As with travel time, home based work trips are typically the longest in length.

On a per household basis, the survey results indicate an average of 42 vehicle miles driven with a total vehicle travel time of over 1.5 hours per day per household in the large urban areas. These values in the small urban areas are, respectively, 24 vehicle miles driven and less than one hour of vehicle time. It should be noted that while vehicle trips are shorter in distance and time within the small urban areas, households in these areas typically make more vehicle trips than those in the large urban areas.

Trips per Employee

In the workplace surveys, workplaces were arranged into three groups: basic, retail, and service. Both employees and non-employees were surveyed at each workplace with the sample results expanded to estimate the total person and vehicle trips made to and from the workplace. These trips are referred to as attractions and are normally represented in terms of the number of attractions per employee. Figure 18 presents the average attractions per employee for each type of industry in the large and small urban areas surveyed. These values represent simple averages, and care should be exercised in their use and interpretation. It was noted that the attractions varied considerably between the workplaces surveyed. The values do illustrate the differences in the attractiveness of these three types of industry and provide better tools for predicting and modeling attractions.



Based on computed travel distance from transportation network

Figure 17. Average Trip Length per Vehicle Trip (1990)

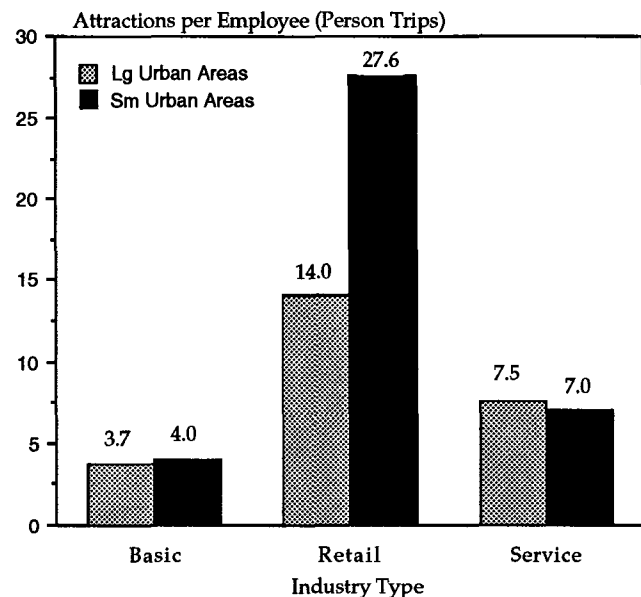


Figure 18. Average Attractions per Employee by Industry Type (1990)

Special Generators

In addition to the workplace surveys, special generators were identified and surveyed independently in four of the urban areas. These activity centers are considered unique in their trip generating characteristics and independent efforts are made to model the trips produced and attracted by these activity centers to more accurately reflect their unique characteristics. Figures 19 and 20 present the average attraction rates for the generators surveyed in both large and small urban areas.

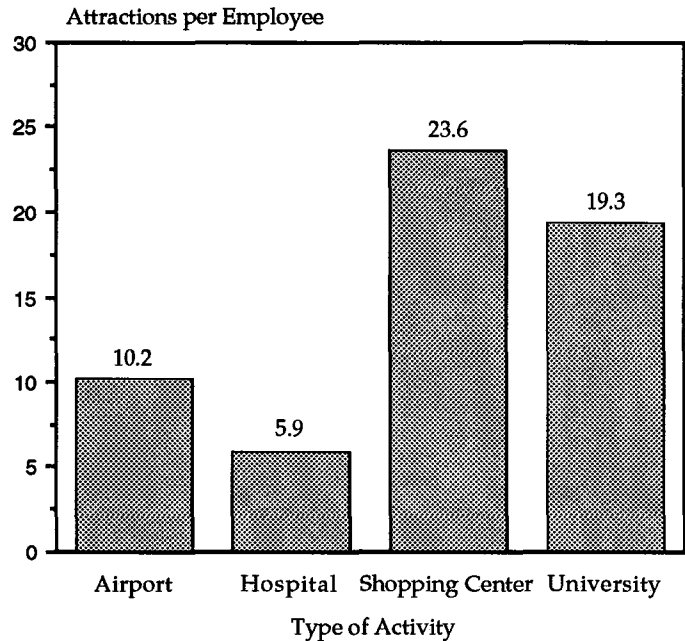
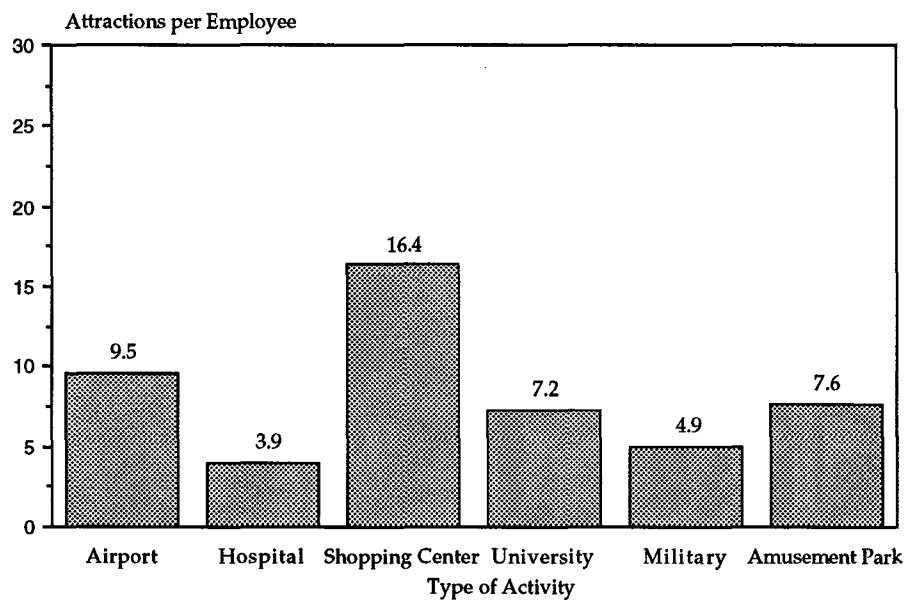


Figure 19. Special Generator Attraction Rates, Small Urban Areas



Data from San Antonio and
Dallas-Fort Worth

Figure 20. Special Generator Attraction Rates, Large Urban Areas



Other Major Findings

The analysis of the survey data has encompassed a wide area of subjects, many of which are only mentioned in this report and will be documented in later reports. Two areas deserve mention, however; those deal with the issue of transferability of trip rates and the stability of trip rates over time.

Transferability of Trip Rates

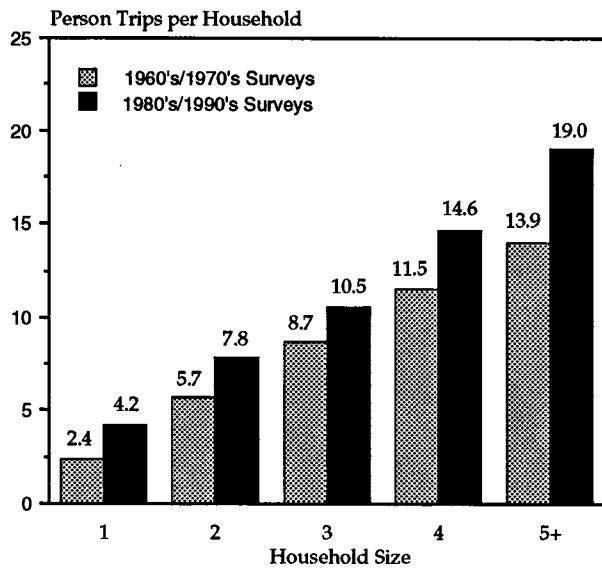
One of the primary uses for information from the travel surveys is the development of trip rates for use in trip generation models which estimate the number of trips that will be produced and attracted by subareas (called zones) within urban areas. Since these models must be developed and used within 25 urban areas in Texas, one of the issues raised has been the transferability of the trip rates between urban areas. Following an analysis of the differences between trip rates stratified by different variables, a recommendation was made that TxDOT use household income and household size as independent variables in stratifying trip rates. Five categories were recommended for each variable. With this established, it was then possible to compare the stratified trip rates between the urban areas surveyed to determine if any significant difference could be found. A finding of no significant difference would indicate that the trip rates were essentially the same and could be transferred between the areas.

It was necessary to divide the urban areas surveyed into categories of large and small since it had already been established that a significant difference existed between the trip rates for large urban areas and small urban areas. Of the five small urban areas surveyed, only four were comparable in terms of stratified trip rates (i.e., based on the recommended stratifications). These areas were Amarillo, Brownsville, Tyler, and Sherman-Denison. The stratified person and vehicle trip rates for three trip purposes, plus totals, were compared between the four urban areas and analyzed statistically to determine if there were any significant differences. A total of 1,200 pairs of trip rates were compared. Of the 1,200 comparisons, just over 13 percent were found to be significantly different. The trip rates found to be significantly different appeared in different strata with no identifiable pattern. The implication was that the stratified trip rates for the small urban areas were very similar. The data from the small urban areas were combined

(i.e., pooled) into one data set and used to develop a set of pooled trip rates. A set of weighted average trip rates was also developed for analysis. These were then used to estimate the trips for those small urban areas, and the results were compared to the results from the individual surveys. The findings indicated that use of the pooled trip rates would result in estimates with errors ranging from less than 1 percent to as high as 12.3 percent. The average error was 5.3 percent. Similar results were found when the weighted averages were used. These were not considered significant due to the small sample sizes in the surveys. It was found, however, that using pooled (or weighted average) trip rates produced more error in the estimates of trips (by trip purpose) for the stratification variables. For example, the average error for estimates of home based work trips being produced by households with an annual income between zero and \$4,999 was 34 percent. The average error for all income stratifications ranged from 9 to 14 percent and for the household size stratifications from 5 to 9 percent. The use of pooled or weighted average trip rates will yield reasonable estimates of overall trips but may have significant errors in estimating trips by stratification category.

The different time periods and survey methodologies precluded the direct comparison of stratified trip rates (using the recommended stratifications) between the large urban areas. A comparative analysis was done on trip rates stratified by household size and vehicle availability from Dallas-Fort Worth, Houston, and San Antonio. Of the 480 trip rates compared, 10 percent were found to be significantly different. The implication is that, as with the small urban areas, the trip rates for the large urban areas are very similar. As with the small urban areas, it was felt that the use of pooled (or weighted average) trip rates would produce reasonable estimates of the overall trips being produced but significant error may result for certain categories of households.

A recommendation was made to TxDOT that trip rates be transferred between urban areas of similar size and socioeconomic characteristics for use in estimating trip productions until travel surveys could be conducted in those areas and used to update the travel models. Trip rates were developed for use in all major urban areas in Texas.



Data are for Amarillo, Brownsville, and Texarkana

Figure 21. Temporal Changes in Person Trips per Household, Small Urban Areas

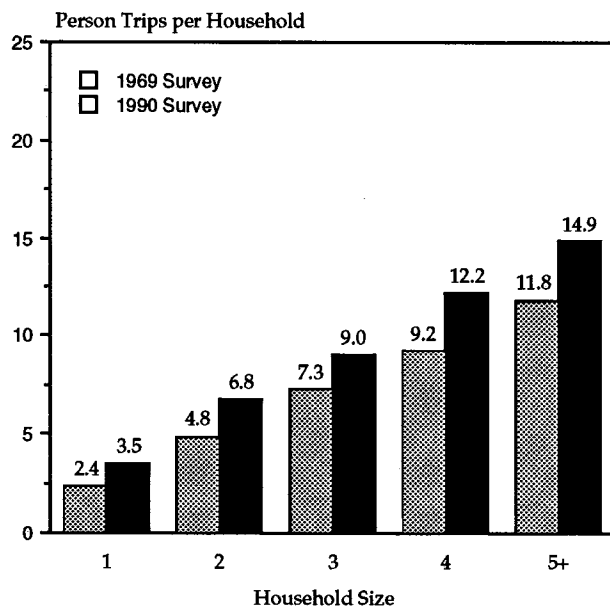


Figure 22. Temporal Changes in Person Trips per Household, San Antonio

in travel patterns and those likely to occur in the future will require more frequent surveys and an ongoing effort to monitor travel patterns.

Stability of Stratified Trip Rates over Time

An analysis was also performed to determine the stability of stratified trip rates over time. In the trip generation phase of travel demand modeling, the assumption is made that stratified trip rates remain constant over time with changes in travel being explained by changes in socioeconomic conditions. Only a limited analysis was possible due to the lack of historical data in most of the urban areas. The analysis found that stratified trip rates have changed significantly over time. This is illustrated in Figures 21 and 22 which present the changes in person trips per household for small urban areas and for San Antonio.

This may appear to be in conflict with the findings presented in the previous sections of this report (i.e., average person trips per household have remained stable), but it is not. The shift in the population distributions toward smaller household sizes has counterbalanced the increase in trip rates at the stratified level. For example, a three-person household in San Antonio with an income between \$5,000 and \$7,000 in 1969 averaged 1.83 person trips per day. In 1990, a three-person household with the same annual income in constant dollars averaged 2.26 person trips per day, an increase of nearly 24 percent. The difference between 1969 and 1990 is that there are fewer three-person households in that income range. The net effect in terms of overall travel is that regional average person trip rates have remained fairly stable while in nearly all cases vehicle trips per household have increased.

The significance of these findings is that the assumptions of constant trip rates over time do not necessarily hold in all cases. To adequately understand and anticipate these types of changes



Summary

In summary, the travel surveys initiated by the Texas Department of Transportation have resulted in the following findings:

- Travel in urban areas with greater than 200,000 population occurs at different rates than travel within urban areas with less than 200,000 population.
- One out of every five person trips is a home based work trip in large urban areas. In small urban areas, one out of every six person trips is home based work. In terms of vehicle trips, one out of every four trips is home based work in large urban areas; and in small urban areas, one out of every five trips is home based work.
- A significant shift has occurred since the 1960's and 1970's in travel patterns for both person and vehicle trips within urban areas in Texas. Home based non-work travel has declined and non-home based travel has increased significantly.
- Since the 1960's and 1970's, home based work person and vehicle trips per household have increased in both large and small urban areas. Home based work vehicle trips per household have increased at three to four times the rate of person trips per household.
- Since the 1960's and 1970's, home based non-work person and vehicle trips per household have declined with the exception of vehicle trips for small urban areas which showed a slight increase. The decline in home based non-work vehicle trips was three to four times less than that for person trips.
- Since the 1960's and 1970's, non-home based person and vehicle trips per household have increased from three to six percent.
- Overall average person trips per household have not changed since the early travel surveys. Overall average vehicle trips per household have increased over 10 percent. These reflect the influence of changing socioeconomic conditions within major urban areas, the primary ones being declining household size, increasing vehicle availability, and increasing numbers of two-worker households.
- Households in large urban areas tend to make more home based work trips and fewer home based non-work and non-home based trips than their counterparts in small urban areas. Total travel per household in the large urban areas is less than in the small urban areas.

-
- The average household size has declined in all of the urban areas surveyed since the original surveys were done in the 1960's and 1970's. This has had a significant impact on travel; the number of person trips per person have increased 13 percent in both large and small urban areas.
 - Average reported vehicle occupancy has declined 18 percent in large urban areas and 15 percent in small urban areas. This is reflected in the 13 percent increase in the percentage of trips by auto drivers and the 27 percent decrease in the percentage of trips by auto passengers.
 - In large urban areas, households average 42 vehicle miles and 1.5 vehicle hours of travel per day. In small urban areas, households average 24 vehicle miles and less than one vehicle hour of travel per day.
 - Attraction rates for basic and service workplaces are approximately the same for both large and small urban areas. A significant difference was found in the attraction rates for retail workplaces in large and small urban areas. The variances associated with the attraction rates indicate a need for additional data and research in this area.
 - Trip production rates were found to be transferable between small urban areas in terms of the recommended stratifications. The analysis also indicated that the trip rates for large urban areas are probably transferable. While found to be transferable, the limited amount of data (i.e., four small urban areas and three large urban areas) requires that caution be exercised in the use of transferred trip rates; and it is recommended that travel surveys be done in all of the urban areas, if feasible.
 - Stratified trip rates have significantly increased since the travel surveys done in the 1960's and 1970's. A three-person household in 1990 made 24 percent more trips than a household of the same size and economic status in 1969.
 - While stratified trip rates have increased significantly, the shifts in the distributions of households by the same stratifications have resulted in no change in overall average person trips per household. If shifts in the distributions of households stabilize in the future, continuing increases in the trip rates may result in unprecedented increases in travel. A need exists to conduct additional travel surveys in urban areas throughout Texas and develop a means for continually monitoring travel trends within Texas.

