GIS Models for Analyzing Intercity Commute Patterns: A Case Study of the Austin-San Antonio Corridor in Texas

0-5345-R2

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EXECUTIVE SUMMARY

The growth of commuting traffic from rural communities to urban centers creates heavier traffic and therefore contributes to traffic congestion along some travel corridors. TxDOT research project 0-5345 aims to achieve a better understanding of intercity commute patterns in Texas and finding regional public transportation solutions for intercity commuting problems. This project is undertaken by an interdisciplinary team consisting of Texas Southern University, Texas State University-San Marcos (Texas State), Texas Transportation Institute, and Prairie View A&M University. The Texas State team is responsible for research Tasks 8-11 as outlined in the TxDOT Project 0-5345 contract (Appendix A of this report). This report summarizes the research activities and accomplishments of the Texas State Team during the period from September 16, 2005 to October 31, 2006. These accomplishments are listed below.

- The development of a set of Geographic Information System (GIS) based analysis models for the identification of intercity commuting patterns and travel corridors in Central Texas;
- An examination of commuting patterns between rural communities and urban areas as well as commuting flows between different counties (cities) in a five-county study area in Central Texas based on the U.S. 2000 Census Journey-to-Work data;
- An identification of traffic corridors that carry a significant amount of intercity and rural-to-urban traffic in the five-county study area based on the U.S. 2000 Census Journey-to-Work data and the 2005 TTI external travel survey data;
- The identification of rural communities that generated the largest numbers of commuting traffic and road segments that carried a high volume of traffic.

Methods and analyses. The Texas State research team developed GIS-based methods to analyze the 2000 Census Transportation Planning Package (CTPP) Part 3 Journey–to-Work data and the 2005 External (Travel) Survey Data provided by the Texas Transportation Institute (TTI) at Texas A&M University. Details of these methods are provided in Sections 2.1 and 3.1 of this report. The team used these models to identify commuting patterns between rural communities and urban areas as well as commuting flows between different counties and cities in the 5-county study area. In addition, the team developed a GIS-based network analysis model for identifying commute routes between different origins and destinations. Details of the network analysis procedures are given in Section 3.2 of this report. Different corridors that carried a significant amount of commuting traffic in the five-county study area were identified using the network analysis model.

Preliminary conclusions. Based on the analysis results, the research team has reached a set of preliminary conclusions as listed below.

- The GIS-based analysis models are effective for analyzing commuting patterns and travel corridors in both the Census Journey-to-Work data and the TTI external survey data.
- Commute flows between urban and rural areas account for about 20% of the total commute traffic in the five-county (Bexar, Comal, Hays, Travis, and Williamson) study area, and Inter-county commute accounts for 13% of the total commute traffic in the five-county study area.
- The majority of the top rural communities with high commute flows to urban communities are located in northern and northwestern parts of Travis County and scattered in the western, northern, eastern, and southeastern parts of Bexar County.
- Road segments with high traffic volumes are on IH-35 between East Martin Luther King Jr. Blvd and US-290 in Austin. This observation indicates that this section of IH-35 receives significantly more commuting traffic than the rest of roadways in the study area.

1. Introduction

1.1 Study Objectives

The growth of commuting traffic from rural and suburban areas to urban centers creates heavier traffic that contributes to traffic congestion along some travel corridors. These heavy congestion scenarios may represent opportunities for transportation demand management efforts, including the development of public transportation services that are regional or intercity in nature. This report summarizes the work completed at Texas State University-San Marcos as part of TxDOT research project 0-5345. Exact tasks of this part of the research project are described in Appendix A of this report. Specific aims of this project included:

- The development of a set of Geographic Information System (GIS) based analysis models for the identification of intercity commuting patterns and travel corridors in Central Texas;

- An examination of commuting patterns between rural areas and urban areas as well as commuting flows between different counties (cities) in a five-county study area in Central Texas based on the U.S. 2000 Census Journey-to-Work data;

- An identification of traffic corridors that carry a significant amount of intercity and rural-to-urban traffic in the five-county study area based on the U.S. 2000 Census Journey-to-Work data and the 2005 TTI external travel survey data;

- The identification of rural areas that generated the largest numbers of commuting traffic and road segments that carried a high volume of traffic.

1.2 Study Area

The study area covers five counties, Bexar, Comal, Hays, Travis, and Williamson, in the Austin-San Antonio corridor in Central Texas (Figure 1). This area encompasses two metropolitan areas: the Austin metropolitan area and the San Antonio metropolitan area. The Austin metropolitan area includes three counties, Williamson, Travis, and Hays. The city of Austin is located in Travis County. The San Antonio metropolitan area consists of Bexar County only. Comal County connects the Austin metropolitan area with the San Antonio metropolitan area. As can be seen from Figure 1, the majority of the urban area in the study area is located in Travis County and Bexar County. There has been significant commuting traffic between different areas in the five-county study area. A clear understanding of the geographic distribution of the origins and destinations of the commuting traffic as well as the traffic flows between different areas within a county and between different counties will provide transportation planners with information to improve public transportation services in the area.

1.3 Overview of This Report

The rest of this report comprises of two sections. Section 2 reviews Census Transportation Planning Package (CTPP) Part 3 Journey-to-Work data (Bureau of Transportation Statistics. 2000). This section analyzes and summarizes the characteristics of the geographic distribution of commuters and vehicles used in commute travels, average travel time of communities, commute

flows between different geographic areas, and commute flows between areas served by different public transportation systems in the study area. Section 3 focuses on identifying the major travel corridors in the study area based on the CTPP Part 3 data and the 2005 external survey data from the Texas Transportation Institute (TTI). Section 4 provides a summary and lists some preliminary conclusions.

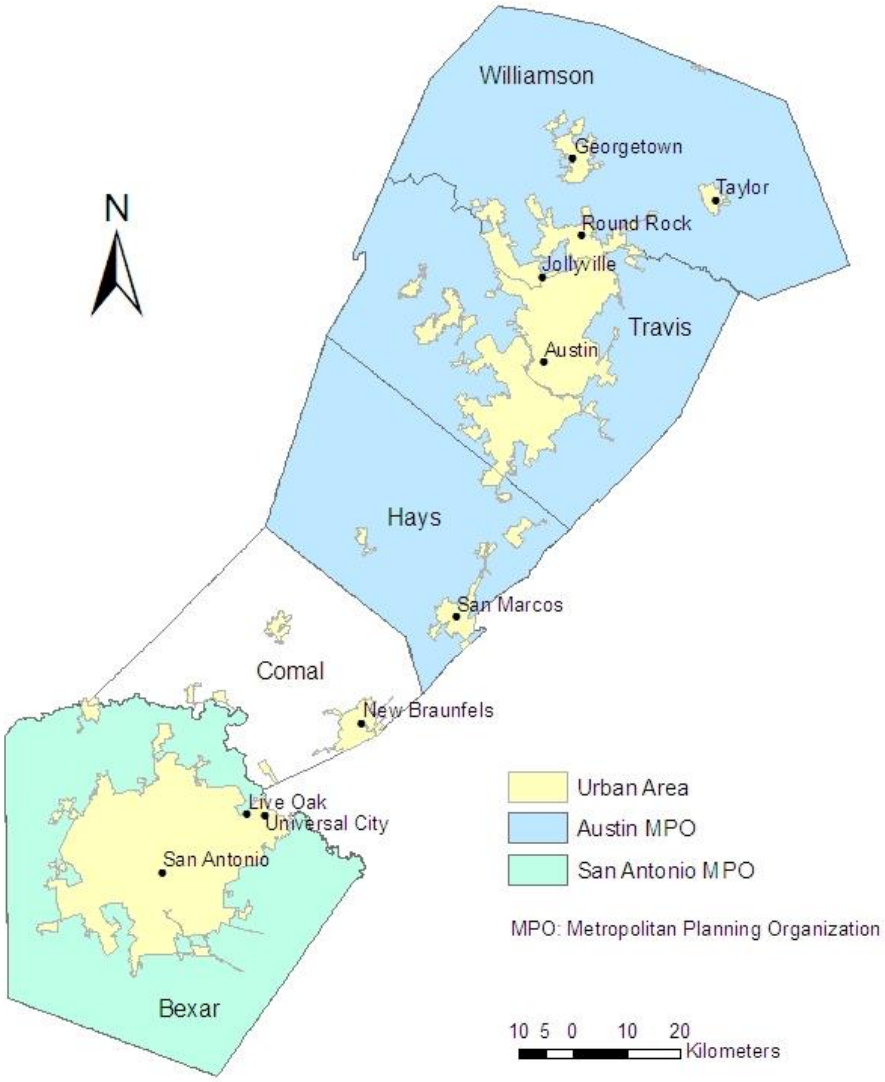


Figure 1. Study Area – Central Texas

2. A Review of Travel Data Related to Home and Job Locations

2.1 Data Source and Data Preparation

2.1.1 Data used in the study

CTPP Part 3 Journey-to-Work data

The analyses discussed in this section are based on the Census Transportation Planning Package (CTPP) Part 3 Journey–to-Work data (Bureau of Transportation Statistics. 2000). The CTPP Part 3 data consist of a set of tables containing journey-to-work characteristics at several summary levels corresponding to different geographic scales. These geographic scales include state level data, county level data, area units of different places, and traffic analysis zones (TAZ). Traffic analysis zones are defined by state and regional transportation agencies and are specifically used for traffic analysis. CTPP is the only dataset that provides information at the TAZ level.

Each table in the CTPP Part 3 database provides data about a unique variable describing some characteristics of commute trip from home to work. These characteristics include the total number of workers, the socio-economic characteristics of workers, the number of workers with regard to travel modes, the average travel time for commute trips with the same origin and destination. We used data from three CTPP Part 3 data tables—Table 001, Table 008, and Table 0010—at the TAZ level for the analysis in this study. Table 001 gives information about the number of workers for each unique pair of residence TAZ and workplace TAZ. Table 008 contains information about workers' average travel time from residences to workplaces for different transportation modes and different time periods during which a person leaves home for work. Table 0010 provides aggregated information about the number of vehicles leaving home for work at different time periods. Different transportation modes and time periods in the three CTPP Part 3 data tables are summarized in Table 1 of this report below.

Table 1: Transportation Modes and Time Periods for a Person to Leave Home for Work

Transportation Modes	Time Leaving Home for Work
Transportation modes	Different time periods leaving home for work
Drove Alone	From 5:00 A.M. to 8:59 A.M
Travel to Work by 2-Person Carpool	From 9:00 A.M. to 4:59 A.M
Travel to Work by 3-or-More-Person Carpool	Working at Home
Travel to Work by Bus	
Travel to Work by Streetcar, Subway, Railroad or Ferryboat	
Travel to Work by Bicycle, Walked, Taxicab, Motorcycle or Other Means	
Worked at Home	

GIS Map Layers of Census Traffic Analysis Zones (TAZ)

In order to visualize spatial variations of the total number of workers, the total number of vehicles leaving home for work, and the average travel time at the TAZ level, it is necessary to associate values of these variables with their corresponding TAZs. We downloaded Census TAZ shapefiles in the five-county area from the Geography Network website (www.geographynetwork.com) and used the shapefiles as the GIS map layers for the analysis and visualization. A shapefile is simply a specific format of storing a GIS map layer in a computer (ESRI 1998). Once we have Table 001, Table 008, and Table 0010 from CTPP Part 3 and the GIS map layers at the TAZ level, we are ready to prepare the data for analyses.

2.1.2 Data preparation

Data Preparation related to TAZ Shapefiles

Shapefiles downloaded from the Geography Network website were for individual counties only. Therefore, it was necessary to merge them together to obtain the GIS map layer for the entire study area. In addition, in order to link the CTPP Part 3 data tables with the GIS map layer, we created a common identifier for each TAZ in the tables and the GIS map layer. We used the steps described below to process the shapefiles.

1) Use the merge tool in ArcGIS to merge the TAZ shapefiles of the five-county area into a single shapefile;
2) Project the merged shapefile using the 'North_America_Lambert_Conformal_Conic' projection using the projection tool in ArcGIS;
3) Create an ID field named "stfid" in the attribute data table of the projected TAZ shapefile;
4) Assign IDs to "stfid" for each TAZ using "county+taz", i.e., combining the values of two existing fields in the attribute data table to create the IDs; This task can be achieved using the 'Calculate' command in ArcGIS.

Data Preparation related to CTPP Part 3 Tables

We used a 7-step procedure described below to prepare data from the CTPP Part 3 data tables for analysis based on workers' residence locations. After the data preparation, we can analyze and map spatial variations of the number of workers, number of vehicles leaving home for work, and the average travel time in each TAZ based on workers' residence locations.

1) Extract data associated with residence locations from the CTTP Part 3 tables-Table 001, Table 008, and Table 0010-within the five-county area and save the data into new tables;
2) Create an ID field named "stfid_res" in each of the new tables.
3) Assign/Calculate the value of "stfid_res" for each record as "residence state+residence county+residence TAZ"; (Note: These attributes are named as "state3", "county", and "detresgeo" in the Tables.)
4) For each new table, aggregate the records based on "stfid_res" using the 'summarize' function in ArcGIS and save the results as another new table;
    - For data from Table 001, summarize the total number of workers for each residence TAZ; the new table is called summarized Table 001;

- For data from Table 008, summarize the average travel time for each transportation mode (Table 1) for every residence TAZ; the new table is called summarized Table 008;
- For data from Table 0010, summarize the total number of vehicles leaving in each time period (Table 1) for every residence TAZ; the new table is called summarized Table 0010;

5) Join summarized Table 001 to the TAZ shapefile using field "stfid_res" in summarized Table 001 and field "stfid" in the TAZ shapefile obtained in the previous steps as the 'key;'
6) Export the TAZ shapefile with the joined attributes from summarized Table 001 to a new shapefile; now we have a shapefile containing information about the number of workers in each TAZ;
7) Repeat Steps 5 and 6 to perform similar operations for summarized Tables 008 and 0010; we then obtain another two shapefiles containing information about the average travel times corresponding to different transportation modes and the number of vehicles leaving home for work in each time period.

We then used a similar procedure to process the data from the CTPP Part 3 data tables for analysis based on workers' workplace locations. There are, however, some differences in the procedure as described below.

1) Extract data based on workplace (rather than residence).
2) Create a unique ID, "stfid_wp", based on workplace.
3) Calculate "stfid_wp" as "workplace state+workplace county+workplace TAZ." (These attributes are defined as "qpowst", "qpowco", and "detworkgeo" in the tables.)
4) Summarize the statistics based on "stfid_wp", and link the data with those in the merged TAZ shapefile using "stfid_wp" in the summarized tables and "stfid" in the TAZ shapefile as the key for linking.

2.2 Geographic Distribution of Commuters

2.2.1 Distribution of workers based on residence locations

Based on workers' residence locations, there are a total of 1,229,662 workers in the five-county area. The destinations of these workers' commute can be anywhere within or outside the five-county area. Among the workers, 1,195,692 (97.24%) worked in the five-county area (Table 2). Because only 2.76% of all workers who lived in the study area had workplaces outside the study area, we decided to focus our analyses on analyzing the distribution of workers whose residences and workplaces were within the five-county area. Figure 2(a) shows the distribution of workers with workplaces within the five-county area based on their residence TAZs. We can summarize the results from the analyses as follows.

- About 82.91% of the workers lived in Bexar County (48.23%) and Travis County (34.68%) (Table 2(a),). This is not surprising because two major cities, San Antonio and Austin, are located in these two counties in the study area.
- About 92.85% workers resided and worked in different TAZs in the five-county study area (Table 2(c)).

- The percentage of workers in Bexar County (93.33%) who had different residence and workplace TAZs was higher than that in other counties (Table 2(c) percentage2).
- About 11.56% workers with workplaces in a county other than their residence county. Among this group, the percentages in Williamson (54.14%), Hays (47.99%), and Comal (41.39%) counties exceeded those in Bexar (1.34%) and Travis (6.78%) counties significantly (Table 2(d)).
- Williamson County had the most number of workers with workplaces in other counties, followed by Travis and Hays counties (Table 2(d), Figure 2(b)).
- Bexar County had the least number of workers with workplaces in another county (Table 2(d), Figure 2(b)).
- A careful inspection of Figure 2(b) reveals that workers whose home and job locations were in different counties mainly resided in areas adjacent to the county in which their workplaces were located.

Table 2: Summary Information about Workers Based on Residence Locations in a TAZ

(a) Total Number of Workers Who Lived within the Five-County Area

County		No. of OD pairs	No. of Workers	Percentage1
Austin MPO	Hays	5,558	49,968	4.06
	Travis	30,029	426,452	34.68
	Williamson	10,443	124,922	10.16
	Sub-Total	**46,030**	**601,342**	**48.90**
San Antonio MPO	Bexar	50,711	593,076	48.23
	Comal	2,909	35,244	2.87
Total		**99,650**	**1,229,662**	**100.00**

(b) Number of Workers Who Lived and Worked in the Five-County Area

County		No. of OD pairs	No. of Workers	Percentage1
Austin MPO	Hays	5,294	47,973	4.01
	Travis	29,043	418,293	34.98
	Williamson	9,915	121,269	10.14
	Sub-Total	**44,252**	**587,535**	**49.13**
San Antonio MPO	Bexar	48,571	575,484	48.13
	Comal	2,600	32,673	2.73
Total		**95,423**	**1,195,692**	**100.00**

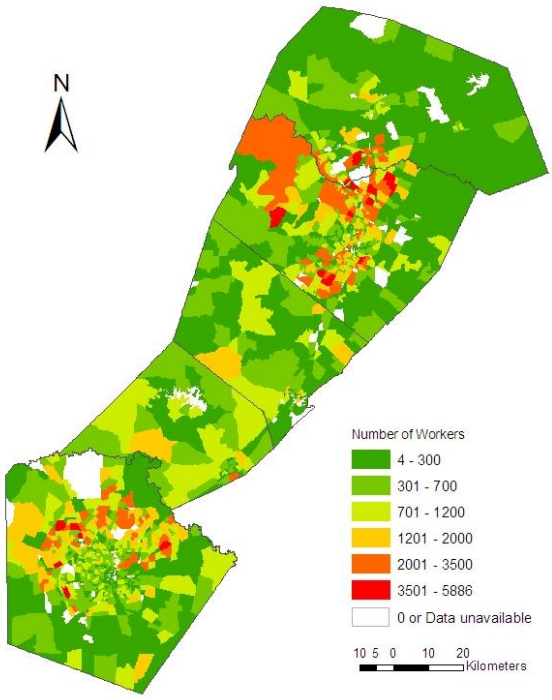
(c) Number of Workers with Their OD Pairs in Different TAZs in the Five-County Area

County		No. of OD pairs	No. of Workers	Percentage1	Percentage2
Austin MPO	Hays	5,189	43,913	3.96	91.54
	Travis	28,627	387,671	34.92	92.68
	Williamson	9,713	111,938	10.08	92.31
	Sub-Total	**43,529**	**543,522**	**48.96**	**n/a**
San Antonio MPO	Bexar	47,880	537,099	48.38	93.33
	Comal	2,543	29,605	2.67	90.61
Total		**93,952**	**1,110,226**	**100**	**n/a**

(d) Number of Workers with Their ODs Pairs between TAZs in Different Counties in the Five-County Area

County		No. of OD pairs	No. of Workers	Percentage1	Percentage2
Austin MPO	Hays	3,198	23,022	16.65	47.99
	Travis	2,479	28,359	20.51	6.78
	Williamson	5,826	65,659	47.48	54.14
	Sub-Total	**11,503**	**117,040**	**84.64**	**n/a**
San Antonio MPO	Bexar	908	7,715	5.58	1.34
	Comal	1,508	13,523	9.78	41.39
Total		**13,919**	**138,278**	**100.00**	**n/a**

Note: Percentage1= (No. of workers for each county / the total No. of workers)*100
Percentage2 = (No. of workers in table (c) or (d) / the No. of workers in the corresponding cell in Table (b))*100
OD = origin (residence location) and destination (workplace location)



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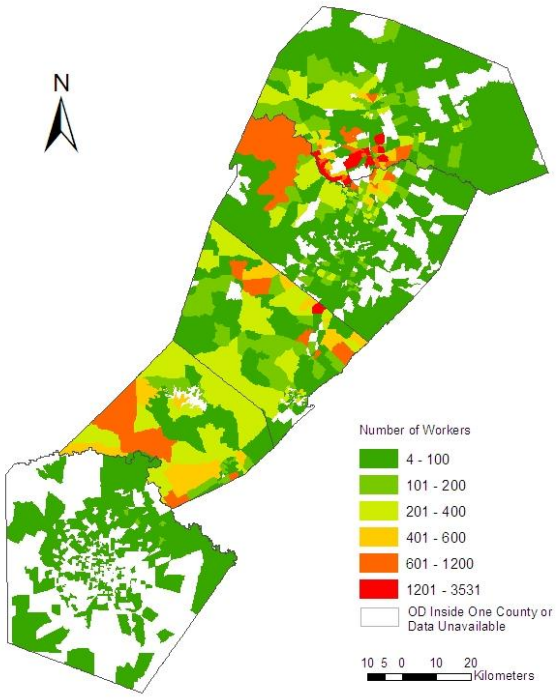


(b)

Figure 2. Distribution of workers based on residence locations in a TAZ: (a) Number of workers with workplaces anywhere within the five-county area; (b) Number of workers with residences and workplaces in different counties.

2.2.2 Distribution of workers based on workplace locations

There were a total of 1,305,535 people who worked in the five-county study area based on the 2000 census. This figure suggests that the number of people who worked in the five-county area exceeded the number of people who had their residences in the five counties. Among these workers, 1,195,692 (91.59%) resided in the five-county area (Table 3 (a) and (b)). A number of observations can be made when reviewing the geographic distribution of workers in the study area based on workplace locations of these workers. These observations are summarized below.

- For workers who had their workplaces inside the five-county study area, about 88.62% of the workers had their workplaces in either Bexar County (48.57%) or Travis County (40.05%) (Table 3(b)).
- Among the workers who worked in Travis County, 18.57% of them lived in other counties in the five-county area. Among the workers who worked in Bexar County, only 2.24% of them lived in other counties in the five-county area (Table 3(d)).
- Compared to the number of workers who lived in Travis County (426,452) (Table 2(a)), 89,220 more workers worked in Travis but lived outside the county (Table 3(a)). In contrast, there were fewer workers who worked in Comal, Hays, and Williamson Counties than those who lived in the three counties (Table 2(a) and Table 3(a)). This trend is especially obvious in Williamson County and Hays County (Table 2(a), Table 3(a), Figure 2 (a), and Figure 3(a)).
- For people who had their residence and workplace locations in different TAZs (Table 3(c)), the number of workers who worked in Bexar (542,386) and Travis (448,215) Counties exceeded the number of workers who lived in Bexar (537,099) and Travis (387,671) Counties. In contrast, the number of workers who worked in Comal (21,653), Hays (26,408), and Williamson (71,564) Counties was less than the number of workers who lived in Comal (29,605), Hays (43,913), and Williamson (111,938) (Table 3(b)).
- In addition, when examining the patterns of workers with residences and workplaces in different counties, we found out that 138,278 workers traveled between counties to work. Travis County attracted significantly more workers from other counties to work there than other counties, followed by Williamson County (Figure 3(b)).
- It can be seen from Tables 2 and 3 that although Bexar County had the most number of workers based on both residence and workplace locations, Travis County attracted more people to work in the county from surrounding counties, especially from Williamson County.
- In Bexar County, people with residence and workplace locations in different counties mostly had their workplaces located in the northern part of the county (Figure 3(b)).
- In Travis County, workers with residence and workplace locations in different counties scattered throughout the county with a higher concentration in the central and northern parts of the county (Figure 3(b)).
- In Williamson County, people with residence and workplace locations in different counties concentrated in the southern portion of the county (Figure 3(b)).

Table 3: Summary Information about Workers Based on Workplace Locations in a TAZ

(a) Number of Workers Who Worked in the Five-County Area

County		No. of OD pairs	No. of Workers	Percentage1
Austin MPO	Hays	3,253	36,230	2.78
	Travis	38,777	515,672	39.50
	Williamson	7,137	88,240	6.76
	Sub-Total	**49,167**	**640,142**	**49.04**
San Antonio MPO	Bexar	54,893	634,082	48.57
	Comal	2,329	31,311	2.40
Total		**106,389**	**1,305,535**	**100.00**

(b) Number of Workers Who Lived and Worked in the Five-County Area

County		No. of OD pairs	No. of Workers	Percentage1
Austin MPO	Hays	2,742	30,468	2.55
	Travis	35,575	478,837	40.05
	Williamson	6,247	80,895	6.77
	Sub-Total	**44,564**	**590,200**	**49.37**
San Antonio MPO	Bexar	49,124	580,771	48.57
	Comal	1,735	24,721	2.07
Total		**95,423**	**1,195,692**	**100.00**

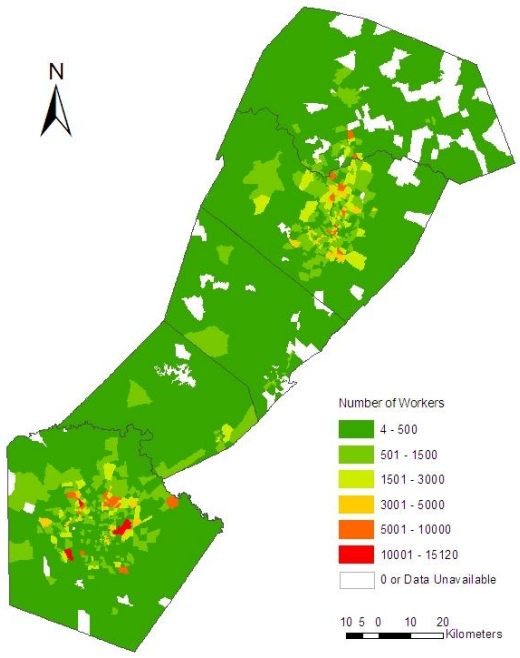
(c) Number of Workers with Their OD Pairs in Different TAZs in the Five-County Area

County		No. of OD pairs	No. of Workers	Percentage1	Percentage2
Austin MPO	Hays	2,637	26,408	2.38	86.67
	Travis	35,159	448,215	40.37	93.60
	Williamson	6,045	71,564	6.45	88.47
	Sub-Total	**43,841**	**546,187**	**49.20**	**n/a**
San Antonio MPO	Bexar	48,433	542,386	48.85	93.39
	Comal	1,678	21,653	1.95	87.59
Total		**93,952**	**1,110,226**	**100.00**	**n/a**

(d) Number of Workers with Their OD Pairs between TAZs in Different Counties in the Five-County Area

County		No. of OD pairs	No. of Workers	Percentage1	Percentage2
Austin MPO	Hays	646	5,517	3.99	18.11
	Travis	9,011	88,903	64.29	18.57
	Williamson	2,158	25,285	18.29	31.26
	Sub-Total	**11,815**	**119,705**	**86.57**	**n/a**
San Antonio MPO	Bexar	1,461	13,002	9.40	2.24
	Comal	643	5,571	4.03	22.54
Total		**13,919**	**138,278**	**100.00**	**n/a**

Note: Percentage1= (No. of workers for each county /the total No. of workers)*100
Percentage2 = (No. of workers in table (c) or (d) / the No. of workers in the corresponding cell in table (b))*100
OD = origin (residence location) and destination (workplace location)



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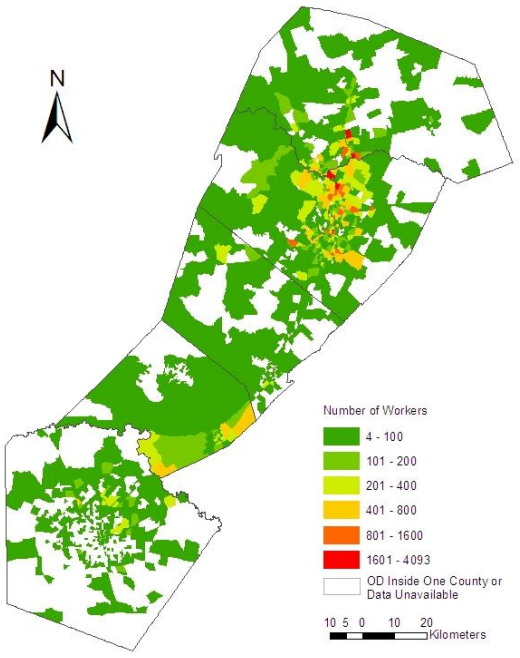


(b)

Figure 3. Distribution of workers based on workplace locations in a TAZ: (a) Number of workers with residences in the five-county area; (b) Number of workers with residences and workplaces in different counties.

2.2.3 Distribution of areas with the largest number of workers

Based on residence locations and workplace locations of commuters, we further investigated the geographic distribution of areas that ranked among the top 20 that had the largest number of workers (Tables 4-9). A number of observations can be made based on the results in Tables 4-9.

- *Observations based on worker's residence locations*
  - In the five-county study area, the majority of the top 20 areas with the largest number of workers are located in Bexar County (6 communities) and Travis County (12 communities) (Table 4). Five of the six areas (except one in Converse) in Bexar County are located in the western part of San Antonio, around W IH-10, W Loop 1604, and NW I-410. Six (ranked 3, 4, 5, 6, 14, and 20) of the twelve areas in Travis County are located in the northern part of the county. Three (ranked 8, 10, and 18) of the twelve areas in Travis County are located in the southern part of the county. It is noticeable that the community in Brushy Creek in west Round Rock is ranked among the top three areas in the list.
  - In the Austin MPO, the top 20 areas with the largest number of workers are located in Travis County (seventeen communities) and Williamson County (three communities) (Table 5). Among the seventeen areas in Travis County, ten (ranked 2, 3, 4, 5, 11, 14, 15, 16, 18, and 20) are located in North Travis, two (ranked 10 and 17) are in West Travis, and five (ranked 6, 7, 8, 9, and 13) are in Southern Travis County.
  - In the San Antonio MPO, the majority of the top 20 areas with the largest number of workers are located in Western and Northern San Antonio (Table 6). Sixteen (ranked 2-6, 9-12, and 14-20) of the 20 areas are located between Loop 1604 and Loop 410. Two (ranked 1 and 13) of the 20 areas are located inside Loop 410 and the other two (ranked 7 and 8) are located outside N Loop 1604.
- *Observations based on worker's workplace locations*
  - In the five-county study area, the majority of the top 20 areas with the largest number of workers with workplaces in these areas are in Bexar County (ten communities) and Travis County (nine communities) (Table 7).
  - In the Austin MPO, the majority of the top 20 areas with the largest number of workers with workplaces in these areas are in Travis County (eighteen communities) (Table 8). Only two are located in Williamson County. Among the eighteen communities, nine areas (ranked1-3, 5, 7, 8, 10, 13, and 15) are located in Central Austin, six areas (ranked 4, 6, 11, 12, 17, and 18) are located in Northern Travis, and three (ranked 16, 19, and 20) are in the southern part of Travis County.
  - In the San Antonio MPO, seventeen (ranked 1, 3, 4, 6-11, and 13-20) of the top 20 areas with the largest number of workers with workplaces in these areas are located north of US-90 (Table 9). Among the seventeen communities, five of them are between US-90 and Loop 410. The other twelve are located outside of N Loop 410.

Table 4: Top 20 Areas with the Largest Number of Workers in the Five-County Area Based on Residence Locations

Rank	Location	County	Number of Workers
1	Lackland AFB	Bexar	5,918
2	Brushy Creek	Williamson	5,859
3	South of Walnut Creek Metropolitan Park	Travis	5,735
4	Windemere	Travis	5,375
5	South Jollyville	Travis	5,096
6	South of Wells Branch	Travis	4,841
7	East of W Loop 1604, south of University of Texas-San Antonio	Bexar	4,759
8	Tanglewood Forest	Travis	4,741
9	Between E Riverside Dr., E Oltorf St, IH-35, and S Pleasant Valley	Travis	4,699
10	East of Dick Nichols District Park	Travis	4,564
11	North of Methodist Specialty Hospital	Bexar	4,523
12	Between Lakeshore Blvd, E Riverside Dr., and S Pleasant Valley	Travis	4,416
13	Lakeway	Travis	4,250
14	Pflugerville	Travis	4,076
15	Jollyville	Williamson	4,000
16	Converse	Bexar	3,922
17	West of W. IH-10, south of University of Texas-San Antonio	Bexar	3,856
18	Dittmar	Travis	3,752
19	East of Hyatt Regency Hill County Resort, West of NW Loop 410	Bexar	3,643
20	Between N Mo-Pac Expy, Spicewood Springs Rd., Mesa Dr., and Far West Blvd	Travis	3,593

Table 5: Top 20 Areas with the Largest Number of Workers in the Austin MPO Based on Residence Locations

Rank	Location	County	Number of Workers
1	Brushy Creek	Williamson	5,859
2	South of Walnut Creek Metropolitan Park	Travis	5,735
3	Windemere	Travis	5,375
4	South Jollyville	Travis	5,096
5	South of Wells Branch	Travis	4,841
6	Tanglewood Forest	Travis	4,741
7	Between E Riverside Dr., E Oltorf St, IH-35, and S Pleasant Valley	Travis	4,699
8	East of Dick Nichols District Park	Travis	4,564
9	Between Lakeshore Blvd, E Riverside Dr., and S Pleasant Valley	Travis	4,416
10	Lakeway	Travis	4,250
11	Pflugerville	Travis	4,076
12	Jollyville	Williamson	4,000
13	Dittmar	Travis	3,752
14	Between N Mo-Pac Expy, Spicewood Springs Rd., Mesa Dr., and Far West Blvd	Travis	3,593
15	Between Rundberg Ln, Powell Ln, N Lamar Blvd, and N IH-35	Travis	3,427
16	South of Wells Branch	Travis	3,412
17	Lago Vista	Travis	3,383
18	West of University of Texas at -JJ Pickle Center	Travis	3,344
19	West of Allen Park, between N Mo-Pac Expy, Northland Dr., Mesa Dr., and Far West Blvd	Travis	3,306
20	Round Rock	Williamson	3,306

Table 6: Top 20 Areas with the Largest Number of Workers in the San Antonio MPO Based on Residence Locations

Rank	Location	County	Number of Workers
1	Lackland AFB	Bexar	5,918
2	East of W Loop 1604, south of University of Texas-San Antonio	Bexar	4,759
3	North of Methodist Specialty Hospital	Bexar	4,523
4	Converse	Bexar	3,922
5	West of W. IH-10, south of University of Texas-San Antonio	Bexar	3,856
6	East of Hyatt Regency Hill County Resort, west of NW Loop 410	Bexar	3,643
7	Between E Evans Rd, N Loop 1604, N US-281, and Bulverde Rd	Bexar	3,528
8	North of The Club at Sonterra	Bexar	3,478
9	Between N Charles Anderson Loop, W Bitters Rd, and Blanco Rd	Bexar	3,441
10	South of Blossom Park	Bexar	3,392
11	West of Woodlake Golf Club, North of Martinez Creek Dam No. 1	Bexar	3,368
12	Between Culebra Rd, W Loop 1604, WeyBridge, and Bowens Crossing St	Bexar	3,331
13	Fort Sam Houston	Bexar	3,317
14	North of Leon Valley, southwest of Methodist Specialty Hospital	Bexar	3,286
15	East of Blossom Park	Bexar	3,209
16	West of Silverhorn Golf Club, east of Blanco Rd	Bexar	3,064
17	Between Dover Ridge, Ridge Path, Cliffbrier Drive, and Timber Path	Bexar	3,060
18	Between W Charles Anderson Loop, Pue Rd, Marbach Rd, and US-90	Bexar	2,902
19	Between Thousands Oaks Dr, Bulverde Rd, Wetmore Rd, and Preston Hollow Dr	Bexar	2,885
20	Between Babcock Rd, Prue Rd, Spring Creek Dr	Bexar	2,800

Table 7: Top 20 Areas with the Largest Number of Workers in the Five-County Area Based on Workplace Locations

Rank	Location	County	Number of Workers
1	USAA	Bexar	16,553
2	Lackland AFB	Bexar	15,019
3	Fort Sam Houston	Bexar	14,884
4	Northwest University of Texas-Austin, between W Dean Keeton St and W 30th St	Travis	12,623
5	Randolph AFB	Bexar	12,160
6	North of State Capital	Travis	10,541
7	South of State Capital, between 11th St, Trinity St, Congress Ave, and 7th St	Travis	10,076
8	IBM	Travis	9,243
9	West of Kennedy Park	Bexar	9,083
10	East of San Antonio International Airport	Bexar	7,950
11	San Antonio International Airport	Bexar	7,906
12	West of W. IH-10, south of University of Texas-San Antonio	Bexar	7,812
13	South of State Capital, between 4th St, Guadalupe St, Congress Ave, and 7th St	Travis	7,668
14	South Jollyville	Travis	7,490
15	South of State Capital, between Guadalupe St, 11th St, , Congress Ave, and 7th St	Travis	7,413
16	East of Walker Ranch Historic Landmark Park	Bexar	7,366
17	North of Shoal Creek, between Cesar Chavez St, 4th St, Trinity St, Congress Ave, and 7th St	Travis	7,046
18	Kensington Park	Williamson	6,952
19	Between N Mo-Pac Expy, W 5th St, W 12th, and N Lamar Blvd	Travis	6,780
20	Southwest of San Antonio International Airport	Bexar	6,780

Table 8: Top 20 Areas with the Largest Number of Workers in the Austin MPO Based on Workplace Locations

Rank	Location	County	Number of Workers
1	Northwest University of Texas-Austin, between W Dean Keeton St and W 30th St	Travis	12,623
2	North of State Capital	Travis	10,541
3	South of State Capital, between 11th St, Trinity St, Congress Ave, and 7th St	Travis	10,076
4	IBM	Travis	9,243
5	South of State Capital, between 4th St, Guadalupe St, Congress Ave, and 7th St	Travis	7,668
6	South Jollyville	Travis	7,490
7	South of State Capital, between Guadalupe St, 11th St, , Congress Ave, and 7th St	Travis	7,413
8	North of Shoal Beach, between Cesar Chavez St, 4th St, Trinity St, Congress Ave, and 7th St	Travis	7,046
9	Kensington Park	Williamson	6,952
10	Between N Mo-Pac Expy, W 5th St, W 12th, and N Larmar Blvd	Travis	6,780
11	Highland Mall	Travis	6,557
12	West of IBM	Travis	6,331
13	State Capital	Travis	6,318
14	Commerce Park	Williamson	6,305
15	South of State Capital, between 4th St, Trinity St, Congress Ave, and 7th St	Travis	5,656
16	Between E Oltorf St, Burleson Rd, and E Ben White Blvd	Travis	5,595
17	Between Spicewood Spings Rd, Mesa Dr, State Loop 1, and Research Blvd	Travis	5,351
18	Between E Anderson Ln, E US-290, Cameron Rd, and Cross Park Dr	Travis	5,284
19	West of Sunset Valley, between Old Bee Cave Rd, US-290, Patton Ranch Rd, and Travis Cook Rd	Travis	5,268
20	Between E Ben White Blvd, E St Elmo Rd, IH-35, Todd Ln	Travis	5,238

Table 9: Top 20 Areas with the Largest Number of Workers in the San Antonio MPO Based on Workplace Locations

Rank	Location	County	Number of Workers
1	USAA	Bexar	16,553
2	Lackland AFB	Bexar	15,019
3	Fort Sam Houston	Bexar	14,884
4	Randolph AFB	Bexar	12,160
5	Kelly USA (formerly Kelly AFB)	Bexar	9,083
6	East of San Antonio International Airport	Bexar	7,950
7	San Antonio International Airport	Bexar	7,906
8	West of W. IH-10, south of University of Texas-San Antonio	Bexar	7,812
9	East of Walker Ranch Historic Landmark Park	Bexar	7,366
10	Southwest of San Antonio International Airport	Bexar	6,780
11	East of USAA	Bexar	6,194
12	Brooks AFB	Bexar	5,953
13	University of Texas Health Ctr-Sa	Bexar	5,902
14	Downtown San Antonio, between Broadway St, Navarro St, N St Marys St, and Brooklyn Ave	Bexar	5,561
15	Downtown San Antonio, between E Martin St, N Main Ave, Navarro St, and Houston St	Bexar	5,290
16	Kirby	Bexar	4,991
17	Kallison Park	Bexar	4,866
18	Brooke Army Medical Center	Bexar	4,769
19	Between NW Loop 410, Horizon Dr, Callaghan Rd, and W Crestline Dr	Bexar	4,706
20	North Star Mall	Bexar	4,575

2.2.4 Distribution of vehicles leaving home for work based on residence locations

We discussed the geographic distribution and variation of the number of workers at the county and TAZ levels with respect to both residence and workplace locations in previous subsections. To estimate commuting traffic between different locations, we need to consider another important factor–the number of vehicles traveling between different pairs of residence (origin) and workplace (destination) locations. Using a similar approach described in the previous two subsections, we obtained the number of vehicles traveling in the area based on residence locations first (Table 10). We then mapped the spatial distribution of these commuting vehicles (Figure 4 (a) and (b)). The general patterns across Table 10 and Figure 4 are similar to the patterns reported in previous subsections. Based on the results from Table 10 and Figure 4, the following observations can be made.

- About 97.33% (995,557) of the commuting vehicles originated within the five counties.
- Among these vehicles, 97% (965,690) traveled between different TAZs.
- In addition, 12.82% (127,630) vehicles traveled between different counties in the area.
- The percentages of vehicles (97.17%, 97.14%, 96.84%, 97.08%, 97.04%, 95.015, and 97.00%) used in commuting between different TAZs are higher than the corresponding percentages (91.54%, 92.68%, 92.31%, 92.51%, 93.33%, 90.61%, and 92.85%) reported in subsection 2.2.1. (percentage2 in Table 2(c) versus percentage2 in Table 10(c)). The percentages of vehicles (52.55%, 7.49%, 57.33%, 22.16%, 1.43%, 44.12%, and 12.82%) with their OD pairs between TAZs in different counties are also higher than the corresponding percentages (47.99%, 6.78%, 54.14%, 19.92%, 1.34%, 41.39%, and 11.56%) reported in subsection 2.2.1 (percentage2 in Table 2(d) versus percentage2 in Table 10(d)).

In addition, we investigated the patterns of vehicle usage in two time periods in which workers left home for work for inter-county commute (Figure 4(c) and (d)). These two time periods are: 5:00am to 8:59am and 9:00am to 4:59am. Comparing results shown in Figure 4(c) and those illustrated in Figure 4(d), as expected, a significant portion of vehicles left home for work between 5:00am and 8:59am. This pattern is especially obvious in Comal, Hays, North Travis, and South Williamson counties.

2.2.5 Distribution of vehicles leaving home for work based on workplace locations

According to results shown in Table 11 and Figure 5, the general distribution of vehicle usage in commute across the five-county area is consistent with the characteristics based on the number of worker. The analysis results are summarized below.

- More than 88.85% (960,064) vehicles were used in commute by people who worked in Bexar and Travis Counties (Table 11(a)). These results indicate that the overwhelming majority of the workers had to travel to either Bexar (48.63%) or Travis (40.22%) Counties for work (Table 11(c)).
- Based on results in Table 5(b) and 5(c), most vehicles (97.00%) used for their journeys from home-to-work traveled to TAZs other than their origin TAZs in all five counties. In this group, 48.63% workers worked in a TAZ in Bexar and 40.22% workers worked in a TAZ in Travis (Table 11(c))

- Considering vehicles commuting between TAZs in different counties, about 64.90% vehicles had their destinations in Travis County, followed by Williamson County (17.9%). In contrast, we found that only a small portion of vehicles had destinations in Comal (3.89%) and Hays (3.9%) counties (Table 11(d)).
- According to Table 11(d), we found that of the total number of destinations, only a small portion (2.48%) had their origins outside Bexar County.
- Similar to the pattern of inter-county commute based on the residence location of commuting vehicles, most vehicles left home to go to work between 5:00am and 8:59am. This pattern is particularly obvious for vehicles commuting to North Travis and South Williamson Counties.

Table 10: Summary Information about Vehicles Used in Travel to Work Based on Residence Locations in a TAZ

(a) Total Number of Vehicles With Their Origins in the Five-County Study Area

County		No. of OD pairs	No. of Vehicles	Percentage1
Austin MPO	Hays	5,558	42,272	4.13
	Travis	30,029	346,811	33.90
	Williamson	10,443	110,353	10.79
	Sub-Total	**46,030**	**499,436**	**48.82**
San Antonio MPO	Bexar	50,711	492,728	48.17
	Comal	2,909	30,727	3.00
Total		**99,650**	**1,022,891**	**100.00**

(b) Total Number of Vehicles with Their Origins and Destinations within the Five-County Area

County		No. of OD pairs	No. of Vehicles	Percentage1
Austin MPO	Hays	5,294	40,584	4.08
	Travis	29,043	340,788	34.23
	Williamson	9,915	107,063	10.75
	Sub-Total	**44,252**	**488,435**	**49.06**
San Antonio MPO	Bexar	48,571	478,642	48.08
	Comal	2,600	28,480	2.86
Total		**95,423**	**995,557**	**100.00**

(c) Total Number of Vehicles with Their OD Pairs in Different TAZs in the Five-County Area

County		No. of OD pairs	No. of Vehicles	Percentage1	Percentage2
Austin MPO	Hays	5,189	39,437	4.08	97.17
	Travis	28,627	331,051	34.28	97.14
	Williamson	9,713	103,678	10.74	96.84
	Sub-Total	**43,529**	**474,166**	**49.10**	**n/a**
San Antonio MPO	Bexar	47,880	464,464	48.10	97.04
	Comal	2,543	27,060	2.80	95.01
Total		**93,952**	**965,690**	**100.00**	**n/a**

(d) Total Number of Vehicles with Their OD Pairs between TAZs in Different Counties in the Five-County Area

County		No. of OD pairs	No. of Vehicles	Percentage1	Percentage2
Austin MPO	Hays	3,198	21,328	16.71	52.55
	Travis	2,479	25,511	19.99	7.49
	Williamson	5,826	61,378	48.09	57.33
	Sub-Total	**11,503**	**108,217**	**84.79**	**n/a**
San Antonio MPO	Bexar	908	6,848	5.37	1.43
	Comal	1,508	12,565	9.84	44.12
Total		**13,919**	**127,630**	**100.00**	**n/a**

Note: Percentage1= (No. of workers for each county /the total No. of workers)*100
Percentage2 = (No. of workers in table (c) or (d) / the No. of workers in the corresponding cell in table (b))*100
OD = origin (residence location) and destination (workplace location)

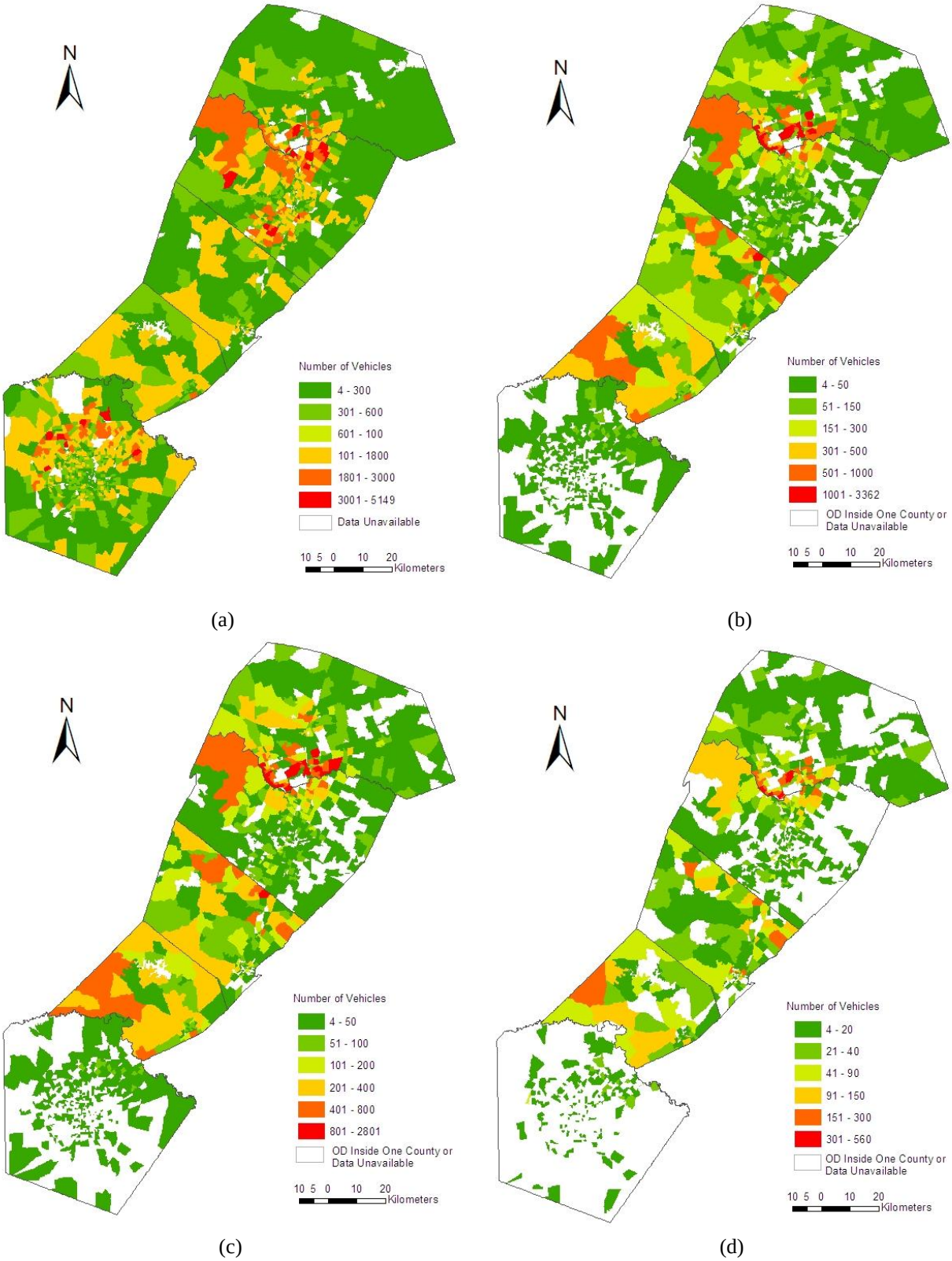


Figure 4. Vehicles used in travel to work based on residence locations in a TAZ: (a) Number of vehicles with their destinations in the five-county area; (b) Number of vehicles with their origins and destinations between counties; (c) Number of vehicles "left home" for work from 5:00 am to 8:59 am; (d) Number of vehicles "left home" for work from 9:00 am to 4:59 am.

Table 11: Summary Information about Vehicles Used in Travel to Work Based on Workplace Locations in a TAZ

(a) Total Number of Vehicles with Their Destinations in the Five-County Study Area

County		No. of OD pairs	No. of Vehicles	Percentage1
Austin MPO	Hays	3,253	29,195	2.68
	Travis	38,777	429,645	39.39
	Williamson	7,137	74,852	6.86
	Sub-Total	**49,167**	**533,692**	**48.93**
San Antonio MPO	Bexar	54,893	530,419	48.63
	Comal	2,329	26,723	2.45
Total		**106,389**	**1,090,834**	**100.00**

(b) Total Number of Vehicles with Their Origins and Destinations in the Five-County Area

County		No. of OD pairs	No. of Vehicles	Percentage1
Austin MPO	Hays	2,742	24,229	2.43
	Travis	35,575	398,110	39.99
	Williamson	6,247	68,529	6.88
	Sub-Total	**44,564**	**490,868**	**49.30**
San Antonio MPO	Bexar	49,124	483,814	48.60
	Comal	1,735	20,875	2.10
Total		**95,423**	**995,557**	**100.00**

(c) Total Number of Vehicles with Their OD Pairs in Different TAZs in the Study Area

County		No. of OD pairs	No. of Vehicles	Percentage1	Percentage2
Austin MPO	Hays	2,637	23,082	2.39	95.27
	Travis	35,159	388,373	40.22	97.55
	Williamson	6,045	65,144	6.75	95.06
	Sub-Total	**43,841**	**476,599**	**49.36**	**n/a**
San Antonio MPO	Bexar	48,433	469,636	48.63	97.07
	Comal	1,678	19,455	2.01	93.20
Total		**93,952**	**965,690**	**100.00**	**n/a**

(d) Total Number of Vehicles with Their OD Pairs between TAZs in Different Counties in the Study Area

County		No. of OD pairs	No. of Vehicles	Percentage1	Percentage2
Austin MPO	Hays	646	4,973	3.90	20.52
	Travis	9,011	82,833	64.90	20.81
	Williamson	2,158	22,844	17.90	33.33
	Sub-Total	**11,815**	**110,650**	**86.70**	**n/a**
San Antonio MPO	Bexar	1,461	12,020	9.42	2.48
	Comal	643	4,960	3.89	23.76
Total		**13,919**	**127,630**	**100.00**	**n/a**

Note: Percentage1= (No. of workers for each county /the total No. of workers)*100
Percentage2 = (No. of workers in table (c) or (d) / the No. of workers in the corresponding cell in table (b))*100
OD = origin (residence location) and destination (workplace location)

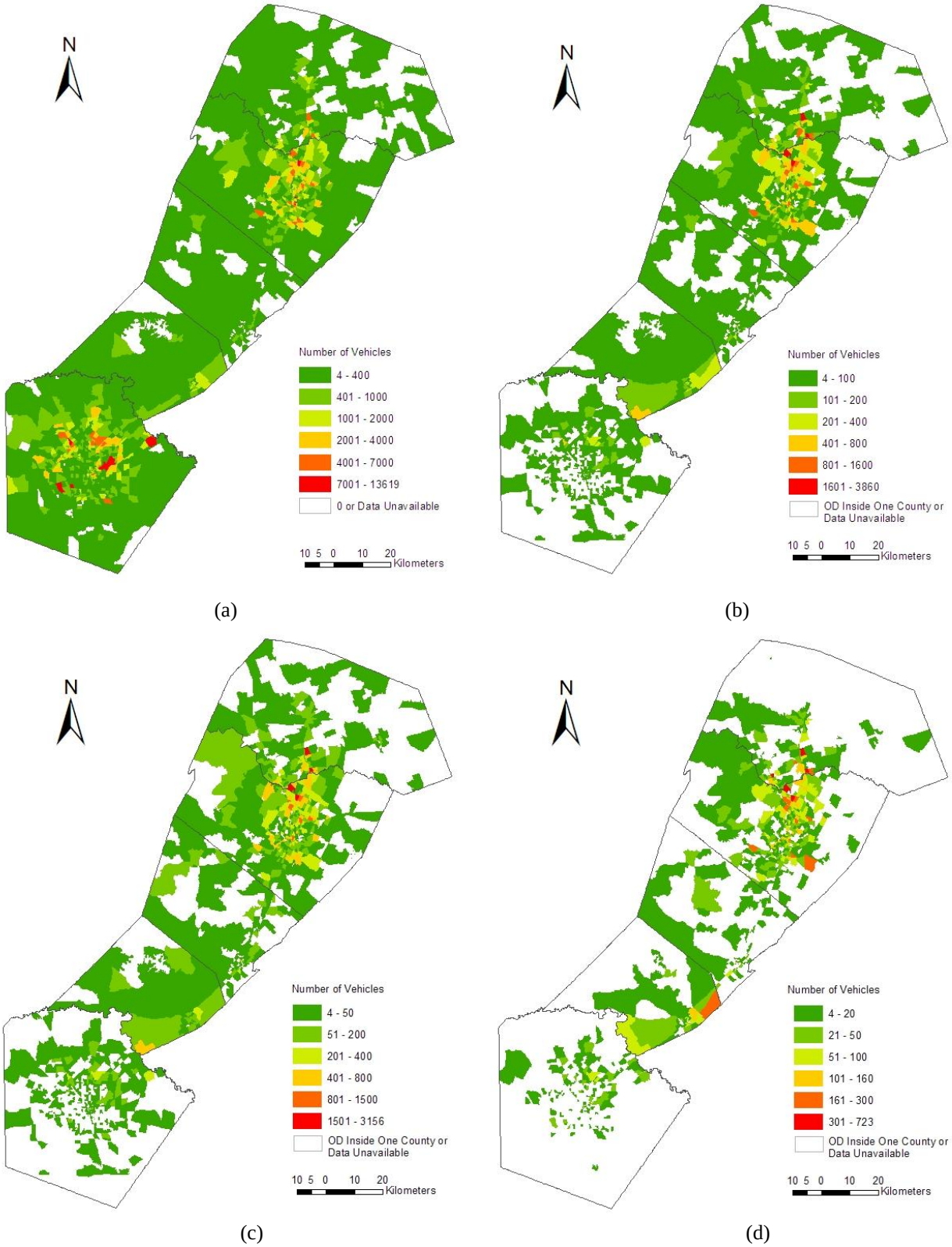


Figure 5. Vehicles used in travel to work based on workplace locations in a TAZ: (a) Number of vehicles with their origins in the five-county area; (b) Number of vehicles with their origins and destinations between counties; (c) Number of vehicles "left home" for work from 5:00 am to 8:59 am; (d) Number of vehicles "left home" for work from 9:00 am to 4:59 am.

2.2.6 Average travel time from home to work based on residence locations

We determined the average travel time for each of the eight transportation modes based on data from Table 008 in the CTPP Part 3 data. Table 008 provides the average travel time for trips with the same origin and destination with regard to travel modes. In other words, an average travel time is assigned to each unique pair of origin and destination with regard to travel modes. We selected four different transportation modes to analyze the spatial variations of average travel time in the study area (Figure 6). These four transportation modes are: (1) all transportation modes combined, (2) drive alone, (3) 2-person carpool, and (4) bus. Based on results shown in Figure 6, we can make the following observations.

- *Travel mode: All transportation modes combined (Figure 6(a))*
    - On average, the average commute time for trips associated with about 94.22% OD pairs was less than 60 minutes..
    - The average commute time for commuters who lived in Central Travis and Central Bexar was below 30 minutes.
    - In contrast, the average commute time for commuters who lived in Comal, Hays, and Williamson Counties was above 30 minutes.
    - It is obvious that workers with their residences in the peripheral areas of Travis and Bexar Counties spent more time on commuting than workers who lived in areas immediately adjacent to or within the city limits of Austin and San Antonio.
- *Travel mode: Drive alone (Figure 6(b))*
    - When driving alone, the average commuting time for most workers who lived in the five-county area was less than that of all transportation modes combined.
    - When driving alone, the average commuting time for most workers who lived in the five-county area was less than 40 minutes.
    - When compared to the average commute time for all transportation modes combined, it is less evident that workers with their residences in the peripheral areas of Travis and Bexar Counties spent more time on commuting than workers who lived in areas immediately adjacent to or within the city limits of Austin and San Antonio.
- *Travel mode: 2-person carpool (Figure 6(c))*
    - The majority of commuters using 2-person carpool spent less than 12 minutes on average to travel from home to work, which indicates that the job locations for this group of people were not very far from their home locations.
    - It took commuters who lived in the peripheral areas of the counties more than 8 minutes to go to work when using the '2-person carpool' travel mode. In contrast, commuters who lived in areas adjacent to the central parts of the counties spent less than 8 minutes to travel from home to work.
- *Travel mode: Bus (Figure 6(d))*
    - The majority of commuters (97.59%) who took bus to from home to work lived in Bexar County or Travis County.
    - In contrast, far fewer commuters (2.41%) residing in other counties took bus to go to work.

- It took the majority of commuters less than ten minutes on average to go to work, which suggests that for people using bus to go to work, the distances between their workplace locations and their residence locations were not very far.

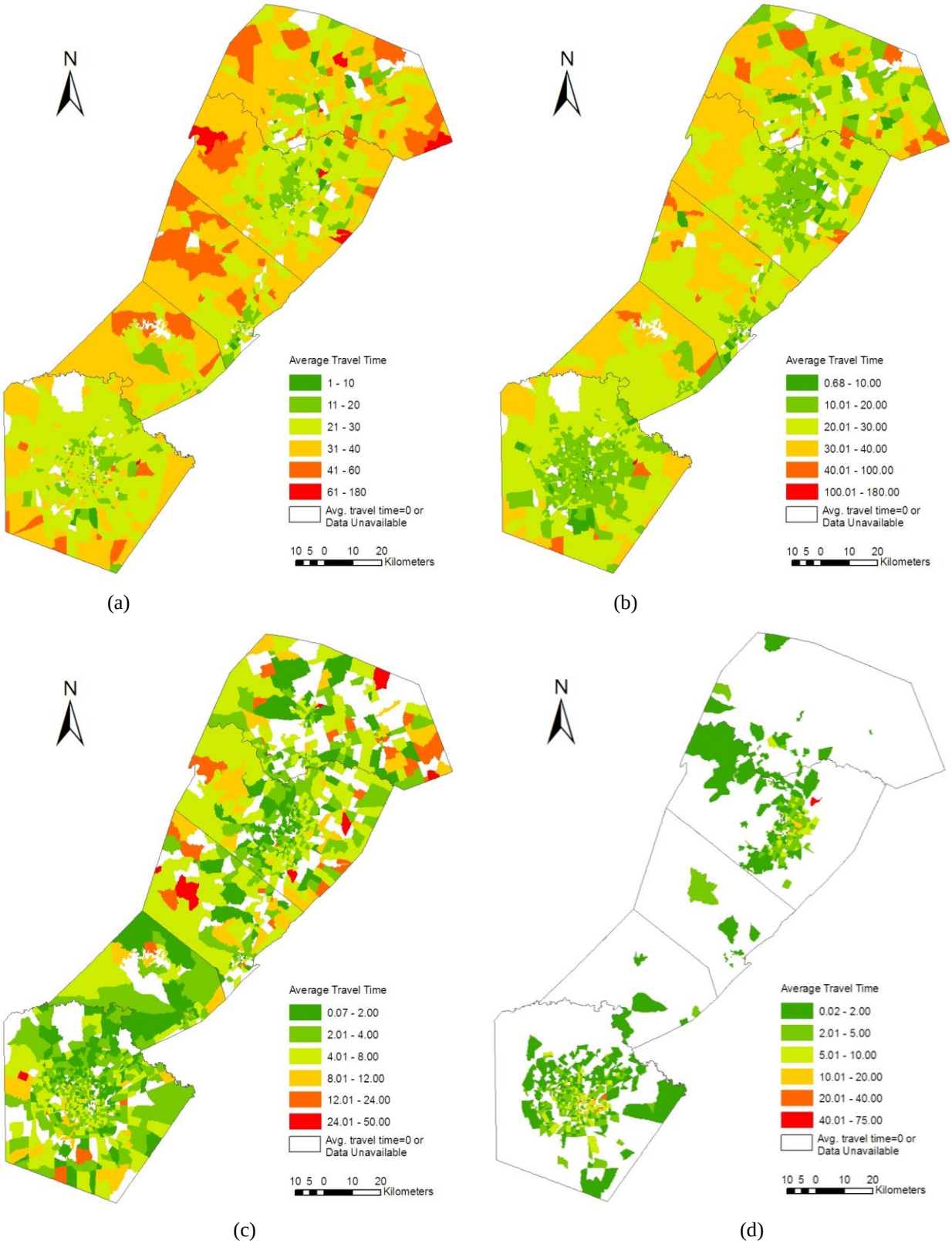


Figure 6. Average travel time (in minutes) based on residence locations in a TAZ: (a) all travel modes combined; (b) drive alone; (c) 2-person carpool; (d) travel by bus or trolley bus.

As one focus of this project is to investigate inter-county commuting patterns, we further analyzed spatial variations of the average travel time for inter-county commute for the four selected travel modes (Figure 7). The findings can help us better understand the relationship between travel time and the choice of travel modes, and therefore, provide useful information for the development of public transportation for inter-county commute. The findings are summarized below.

- *Travel mode: All transportation modes combined* (Figure 7(a))
  - On average, for inter-county commute, the average commute time for trips from about 96.20% OD pairs was less than 81 minutes.
  - For all inter-county trips originated from Comal, Hays, Travis, and Williamson counties, the average travel time for trips from about 94.94% OD pairs was below 61 minutes.
  - Generally, workers who lived in Central Bexar and in most parts of Comal, Hays, and Williamson counties spent more time on commuting from home to work than workers who lived in other areas.
- *Travel mode: Drive alone* (Figure 7(b))
  - The geographic distribution of average travel time associated with the 'drive alone' travel mode is similar to the pattern based on all modes of transportation.
  - On average, for all OD pairs, the average travel time for trips from about 96.86% pairs was less than 81 minutes.
- *Travel mode: 2-person carpool* (Figure 7(c))
  - The average travel time for trips from about 60.60% OD pairs was less than 41 minutes.
  - Compared to the number of trips originated from Comal, Hays, and Williamson counties, only about 25.38% of OD pairs of trips originated from Bexar and Travis counties used 2-person carpool for inter-county commute. This pattern is especially obvious in Bexar County (6.78%).
  - In Bexar County, most commuters using 2-person carpool lived in urban areas of the county.
  - It took longer time for commuters who lived in Bexar, Hays, Travis, and Williamson counties to travel to work than those who lived in Comal County.
- *Travel mode: bus* (Figure 7(d))
  - Very few commuters (about 0.5% OD pairs) took bus as a means of inter-county commute.

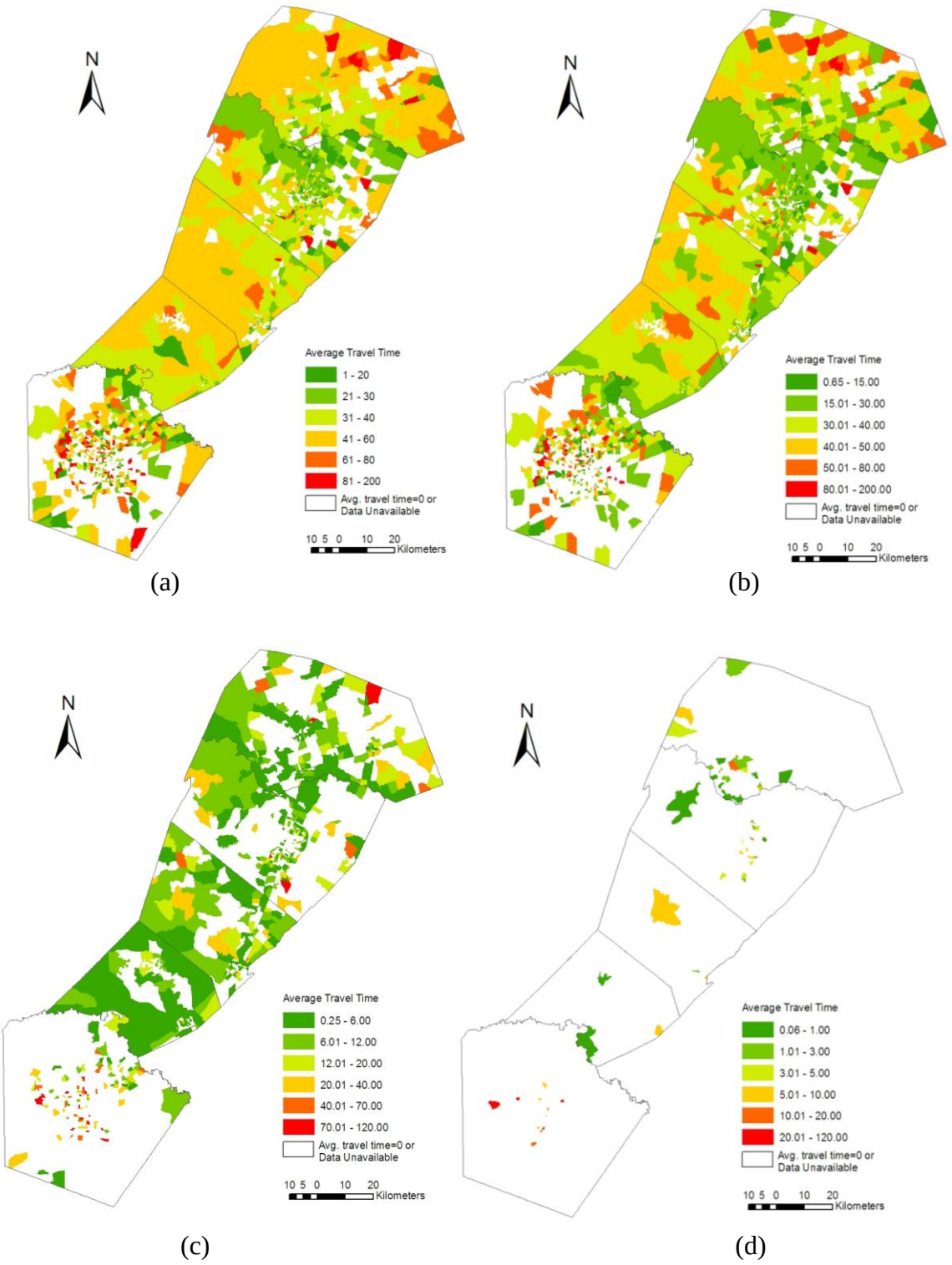


Figure 7. Average travel time (in minutes) for inter-county commute based on residence locations in a TAZ: (a) all travel modes combined; (b) drive alone; (c) 2-person carpool; (d) travel by bus or trolley bus.

2.2.7 Average travel time from home to work based on workplace locations

Based on workplace locations, we examined the characteristics of average travel time for the same four selected travel modes described in previous subsections. Figure 8 shows the spatial variations of average travel time regardless the location of trip origins and destinations. Figure 9 presents the pattern of average travel time only for trips with origins and destinations in different counties in the study area.

Results from Figure 8 suggest that:

- *Travel mode: All transportation modes combined* (Figure 8(a))
  - The average travel time associated with 75.20% OD pairs was less than 31 minutes.
  - Although a lot of workers (about 87%) had their workplaces in Central Bexar and Central Travis Counties (Figure 3), on average they did not spend more time on commuting than those who worked in peripheral areas of the two counties.
  - Commuters who worked in peripheral areas of Travis and Bexar Counties spent more time on their journey from home to work on average, especially those who worked in the southern area of Bexar County and those who worked in the western and eastern parts of Travis County.
- *Travel mode: Drive alone* (Figure 8(b))
  - The average travel time associated with 77.34% OD pairs was less than 31 minutes.
  - Only a small portion of commuters (about 3.37% OD pairs) who worked in the five-county area spent more than 60 minutes on their journeys from home to work.
  - Commuters who had their workplaces in Central Bexar County spent less time on average on commuting than those who had their workplaces in Central Travis.
- *Travel mode: 2-person carpool* (Figure 8(c))
  - Among commuters who used 2-person carpool, most commuters (about 73.29% OD pairs) who worked in Bexar and Travis counties traveled less than 31 minutes on average from home to work.
  - The average travel time associated with 56.29% OD pairs with their destinations in Comal, Hays, and Williamson counties was less than 21 minutes.
- *Travel mode: Bus* (Figure 8(d))
  - Most commuters (97.98%) who took bus from home to work had their workplaces in Bexar County or Travis County. In contrast, very few workers (2.02%) who had their workplaces in other counties took bus to travel from home to work.

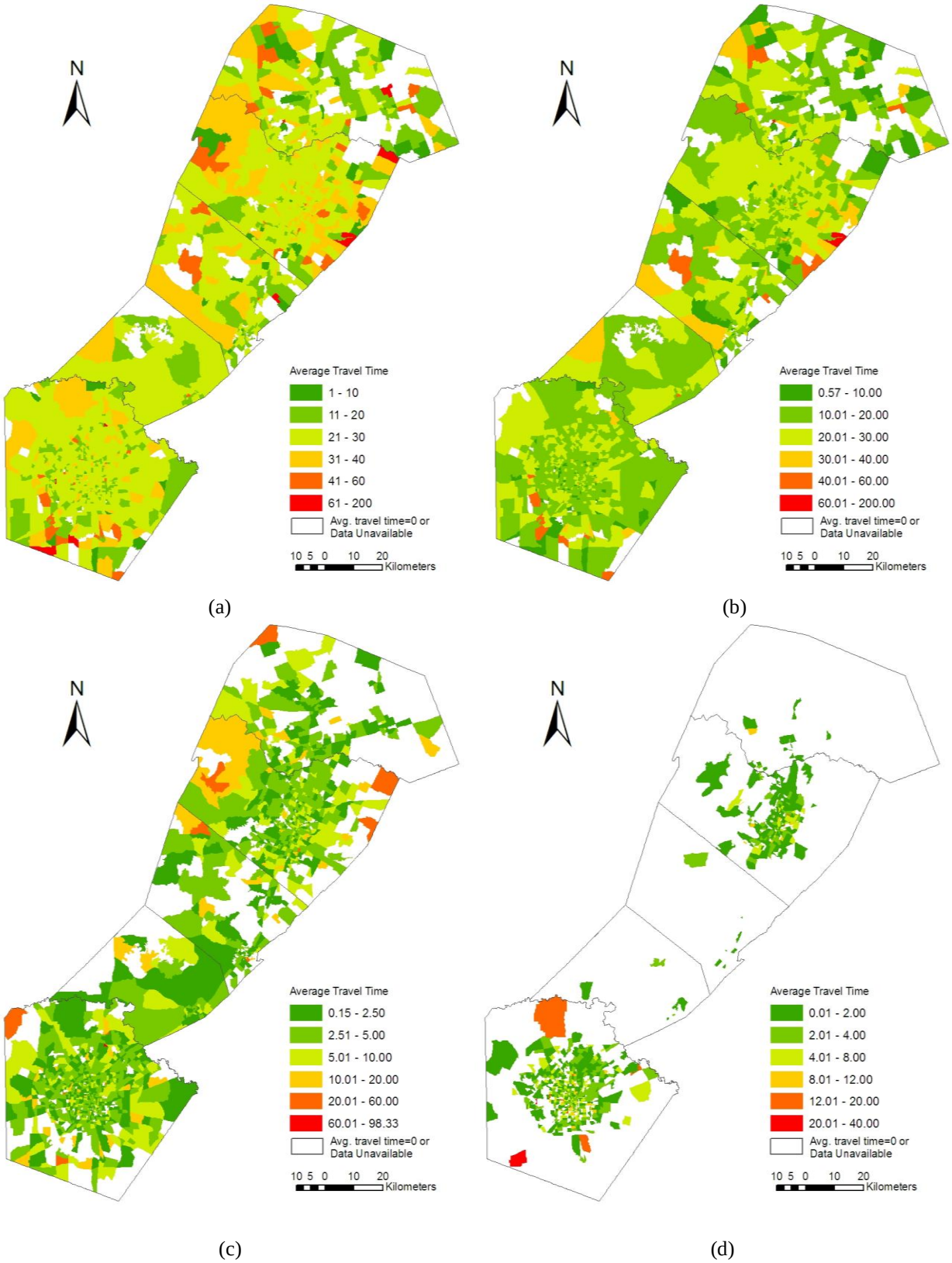


Figure 8. Average travel time (in minutes) based on workplace locations in a TAZ: (a) all travel modes combined; (b) drive alone; (c) 2-person carpool; (d) travel by bus or trolley bus.

Based on results illustrated in Figure 9, the geographic distribution of average travel time for inter-county commute is summarized below.

- *Travel mode: All modes of transportation* (Figure 9(a))
  - Many commuters (61.43% OD pairs) who worked in Bexar, Hays, Travis, and Williamson counties spent 30-60 minutes on average on their journeys from home to work. In both Bexar County and Travis County, workplaces for this group of people were mainly located in the central parts of the counties.
  - Most commuters (68.43% OD pairs) who worked in Comal County spent less than 31 minutes to travel from home to work, while the average travel time for trips associated with 67.88% OD pairs with their destinations in the other four counties was more than 30 minutes.
  - Among workers who spent more than 80 minutes on average on commuting, most of them (about 94.90% OD pairs) had their workplaces in Bexar, Travis, or Williamson County.
- *Travel mode: Drive alone* (Figure 9(b))
  - The geographic distribution of average travel time corresponding to the 'drive alone' mode is similar to that of all transportation modes combined.
  - On average, most commuters (88.06% OD pairs) who worked in the five-county area spent less than 60 minutes to travel from home to work when they drove alone.
  - Compared to the pattern shown in Figure 9(a), fewer commuters (about 9.13% OD pairs) who worked in Travis County spent more than 30 minutes on their journeys from home to work when they drove alone.
- *Travel mode: 2-person carpool* (Figure 9(c))
  - Many commuters (60.67% OD pairs) traveled less than 41 minutes on average from home to work.
  - There were more commuters who worked in Travis County (22,031) using 2-person carpool for inter-county commute than those who worked in Bexar (21,078), Comal (1,550), Hays (1,284), and Williamson (3,509) counties.
- *Travel mode: bus* (Figure 9(d))
  - Few commuters (about 0.5% OD pairs) used bus as a means of inter-county commute.
  - Among commuters who used bus, most of them (96.9% OD pairs) spent more than 10 minutes to travel from home to work.

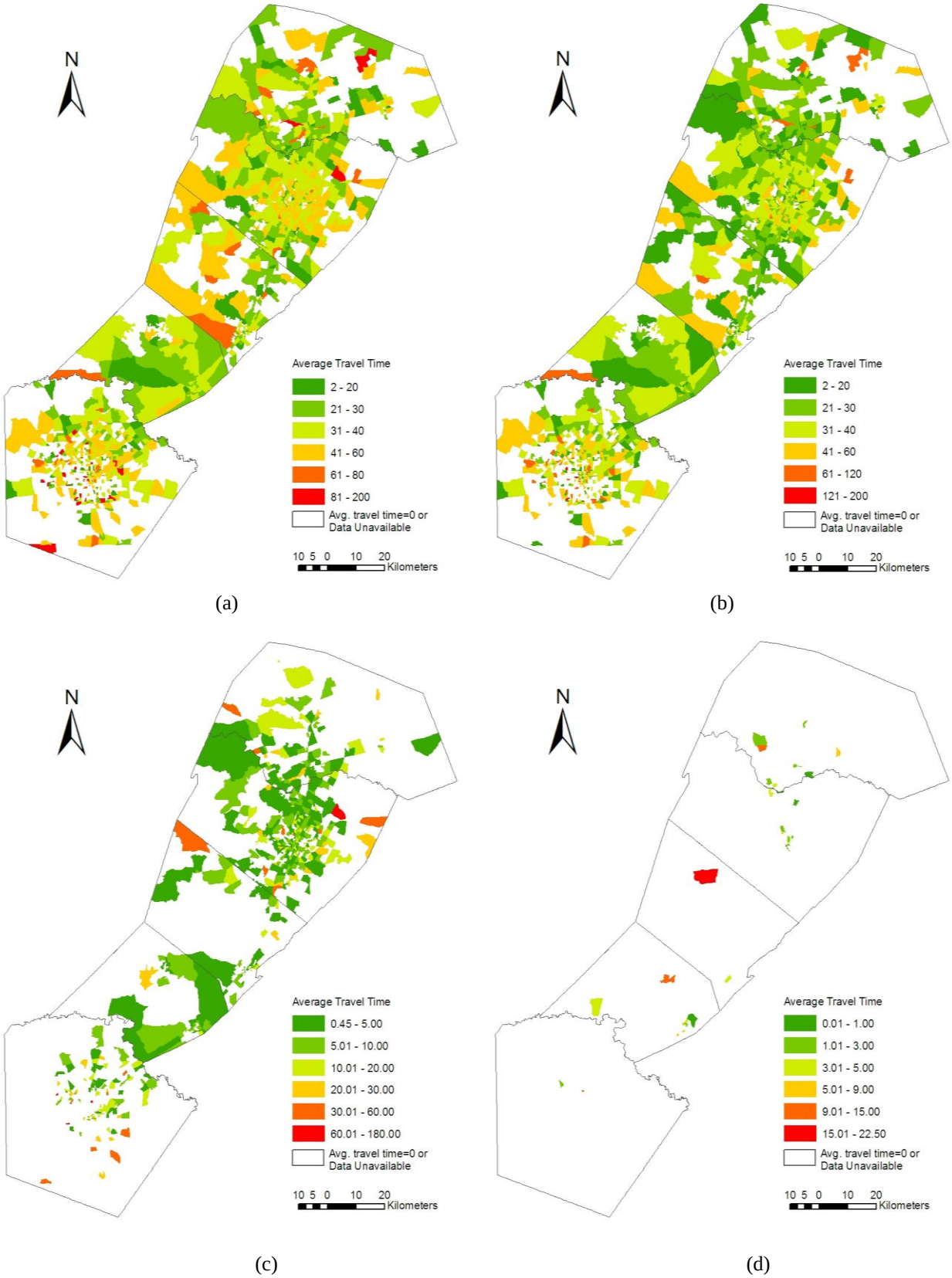


Figure 9. Average travel time (in minutes) for inter-county commute based on workplace locations in a TAZ: (a) all travel modes combined; (b) drive alone; (c) 2-person carpool; (d) travel by bus or trolley bus.

2.2.8 Geographic distribution of commuters: Summary

The geographic distribution of workers within each of the five counties based on residence locations is summarized in Figure 10. The bars in Figure 10 associated with each county represent the number of workers in different categories of workplace locations or the relative locations of residence and workplaces. As can be seen in Figure 10, Bexar County had the most number of workers compared to other counties, followed by Travis and Williamson counties. The percentage of workers who traveled from home to work in another county is very small compared to those who had residences and workplaces within the same county.

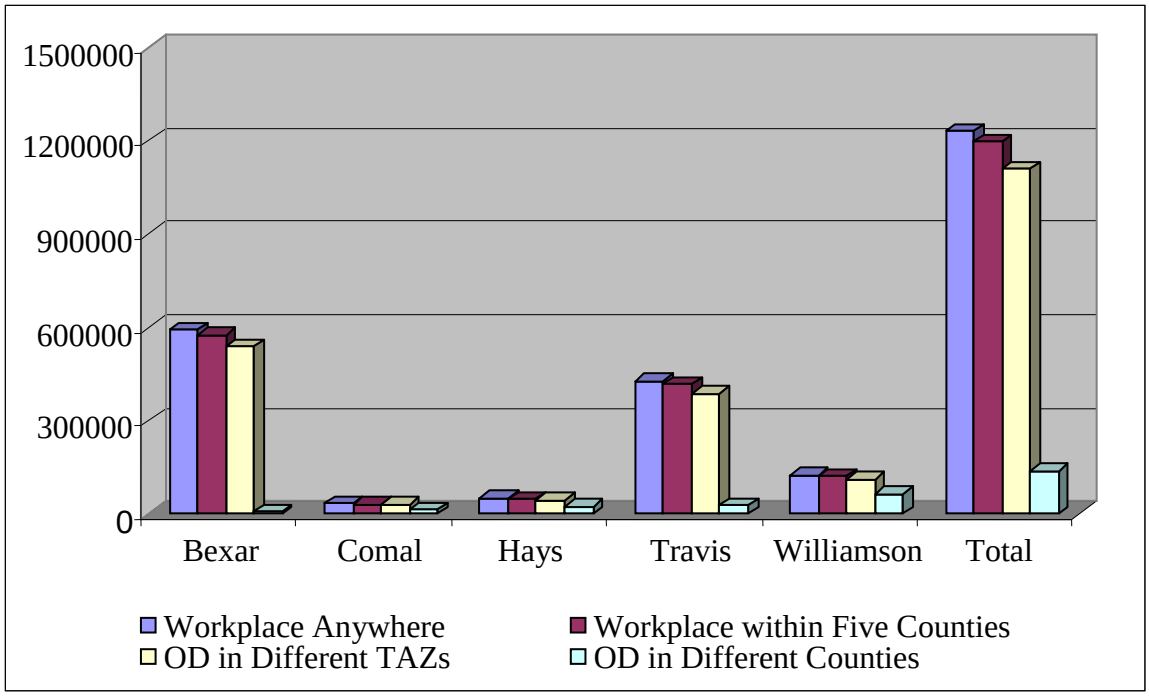


Figure 10. Geographic distribution of workers in the five-county area based on residence locations

2.3 Commute Flows between Different Geographic Areas

2.3.1 Overall characteristics of commute flows between different geographic areas

In order to analyze traffic flows between different geographic areas, we divided areas in each county into two general categories: urban or non-urban based on the information from the US Census Bureau. We therefore have four sets of commute flow data within each county: (1) Urban-to-Urban, (2) Urban-to-Rural, (3) Rural-to-Urban, and (4) Rural-to-Rural. For each pair of counties, we can also have four sets of inter-county commute flows: Urban-to-Urban, (2) Urban-to-rural, (3) Rural-to-Urban, and (4) Rural-to-Rural. We determined the commute flows for each pair of counties in the study area (Table 12). For example, commute flows within the urban areas of Bexar County constituted 397,902 vehicles, representing 84% of the trips with both origins and destinations within the county; commute flows from urban to non-urban areas in Bexar County involved 31,221 vehicles, representing 7% of the flows within the county; the number of trips from

rural to urban areas was 35,470 (or 8%); and the number of trips between different locations in the rural areas in Bexar County was 7,201 (or 2%).

We can look at the situation between Bexar and Travis counties as an example to understand commute flows between a pair of counties (Table 12). The number of trips from urban areas in Bexar County to urban areas in Travis County was 1,782, constituting 79% of all trips from Bexar County to Travis County. Similarly, the number of trips in Urban-to-Non-Urban, Non-Urban-to-Urban, and Non-Urban-to-Non-Urban is 308, 143, and 10, respectively. The number of trips within Bexar County and Travis County as well as the number of trips between different areas of the two counties are also illustrated in Figure 11. Figure 12 provides similar information for Travis and Williamson counties.

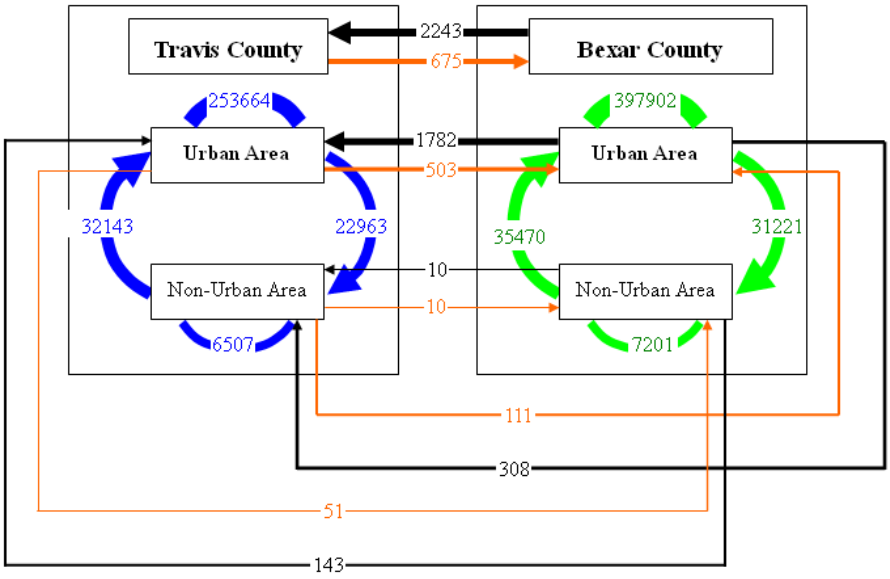
Another piece of important information in Table 12 is the in-flows to each of the five counties. The total in-flows are trips to a county, including all trips originated in that county. The in-flows associated with a county from other counties are flows from other counties with destinations in that county. For example, the total in-flows in Travis County were 398,110 trips. Of these 398,110 trips, 306,169 (77%) were trips between urban areas, 28,624 (7%) from urban areas to non-urban areas, 53,849 (14%) from non-urban areas to urban areas, and 9,468 (2%) between non-urban areas. In addition, a total of 82,833 trips were from other counties in the study area to Travis County.

For the entire study area, the total number of trips was 995,557 (Table 12). Among these 995,557 trips, 763,661 (77%) were trips between urban areas, 81,943 (8%) from urban areas to non-urban areas, 116,955 (12%) from non-urban areas to urban areas, and 32,998 (3%) between non-urban areas. Therefore, the total number of trips between urban and non-urban areas accounted for 20% of the total trips in the study area. The total number of inter-county trips was 127,630, accounting for 13% of the total number of trips. *It therefore can be concluded that the total number of trips between urban and non-urban area plus the number of trips between different counties account for 33%, or one third, of the total commute flows in the study area.*

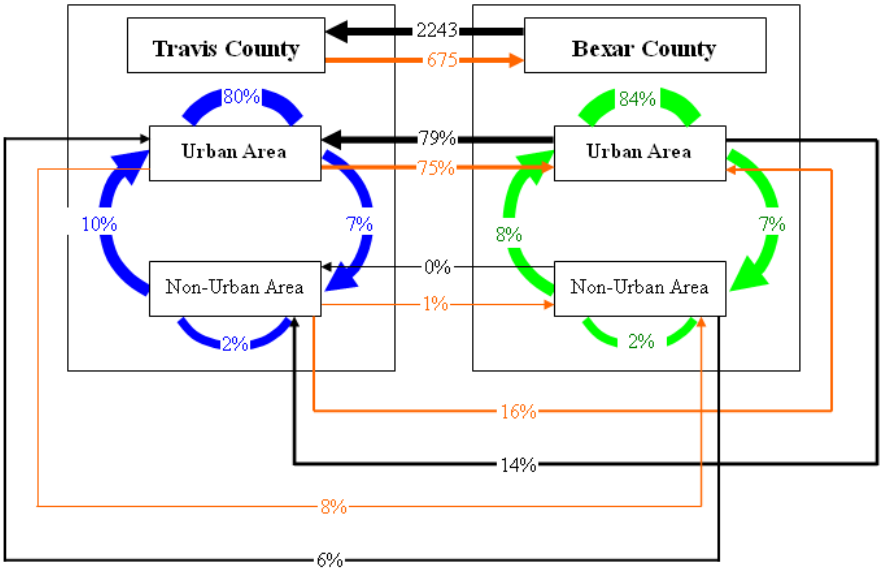
Table 12: Commute Flows between Different Geographic Areas in Central Texas

	Bexar County				Comal County				Hays County				Travis County				Williamson County			
	Urban	%	Rural	%	Urban	%	Rural	%	Urban	%	Rural	%	Urban	%	Rural	%	Urban	%	Rural	%
Bexar County																				
Urban	397,902	84%	31,221	7%	1,370	36%	1,894	50%	406	70%	113	19%	1,782	79%	308	14%	131	61%	85	39%
Rural	35,470	8%	7,201	2%	225	6%	316	8%	31	5%	34	6%	143	6%	10	0%	-	0%	-	0%
Comal County																				
Urban	2,176	21%	158	2%	5,823	37%	2,128	13%	389	29%	196	15%	224	26%	47	5%	10	29%	4	12%
Rural	7,303	71%	684	7%	3,543	22%	4,421	28%	515	39%	236	18%	561	64%	42	5%	12	35%	8	24%
Hays County																				
Urban	513	62%	4	0%	335	34%	381	38%	8,692	45%	2,380	12%	5,719	30%	691	4%	173	25%	127	18%
Rural	301	37%	4	0%	164	16%	119	12%	3,955	21%	4,229	22%	10,888	58%	1,514	8%	313	45%	82	12%
Travis County																				
Urban	503	75%	51	8%	72	54%	52	39%	1,217	43%	1,195	43%	253,664	80%	22,963	7%	13,145	60%	4,854	22%
Rural	111	16%	10	1%	-	0%	10	7%	176	6%	215	8%	32,143	10%	6,507	2%	2,728	12%	1,172	5%
Williamson County																				
Urban	145	72%	-	0%	14	64%	-	0%	112	45%	114	46%	44,780	74%	4,615	8%	24,364	53%	8,362	18%
Rural	57	28%	-	0%	4	18%	4	18%	16	6%	8	3%	10,114	17%	1,395	2%	8,182	18%	4,777	10%
Total Commute In-Flows (summation of corresponding cells in the same column)																				
Urban	401,239	83%	31,434	6%	7,614	36%	4,455	21%	10,816	45%	3,998	17%	306,169	77%	28,624	7%	37,823	55%	13,432	20%
Rural	43,242	9%	7,899	2%	3,936	19%	4,870	23%	4,693	19%	4,722	19%	53,849	14%	9,468	2%	11,235	16%	6,039	9%
County total			**483,814**				**20,875**				**24,229**				**398,110**				**68,529**	
Commute In-Flows from Other Counties (summation of corresponding cells in the same column)																				
Urban	3,337	28%	213	2%	1,791	36%	2,327	47%	2,124	43%	1,618	33%	52,505	63%	5,661	7%	13,459	59%	5,070	22%
Rural	7,772	65%	698	6%	393	8%	449	9%	738	15%	493	10%	21,706	26%	2,961	4%	3,053	13%	1,262	6%
County total			**12,020**				**4,960**				**4,973**				**82,833**				**22,844**	
Overall Summary																				
Total commute flows in the area: 995,557									Urban-to-Urban: 763,661 (77%); Urban-to-Rural: 81,943 (8%)											
									Rural-to-Urban: 116,955 (12%); Rural-to-Rural: 32,998 (3%)											
									Total number of inter-county trips: 127,630 (13% of total commute flows)											

Note: The percentages are computed using flows in the four related areas either within a county or between a pair of counties.
Urban areas are defined as areas with population density of at least 1,000 people per square mile and surrounding census block groups with at least 500 people per square mile.

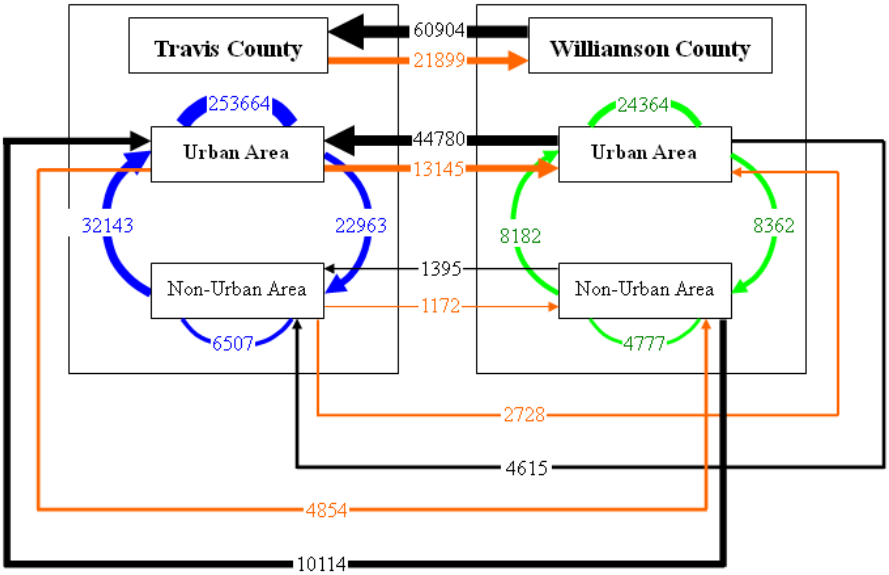


(d) **No. of Vehicles of the four types of flows within a county and between two counties**

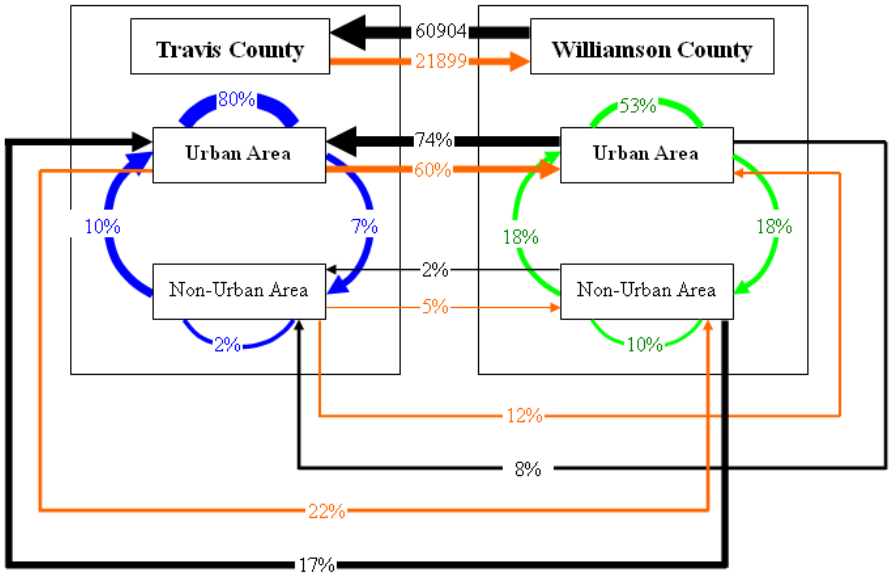


(e) **Percentages of the four types of flows within a county and between two counties**

Figure 11. Commute flows between different areas in Travis and Bexar County



(a) No. of Vehicles of the four types of flows within a county and between two counties



(b) Percentages of the four types of flows within a county and between two counties

Figure 12. Commute flows between different areas in Travis and Williamson County

2.3.2 Distribution of rural areas with a significant amount of commute flows to urban areas

Based on the analyses of urban-to-rural traffic flows, we attempted to identify the top 20 rural areas with the largest amount of commute flows to an urban area in the 5-county area. As can be seen from Table 13, ten out of the top 20 areas are from rural area of Travis County, seven are located in rural areas of Bexar County, two in Williamson County, and one is located in Comal County. Among the ten areas in Travis County, eight (ranked 2-4, 7, 10, 16, 17, and 19) are located in the northern and northwestern parts of the county (Figures 13 and 14). The seven rural areas in Bexar County are scattered in the western, northern, eastern, and southeastern parts of the county.

Table 13: Top 20 Rural Areas with the Largest Amount of Commute Flows from Rural to Urban Areas in the Five-County Area

Rank	Place Name	County	Number of Vehicles	% of Commuting Traffic From Rural Areas
1	North Bexar, between N Loop 1604, Redland Rd, Encino Rio, and Bulverde Rd	Bexar	2,768	6.37
2	Oak Grove Cemetery, St Edward's Park	Travis	2,466	5.73
3	Lago Vista	Travis	1,808	4.20
4	Balcones Country Club-Spicewood	Travis	1,788	4.15
5	San Leanna	Travis	1,724	4.00
6	China Grove	Bexar	1,384	3.19
7	Northwest Travis, between FM Rd 1431 and county boundary	Travis	1,380	3.20
8	Helotes	Bexar	1,342	3.09
9	Forest Creek Golf Club and Gulf Club at Star Ranch	Williamson	1,200	4.89
10	BlackHawk Gulf Club	Travis	1,192	2.77
11	Northeast of New Braunfels, between I-35, Loop 337, FM Rd 306, and Railway	Comal	1,086	6.27
12	West of W Loop 1604, between FM Rd 471, Talley Rd, and Potranco Rd	Bexar	1,076	2.48
13	Southeast Bexar, East of I-37, South of S Loop 1604	Bexar	1,056	2.43
14	Scenic Oaks	Bexar	1,031	2.37
15	Southwest of Georgetown, between County Rd 175, FM Rd 1431, and Deer Draw St	Williamson	1,025	4.17
16	River Place Country Club	Travis	989	2.30
17	Immanuel Cemetery	Travis	967	2.25
18	Converse	Bexar	955	2.20
19	Shady Hollow	Travis	913	2.12
20	West of Cedar Park and Anderson Mill	Travis	906	2.10
	Total		**27,056**	**18.04**

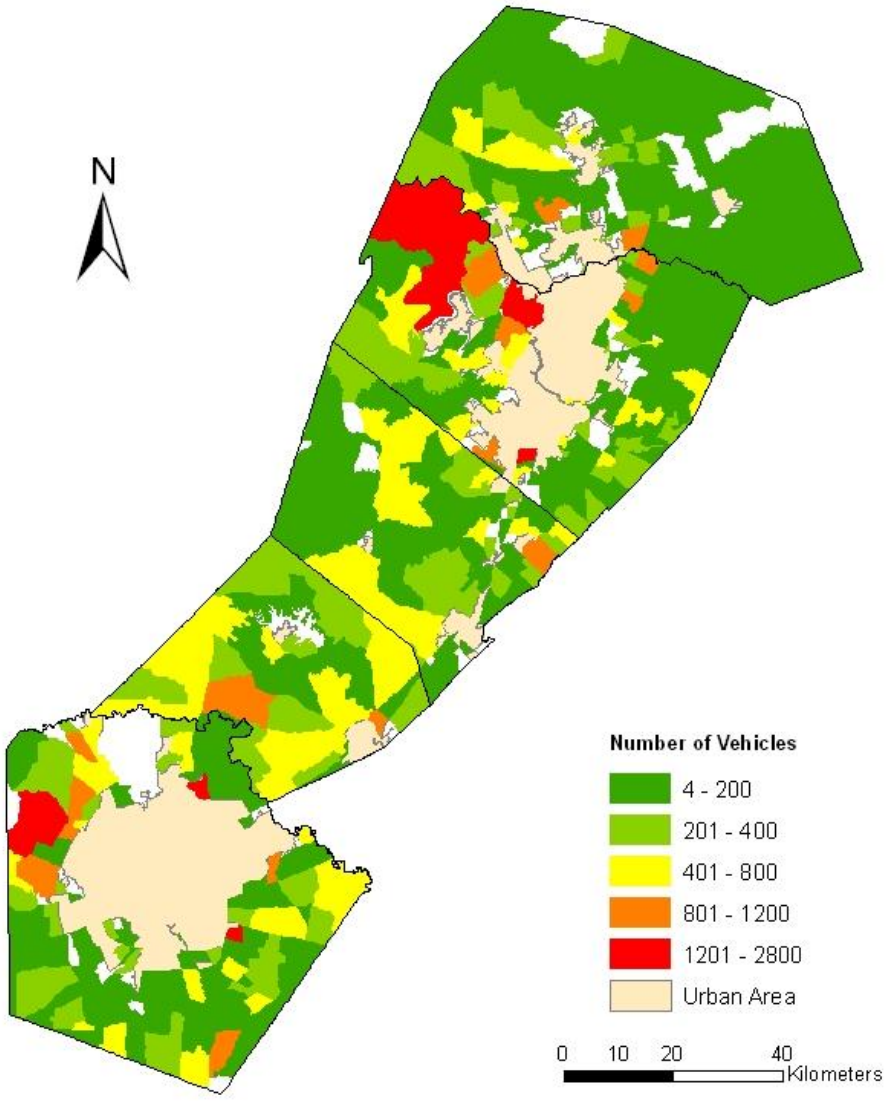


Figure 13. Distribution of vehicles with origins in rural areas and destinations in urban areas based on residence locations in a TAZ.

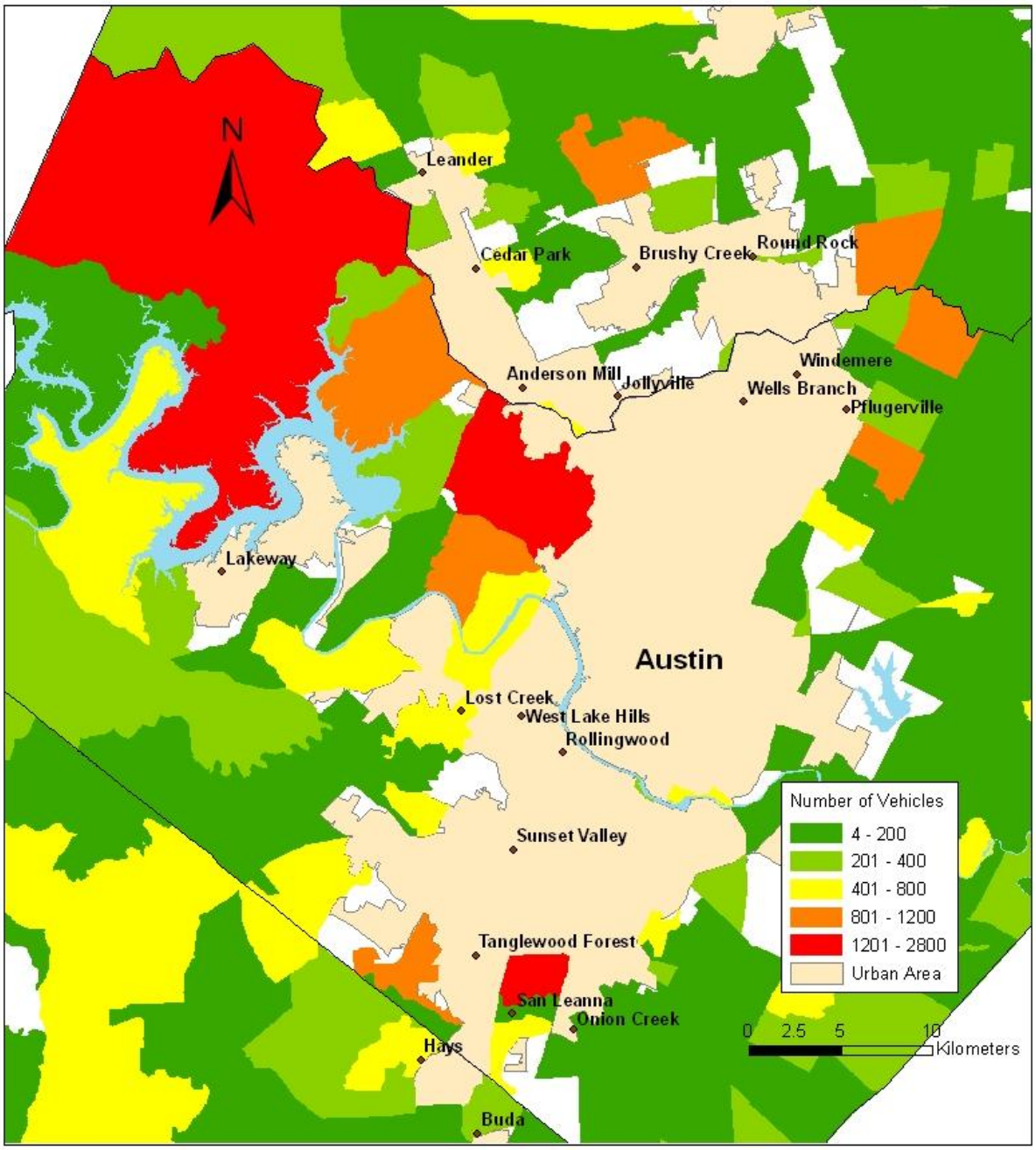


Figure 14. Distribution of vehicles with origins in rural areas and destinations in urban areas based on residence locations in Travis County.

2.4 Commute Flows between Different Transit Agency Service Areas

There are four public transportation agencies that provide services in the five-county study area. Capital Metro serves the Austin urban area, VIA metropolitan transit serves the San Antonio Metropolitan Area, Capital Area Rural Transportation System (CARTS) serves Hays County, Williamson County, as well as rural areas of Travis County, and Alamo Regional Transit (ART) serves Comal County. In order to identify commute flows between different transit agency service areas, we analyzed the number of trips between different transit agency service areas. These results are summarized in Tables 14 and 15.

Table 14 is a commute flow matrix showing the total commute trips within a transit agency service area and between different transit agency service areas. For example, the first row in Table 14 with numbers are the commute trips within Capital Metro service area itself, from the Capital Metro service area to the CARTS service area, to the ART service area, and to the VIA Metro service area. The number in Column 6 in that row is the total number of trips from the Capital Metro service area to the other three service areas. The number in Column 7 in that row is the total number of commute trips originated in the Capital Metro service area. Numbers in other rows with the exception of the last row can be understood similarly. The number in each cell in the last row of Table 14 indicates the number of trips with destinations located in a transit agency service area indicated by the heading of that column. For instance, there were 360,570 trips with their destinations located in the Capital Metro service area, which accounted for 36.24% of the total number of trips in the study area. In contrast, there were only 21,731 trips (or 2.08%) with their destinations located in the ART service area. The number of trips originated in the Capital Metro service area was 297,716 and that in the VIA Metro service area was 478,642. These two service areas contributed 78.13% of trip generations in the study area.

Table 15 provides additional details about the top 20 communities that generated the largest number of trips between different transit service areas in the five-county study area. Figure 15 shows the origins and distribution of the number of trips that had their origins and destinations in different transit service areas. These trips are the commute flows between different transit service areas. As can be seen in Figure 15, the areas that generated high numbers of commute trips to other transit agency service areas are communities in northwestern Travis County and southwestern Comal County.

Table 14: Total Commute Trips between Different Transit Agency Service Areas in the Five-County Study Area

Transit Agencies	Capital Metro	CARTS	ART	VIA Metro	No. of Trips to other Transit Service Areas		Total (Columns 2-4)
	No. of Trips (%)	No. of Trips (%)	No. of Trips (%)	No. of Trips (%)	No. of Trips (%)		No. of Trips (%)
Capital Metro	254,061 (85.34)	42,977 (14.44)	124 (0.04)	554 (0.19)	43,655 (25.82)		297,716 (29.92)
CARTS	103,781 (54.58)	84,200 (44.28)	1,031 (0.54)	1,145 (0.60)	105,957 (62.66)		190,157 (19.11)
ART	785 (2.76)	1,459 (5.12)	15,805 (55.50)	10,431 (36.63)	12,675 (7.50)		28,480 (2.86)
VIA Metro	1,943 (0.41)	1,100 (0.23)	3,771 (0.79)	471,828 (98.58)	6,814 (4.03)		478,642 (48.11)
Total	**360,570 (36.24)**	**129,736 (13.04)**	**20,731 (2.08)**	**483,958 (48.64)**	**169,101 (100)**		**994,995 (100.00)**

Note: Capital Metro serves Austin, CARTS serves Hays County, Williamson County, and rural areas of Travis County, ART serves Comal County, and VIA Metro serves the San Antonio MPO. Percentages in columns 2 to 5 are across the 4 columns in the same row; percentages in the last two columns are summed across rows in that column. The trips are combined counts of all trips made by all modes of transportation.

Table 15: Top 20 Areas with the Largest Number of Trips between Different Transit Agency Service Areas in the Five-County Study Area

Location	County	Number of Trips
Brushy Creek	Williamson	3,050
Jollyville	Williamson	2,599
St Edward's Park	Travis	2,297
San Leanna	Travis	1,706
East of Kinningham Recreation Center	Williamson	1,665
Anderson Mill, West of Balcones Country Club-Spicewood to Ranch Road 620	Travis	1,575
Anderson Mill	Williamson	1,560
Anderson Mill	Williamson	1,530
Cedar Park	Williamson	1,483
Jonestown, Lago Vista	Travis	1,452
Jollyville	Williamson	1,348
Round Rock West Park	Williamson	1,319
Cedar Park	Williamson	1,311
South of Avery Ranch Golf Club	Williamson	1,278
Anderson Mill	Williamson	1,260
South of Teravista Golf Club	Williamson	1,208
Buda	Hays	1,196
Palm Valley	Williamson	1,189
South of Cedar Park	Williamson	1,150
Windemere, Pflugerville	Travis	1,103

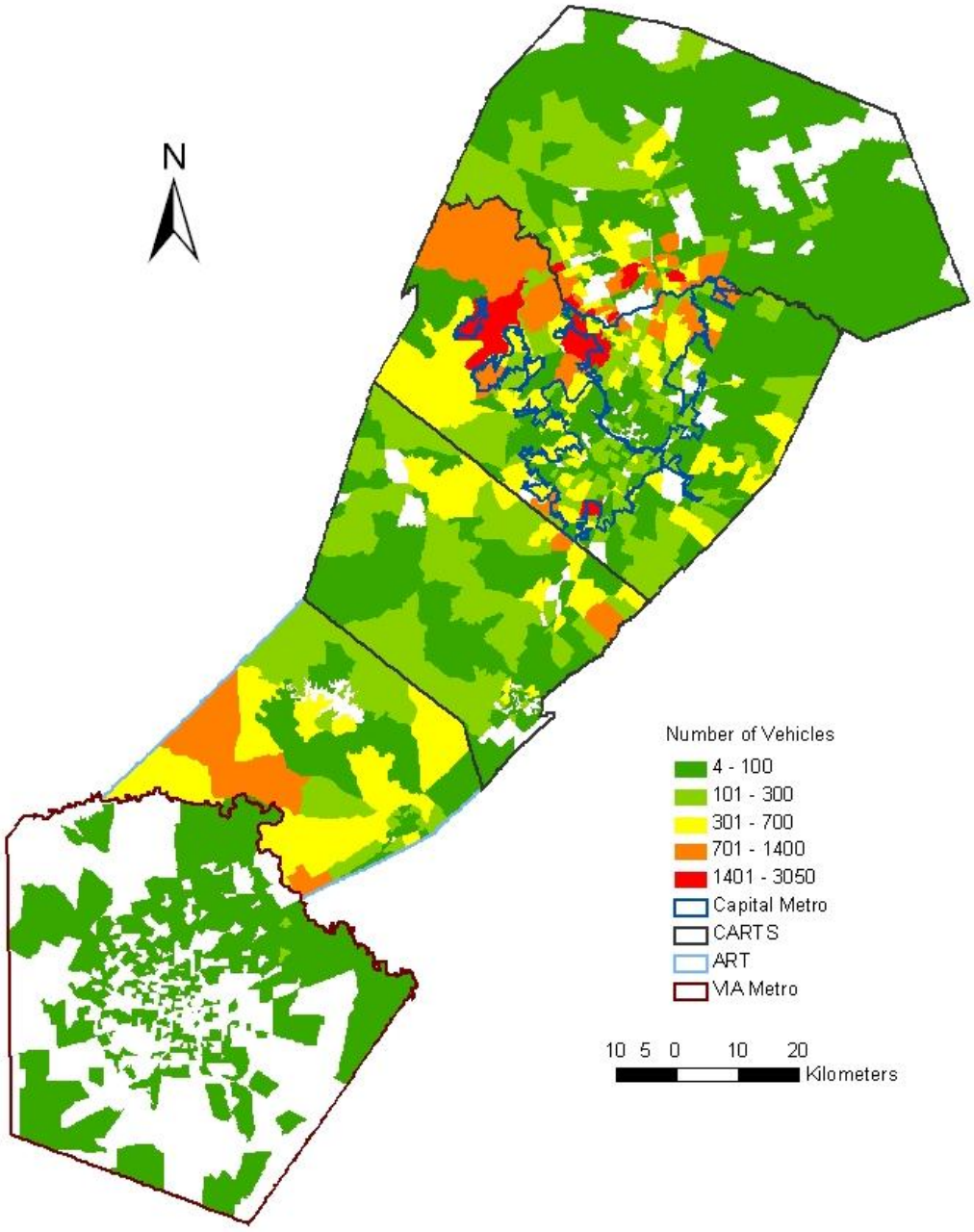


Figure 15. **Distribution of the number of trips with origins and destinations located in different transit agency service areas. (Note: What is shown in this figure are TAZs where trips were originated).**

3. Major Travel Corridors in Central Texas

3.1 Data Source and Data Preparation

3.1.1 Data sources

In order to identify major travel corridors that carry a significant amount of traffic in Central Texas, this study used four sets of data: (1) The U.S. Census CTPP Part 3 Journey-to-Work Data, (2) an external survey data provided by the Texas Transportation Institute (TTI), (3) network data in the study area, and (4) GIS map layers of county boundaries in the study area.

CTPP Part 3 Journey-to-Work data

The first dataset—Table 0010 from the CTPP Part 3 Journey-to-Work data—contains records of the number of vehicles used for commute from home to work at the Traffic Analysis Zone (TAZ) level. We used the number of vehicles with both their origins and destinations within the five-county area for the network analysis in this study.

TTI External Survey Data

The second dataset—the TTI external survey data—contains records of trips associated with both commercial and non-commercial vehicles (TTI 2005). The primary objective of using the external survey data in this study was to complement analyses based on the CTPP Part 3 data. The survey area in the external survey data covers the Austin survey area and the San Antonio survey area (Table 16). The external survey data were collected for traffic going out of the survey areas at highway locations during a 24-hour period. At each survey location, the origins and destinations of all surveyed vehicles were recorded. Therefore, the data can be used to map the origins and destinations of all surveyed vehicles and analyze the travel routes of those vehicles. Because the origins and destinations of the surveyed vehicles do not necessarily fall inside the five-county area in Central Texas, this study added additional 13 counties adjacent to the five-county area in the analysis to ensure that sufficient records were included in the identification of travel corridors in the study area (Figure 16).

Table 16: External Survey Area

Austin Survey Area	San Antonio Survey Area
Williamson County	Bexar County
Travis County	Comal County
Bastrop County	Guadalupe County
Hays County	Wilson County
Caldwell County	

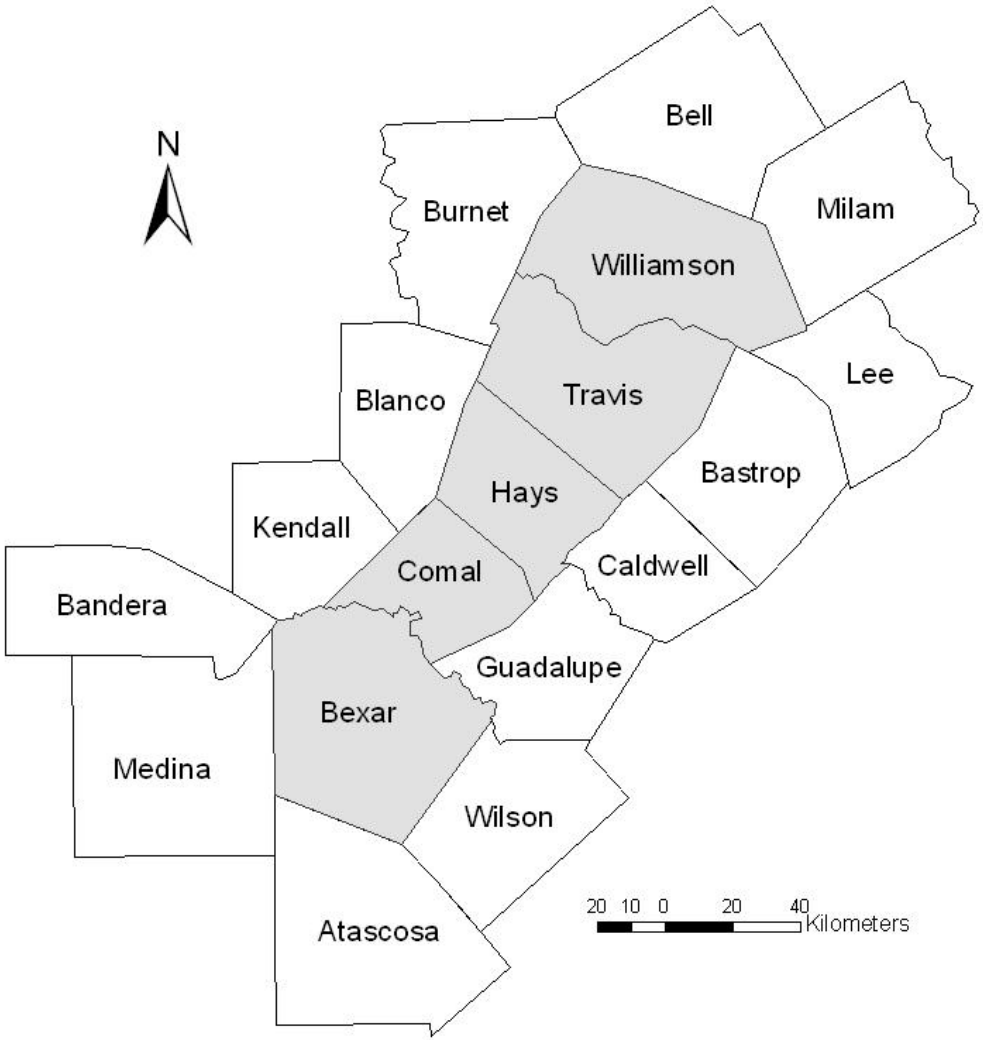


Figure 16. Expanded study area

Road networks

In order to identify the travel routes between origins and destinations and perform network analysis, we obtained the road network data in the study area from Geography Network (www.geographynetwork.com). This is the third dataset used in the analysis reported in this section.

GIS Map Layers of Counties in the Study Area

The fourth dataset is the GIS map layers showing counties in the study area. Because both Table 0010 and the external survey data only provide tabulated information about origins and destinations, we need to have county maps to associate this information with the actual county where trips occurred and visualize analysis results. We obtained GIS map layers (shapefiles) for the eighteen counties (Figure 16) from Geography Network (www.geographynetwork.com).

3.1.2 Data preparation

Preparation of GIS Map Layers of Traffic Analysis Zones (TAZ)

We generated the GIS map layer of TAZs through merging all TAZ shapefiles from individual counties into a single GIS map layer covering the five-county area. The GIS map layer was used in conjunction with Table 0010 from CTPP Part 3 to analyze commute trips. Data preparation related to the TAZ GIS map layer involves two major tasks: (1) Generate a map layer (shapefile) containing the centroid of each TAZ, and (2) snap the controids of all TAZs to their closed nodes on the road network. For each TAZ shapefile, we followed the steps given below to complete these tasks.

1) Project the TAZ shapefile using the North_America_Lambert_Conformal_Conic projection;
2) Add two new fields, e.g., "Res_X" and "Res_Y", to represent the x, y coordinates of TAZ centroids in the TAZ shapfile;
3) Calculate the x, y coordinates of the centroids for all TAZs;
4) Generate a point layer based on the x, y coordinates of centroids of the TAZs. Because each TAZ can serve as a trip origin, the points in the point layer can be used as trip origins;
5) Project the road network shape file using the North_America_Lambert_Conformal_Conic projection;
6) Snap the points in the point layer to the road network using Hawth's Tools, which can be downloaded from http://www.spatialecology.com/.

Preparation of CTPP Part 3 Table 0010

Table 0010 contains records for each pair of origin TAZ and destination TAZ for commute trips. Each TAZ can serve as a trip origin. Then, there can be a number of TAZs that serve as the destinations in associated with an origin TAZ. For example, there are ten commuters residing in TAZ 1, two of them have workplaces in TAZ 2, four of the workplaces in TAZ 3, and four of them have workplaces in TAZ 4. Then, for TAZ 1, there are ten trips to three destinations. The major task in processing Table 0010 for the subsequent network analysis is to create a destination point layer. We followed the steps described below to accomplish this task.

For each county in the five-county area

1) Create two new fields in Table 0010 of each county to represent the x, y coordinates of the destination TAZs (e.g., Des_X, Des_Y);
2) Associate the TAZ shape file with Table 0010 based on the field "TAZ" in the TAZ shapefile and the field "detworkgeo" in Table 0010. The field "detworkgeo" in Table 0010 represents workplace TAZ;
3) Assign the values of the x, y coordinates in TAZ shapefile to Des_X and Des_Y for all records in Table 0010;
4) Generate a point layer based on Des_X and Des_Y in Table 0010. This layer thus contains all destination points;
5) Snap the destination points to the road network using Hawth's Tools.

Preparation of Road Network Data

A major task in the preparation of road network for network analysis is to define travel cost associated with each road segment. Either travel distance or travel time can be used to represent the travel cost of a road segment. We used the five steps shown below to determine the length of a road segment and the travel time associated with each road segment.

1) Add a new field to represent the length of a road segment, e.g. "length", in the attribute table of the road network shapefile;
2) Calculate the length for each road segment in the road network;
3) Add a new field to represent the speed of a road segment, e.g. "speed", in the attribute table of the road network shapefile;
4) Calculate the speed for each road segment based on the class of a road in the attribute table of the road network file. The road class is an attribute in the original road network shapefile representing the type of road (e.g., interstate highway, state highway, and major arterials).
5) Calculate the average travel time of a road segment based on its speed and length.

Once the length of each road segment and its travel time in the road network were defined, we then converted the road network to a network dataset in order to perform network analysis in ArcGIS. This was implemented through ArcCatalog in ArcGIS. We can set either travel distance or travel time as the travel cost associated with each road segment in the conversion.

Preparation of External Survey Data

The external survey data recorded the origins and destinations of trips as geographic coordinates in text files. Therefore, rather than using TAZs to represent trip origins and destinations, we can directly use geographic coordinates to create map layers representing trip origins and destinations. For both commercial vehicles and non-commercial vehicles in the survey data, we follow the 10-step procedure described below to create map layers (shapefiles) of origins and destinations for the analysis.

1) Extract the x, y coordinates of survey locations, origins, and destinations of vehicles from the external survey data.
2) Create a point GIS map layer based on the coordinates of the survey locations.

3) Create a point GIS map layer based on the coordinates of the origins.

4) Project the two point layers using the North_America_Lambert_Conformal_Conic projection.

5) Overly the point layers with the GIS map layer (shapefiles) covering the eighteen-county area.

6) From the origin point layer, select the points that fall within the eighteen-county extended study area. Export selected points and create a new origin shapefile. Therefore, we refined the trip origins inside the eighteen-county area.

7) Based on the new origin GIS map layer (shapefile) obtained in step 6, create another point map layer using the x, y coordinates of the destinations in the attribute table. We therefore obtained a point GIS map layer containing destinations.

8) From the destination point GIS map layer obtained in step 7, select the points that fall within the eighteen-county area. Export the selected points and create a new point GIS map layer containing all destinations within the eighteen-county area.

9) From the origin point GIS map layer obtained in step 6, delete the points whose destinations are outside the eighteen-county area. Now, we obtained all pairs of trip origins and destinations that are within the eighteen-county area.

10) Snap the survey location point GIS map layer, the destination point GIS map layer obtained in step 8, and the origin GIS map layer obtained in step 9 to the road network using Hawth's Tools.

3.2 Network Analysis

The goal of network analysis is to identify the routes between trip origins and destinations. To implement this task, we used the closest facility solver in the network analysis extension in ArcGIS 9.1. Basically, a trip origin was set as a facility. Then, all the trip destinations associated with the trip origin were set as incidents. The closest facility solver then was used to determine the shortest paths from the trip origin to all destinations. The shortest path can be determined based on either the shortest travel distance or the shortest travel time if travel time is set for each road segment.

The close facility solver in ArcGIS was designed to conduct path search for one facility at one time. There are many origins in this study. Therefore, we wrote a program using Visual Basic Application (VBA) in ArcGIS to implement a batch process of searching all shortest paths associated with trips from all origins. In addition, the program also assigns the number of vehicles traveling on each road segment in the shortest path between an origin and destination pair. The total traffic volume for a road segment can be then obtained by summing up the number of vehicles that pass through that road segment in all shortest paths. Based on the traffic volume of each road segment, we were able to identify travel corridors that carry a significant amount of traffic in the study area.

The flow chart in Figure 17 shows the steps used to identify the travel corridors.

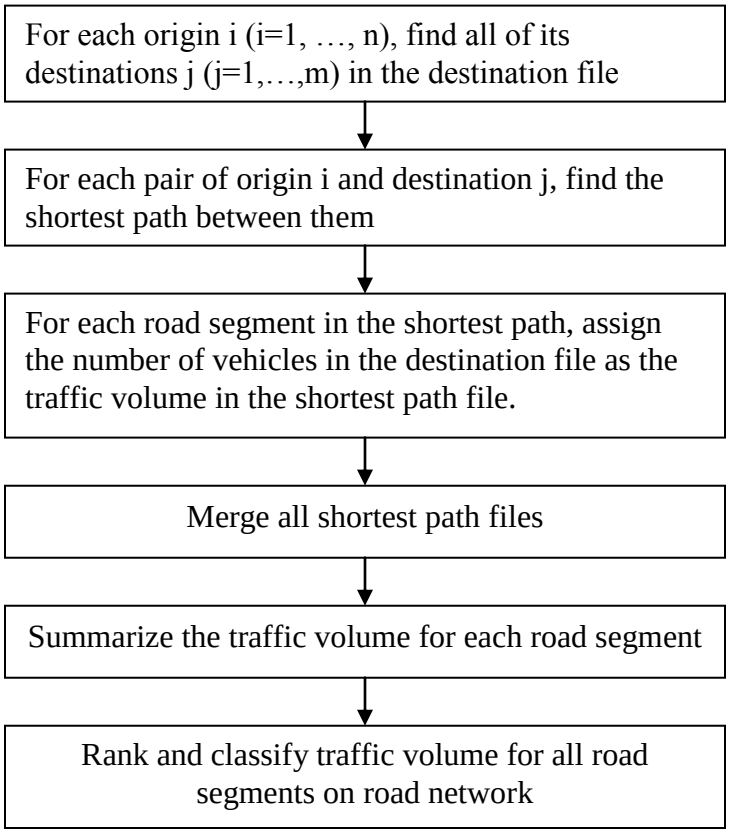


Figure 17. Procedure to identify traffic corridors

It is important to note that Table 0010 from CTPP Part 3 contains the number of vehicles between a pair of origin and destination, which can be defined as the traffic volume on the shortest path between an origin and destination pair (o-d pair). But, the external survey data was conducted for individual vehicles. Therefore, it is unnecessary to include the step that assigns traffic volume to road segments in the shortest path as described in Figure 17.

3.3 Analyses and Results

3.3.1 Overview the major travel corridors

Assuming that commuters select the routes with the shortest travel distance, Figure 18 provides an overview of the major travel corridors based on Table 0010 from CTPP Part 3. Assuming that commuters select the routes with the least amount of travel time, Figure 19 shows the overall distribution of the major travel corridors based on Table 0010 from CTPP Part 3. Given that travel time takes into account speed limits in association with different road classes, the results shown in Figure 19 should be more reasonable. Based on the shortest travel time, Figure 20 represents travel corridors identified using the external survey data for both non-commercial and commercial vehicles.

Based on results shown in Figures 18 and 19, it can be seen that inter-county commuting traffic was concentrated in two geographic areas in the study area: (1) Williamson-Travis-Hays, and

(2) Bexar-Comal. This pattern is expected. There is no significant traffic observed between Hays County and Comal County. Figure 19 also suggests that IH-35 in Central Austin carries the most amount of commuting traffic when compared to other major highways in the five-county area.

A comparison between the results in Figures 18 and 19 and those in Figure 20 reveal that the configuration of travel corridors in Figure 20 is closely related to the survey locations in the external survey data. Figure 20(a) shows a clear pattern of non-commercial traffic from adjacent counties to the five-county area. Results from Figure 20(b) indicate that IH-35 is a major passage of commercial vehicles, particularly in the part between Hays and Travis counties.

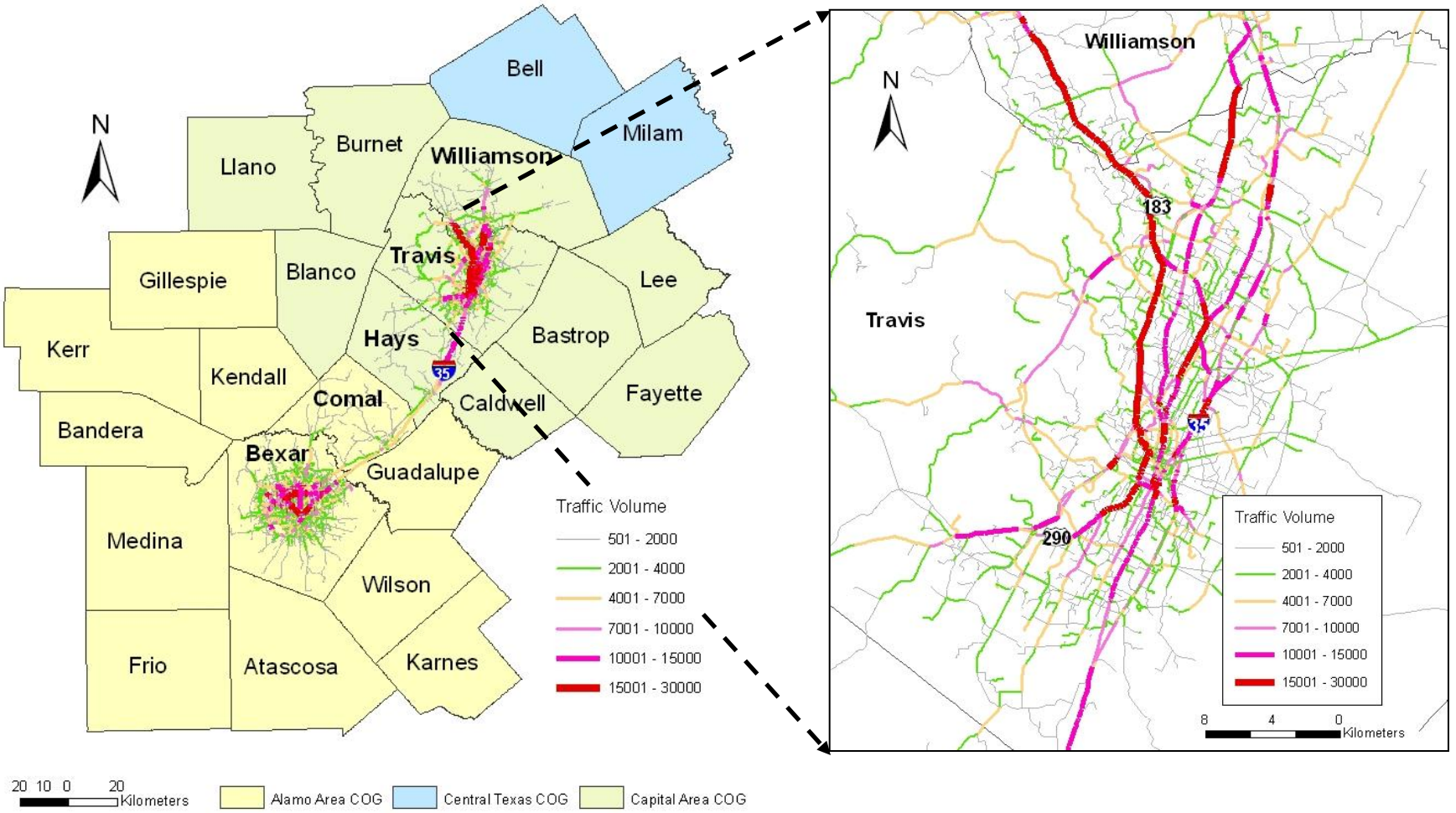


Figure 18. Computed traffic volume based on shortest travel distance using data from CTPP Part 3 Table 0010.

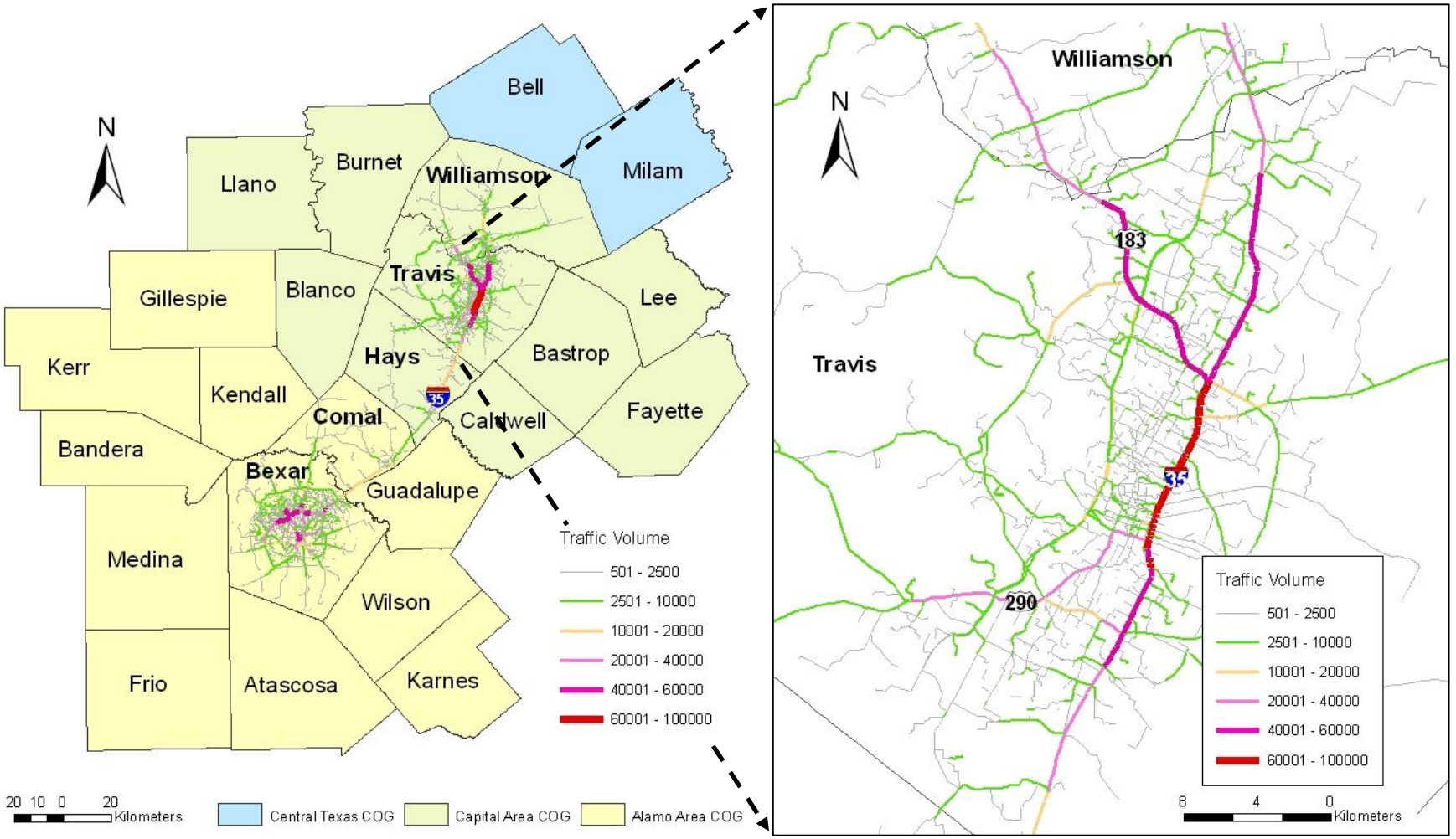
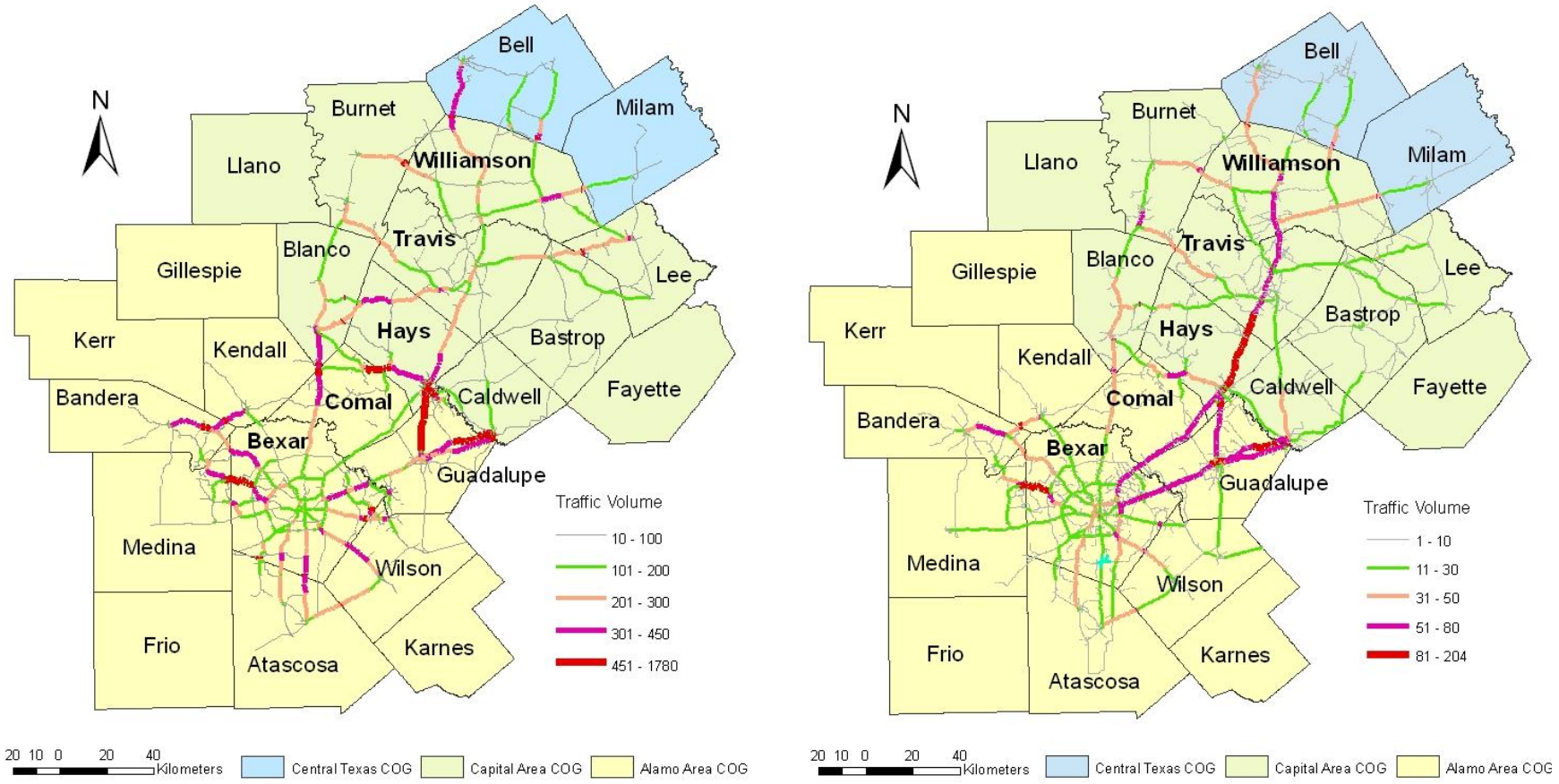


Figure 19. Computed traffic volume based on shortest travel time using data from CTPP Part 3 Table 0010.



(a) (b)

Figure 20. Computed traffic volume based on shortest travel time using data from external survey data: (a) non-commercial vehicles, (b) commercial vehicles. (Note: Computed traffic volumes in this figure are based on the survey data, and thus only represent a portion of the overall traffic volumes in the study area.)

3.3.2 Geographic distribution of major road segments with the largest computed traffic volumes when commuters use travel time to select their commute routes

To identify the locations of those road segments that carry the largest amount of commute flows in the study area, we ranked the computed traffic volumes based on the assumption that commuters use travel time to select their commute routes using the CTPP Part3 data. Because the external survey data are only based on samples of traffic at survey locations, we do not intend to discuss results related to the external survey data in this part of the study.

Based on results shown in Table 17 and Figure 21, the top 21 road segments with the largest computed traffic volume based on the CTPP Part 3 data are all on IH-35 between E Martin Luther King Jr Blvd and US-290 in Austin. This observation indicates that this section of IH-35 receives significantly more commuting traffic than the rest of roadways in the area. The list of top 21 road segments does not contain any road segment in the San Antonio area.

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Table 17: Top 21 Road Segments with the Largest Computed Traffic Volumes When Commuters Select their Travel Routes with the Least Travel Time (Based on CTPP Part3 Data)

ID	Road Name	County	Starting Place	Ending Place	Traffic Volume
1	I-35	Travis	E 46th St	Airport Blvd	99,037
2	I-35	Travis	E 46th St	E 48th St	99,037
3	I-35	Travis	E 46th St	E 51th St	98,569
4	I-35	Travis	E 38th 1/2 St	E 41st St	95,091
5	I-35	Travis	E 41st St	Airport Blvd	94,324
6	I-35	Travis	Intersection of US-290 E and I-35		94,165
7	I-35	Travis	E Dean Keeton St	E 32th St	93,653
8	I-35	Travis	E 53 1/2 St	Reinli St	93,622
9	I-35	Travis	E 32nd St	Concordia Ave	93,481
10	I-35	Travis	Reinli St	US-290 E	93,469
11	I-35	Travis	Concordia St	E 38th1/2 St	93,468
12	I-35	Travis	E 53rd St	E 53 1/2 St	93,233
13	I-35	Travis	E 51st St	E 53rd St	93,229
14	I-35	Travis	Manor Rd	E Dean Keeton St	92,673
15	I-35	Travis	E Martin Luther King Jr Blvd	Manor Rd	90,923
16	I-35	Travis	11th St E	12 St E	89,692
17	I-35	Travis	US-290 E	Tirado St	89,557
18	I-35	Travis	E 15th St	E Martin Luther King Jr Blvd	89,059
19	I-35	Travis	E 12nd St	E 15th St	88,141
20	I-35	Travis	Tirado St	Camino la Costa	88,047
21	I-35	Travis	E St Johns Ave	E Anderson Ln	87,499

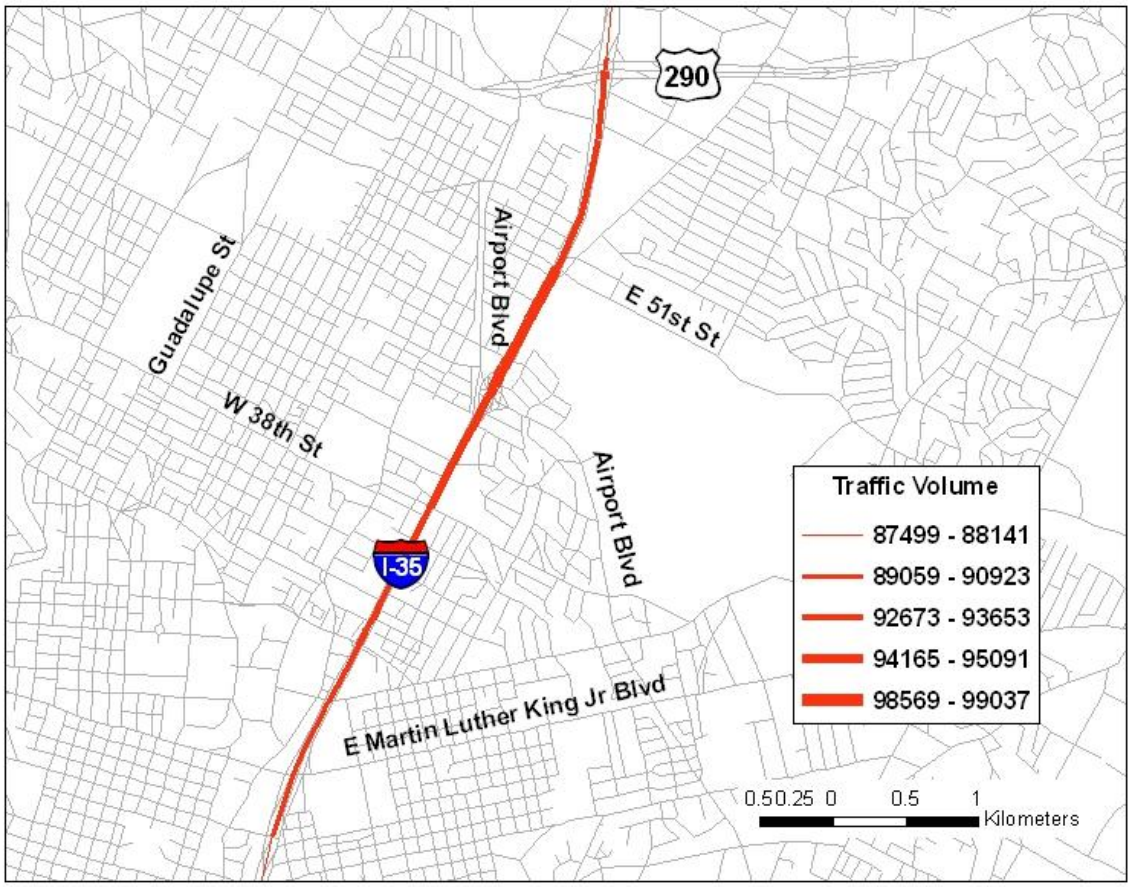

Figure 21 Top 21 road segments with the largest amount of computed traffic volumes When Commuters Select their Travel Routes with the Least Travel Time (based on CTPP Part 3 data

3.3.3 Major road segments connecting rural and urban areas

We identified the road segments connecting rural and urban areas in the study area and ranked these road segments based on the computed traffic volumes when assuming that commuters use the routes with the least travel time for commuting. Table 18 lists the top 23 road segments connecting rural and urban areas that carry the largest share of computed traffic volumes in the five-county area based on the CTPP Part 3 data. Most of the road segments on the top 23 list are located in Travis County. Only four are from Bexar County. Figure 22 shows a section of South IH-35 that connects rural and urban areas in Southern Travis County with a high computed traffic volume. Figure 24 provides another similar example in Northern Bexar County.

Table 18: Top 23 Road Segments Connecting Rural and Urban Areas with the Largest Computed Traffic Volumes When Commuters Select their Travel Routes with the Least Travel Time (Based on CTPP Part3 Data)

ID	Road Name	County	Starting Place	Ending Place	Traffic Volume
1	S I-35	Travis	E Riverside Dr	Festival Beach Rd	61,443
2	US-183 W	Travis	Technology Blvd	Barrington Way	39,424
3	I-35	Travis	Parker Dr	Louis Henna Blvd	33,492
4	I-35	Bexar	Toepperwein Rd	Judson Rd	28,303
5	S Lamar Blvd	Travis	Riverside Dr W	W Cesar Chavez St	26,628
6	US-183	Travis	Pecan Park Blvd	FM Rd 620	25,387
7	US-290	Travis	McCarty Ln	William Canon Dr W	23,789
8	S I-35	Travis	Onion Creek Pky	Old San Antonio Rd	23,776
9	S I-35	Travis	Old San Antonio Rd	Turk Ln	23,641
10	US-290	Travis	Patton Ranch Rd	McCarty Ln	22,948
11	I-35	Bexar	Toepperwein Rd	Shin Oak Dr	22,841
12	US-290	Travis	Parkwood Dr	Joe Tanner Ln	22,810
13	US-290	Travis	Joe Tanner Ln	Patton Ranch Rd	22,731
14	US-290	Travis	Oakclaire Dr	Parkwood Dr	22,629
15	US-183	Travis	Farm_Market Rd 620	Lakeline Mall Dr	22,211
16	I-35	Bexar	Shin Oak Dr	Pat Booker Rd	21,837
17	US-183	Travis	Lakeline Mall Dr	Straightline Dr	21,701
18	S Bell Blvd	Travis	Straightline Dr	Riviera Dr	21,680
19	US-183	Travis	Straightline Dr	South Lakeline Blvd	21,680
20	S Bell Blvd	Travis	Riviera Dr	Cypress Creek Rd	21,037
21	US-290	Travis	William Canon Dr W	Old Bee Caves Rd	20,437
22	I-10	Bexar	Mission Rd	Steves Ave	20,132
23	S Bell Blvd	Travis	Cypress Creek Rd	Buttercup Creek Blvd	20,027

Figure 22 An example high traffic volume road segment connecting rural and urban areas in Southern Travis County.

Figure 23. An example high traffic volume road segment connecting rural and urban areas in Northern Bexar County.

4. Summary and Conclusion

4.1. Research Objectives and Tasks

The growth of commuter traffic from rural areas to urban centers creates heavier traffic and therefore contributes to traffic congestion in some travel corridors. The increasing numbers of commuters who travel between jurisdictions often find public transit inconvenient or not accessible. TxDOT project 0-5345 aims at achieving a better understanding of intercity commute patterns in Texas, identifying major intercity and rural-to-urban travel corridors, and finding regional public transportation solutions for intercity commuting problems.

We formed an interdisciplinary research team to undertake research activities related this project. The team consists of Texas Southern University, Texas State University-San Marcos (Texas State), Texas Transportation Institute (TTI), and Prairie View A&M University. The Texas State team is responsible for research Tasks 8-11 as outlined in the TxDOT Project 0-5345 contract. Specific objectives of the Texas State team include examining commuting patterns from outlying cities, suburbs, and rural areas to urban areas and identifying traffic corridors that carry a significant amount of intercity and rural-to-urban traffic. The study area covers five counties, Bexar, Comal, Hays, Travis, and Williamson, in Central Texas. This study area encompasses two metropolitan areas: the Austin metropolitan area and the San Antonio metropolitan area.

The Texas State Team accomplished a number of tasks during the period from September 16, 2005 to October 31, 2006. These accomplishments are listed below.

- The development of a set of Geographic Information System (GIS) based analysis models for the identification of intercity commuting patterns and travel corridors in Central Texas;
- An examination of commuting patterns between rural areas and urban areas as well as commuting flows between different counties (cities) in a five-county study area in Central Texas based on the U.S. 2000 Census Journey-to-Work data;
- An identification of traffic corridors that carry a significant amount of intercity and rural-to-urban traffic in the five-county study area based on the U.S. 2000 Census Journey-to-Work data and the 2005 TTI external travel survey data;
- The identification of rural areas that generated the largest numbers of commuting traffic and road segments that carried a high volume of traffic.

4.2. Methods and Analyses

To accomplish the research tasks, the Texas State research team based the analyses on two datasets: the 2000 CTPP Part 3 Journey-to-Work data and the 2005 External (travel) Survey Data. The CTPP Part 3 data provide statistics of commute trips with regard to home and job locations. The External Survey Data give information about outbound traffic from highways at county boundaries in the survey area during a 24-hour period.

The team developed a set of GIS-based methods to analyze the characteristics of commute patterns and commute flows, including the geographic distribution of commuters and commuting vehicles in rural and urban communities, the average travel time with regard to home and job

locations, commute flows between different transit service areas, and commute flows between rural and urban areas and between different counties (cities) in the five-county study area. Details of these method and analyses are provided in Section 2 of this report.

In addition, the research team developed a GIS-based network analysis model for identifying commute routes between different origins and destinations at the Traffic Analysis Zone (TAZ) level. For each road segment in the study area, the model determines the number of trips it carried. Based on both the CTPP Part 3 data and the External Survey data, corridors that carried a significant amount of commuting traffic were identified using the network analysis model. A detailed discussion of the network analysis procedures and analyses is given in Section 3 of this report.

4.3. Preliminary Conclusions and Recommendations

Based on the analysis results, the research team has reached a set of preliminary conclusions as listed below.

- The GIS-based analysis models are effective for analyzing commuting patterns and travel corridors in both the Census Journey-to-Work data and the TTI external survey data.
- Commute flows between urban and rural areas account for about 20% of the total commute traffic in the five-county (Bexar, Comal, Hays, Travis, and Williamson) study area, and Inter-county commute accounts for 13% of the total commute traffic in the five-county study area.
- The majority of the top rural areas with high commute flows to urban areas are located in northern and northwestern parts of Travis County and scattered in the western, northern, eastern, and southeastern parts of Bexar County.
- Road segments with high traffic volumes are on IH-35 between East Martin Luther King Jr. Blvd and US-290 in Austin. This observation indicates that this section of IH-35 receives significantly more commuting traffic than the rest of roadways in the study area.
- Traffic volumes between counties and urban and rural areas could be evaluated in an intercity bus service context to estimate the need for public transportation services that are intercity or regional in nature.

References Cited

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Environmental Systems Research Institute, Inc. (ESRI). 1998. ESRI Shapefile Technical Description. Available from http://www.esri.com/library/whitepapers/pdfs/shapefile.pdf. (accessed November 20, 2005)

Texas Transportation Institute (TTI). 2005. Austin and San Antonio External Station Travel Survey.

Appendices

Appendix A Texas State Research Tasks in TxDOT Project 0-5345

The four main tasks of the Texas State Research Team are listed below.

Task 8	Review existing travel data relating home and job locations for Austin and San Antonio
Task 9	Identify travel corridors that carry a significant amount of commuting traffic originating outside the urban transit service areas for Austin and San Antonio
Task 10	Develop location-specific guidelines for potential public transportation coordination solutions along selected travel corridors
Task 11	Document all tasks and results in a technical report

Appendix B Procedures Used in Network Analysis for Identifying Travel Corridors

This appendix describes the procedures used in this study to conduct network analysis and identify major travel corridors. There are two subsections in this appendix. Section B.1 discusses the procedures used to analyze the data from CTPP Part 3 Table 0010. Section B.2 describes the procedures used to analyze the external survey data.

B. 1 Procedures for Analyzing the U.S. Census CTPP Part 3 Table 0010 Data

In CTPP Part 3 Table 0010, the number of vehicles for a pair of origin and destination was recorded according to four categories of time leaving home to go to work. The model developed by this study provides capabilities of computing traffic volume for the first three categories (Table 1).

It is suggested to run the model for one county at one time in order to reduce the overall computational time if the size of the road network is large. Before running the program, please check the fields in the attribute tables of the origin and destination shapefiles first.

- In the attribute table of the origin shapefile, the field "Min_DETRES" defines the TAZ number of the origin. Other name can be used. But the name in the script shall be changed accordingly (line 58, Line 212).

- In the attribute table of the origin shapefile, the field "DETRESGEO" defines the TAZ number of origin for each destination. This name shall be the same as what it is in CTPP Part 3 Table 0010 (line 315, Line 598). So there is no need to change the name of the field.

Then follow the steps below to run the model

1) Open sp.mxd file from folder /Task2_corridor/model in ArcMap
2) Add road network dataset into the data frame
3) Add destination shapefile into the data frame
4) Add origin shapefile into the data frame (Note: make sure the first layer is the origin file, the second layer is the destination file.)
5) Turn on the network analyst extension
6) Open Visual Basic Editor from tools/macro in ArcMap, make sure that the references to ESRI Networkanalyst UI object library, ESRI Network Analyst object library, and ESRI Networkanalysis object library are turned on. Now, the script is shown in the window.
7) Go to line 476 in the script, input/change the path of the folder where the shortest path files will be saved, e.g.

   Set pWkSp = pWkSpFactory.OpenFromFile("**C:\TxDOT-0-5345\CTPP_30010\Bexar\ Route_Time**", 0)

   Here "**C:\TxDOT-0-5345\CTPP_30010\Bexar\ Route_Time**" is the path of the folder for saving the shortest path files.

8) Go to line 483, input/change the suffix of the output shortest path files, e.g. use the county FIPS)

   pOutDSName.Name = "" & ResID & "" + "**_48029**"

   Here "**_48029**" is the county FIPS of Bexar County.

9) Go to line 586, input/change the name of the destination file, e.g.

   If pMap.Layer(i).Name = "**ctpp30010_TAZ_48029_W_snaped**" Then Set pFLayer2 = pMap.Layer(i)

   Here "**ctpp30010_TAZ_48029_W_snaped"** is the file containing records of destinations.

10) Save the sp.mxd file

11) Go to line 2 in the script, run the model

12) After the program finishes, use merge tool in Arctoolbox to merge all output shortest path files saved under the pre-specified output folder

13) Repeat step 1 to step 12 for all counties under study.

14) Merge all shortest path files obtained in step 12 for all counties.

15) Summarize traffic volume in the attribute table of the final network file obtained in step 14 based on "SourceOID" for different categories of time leaving home to go to work and output the results to a new table.

16) Create a new field representing traffic volume, e.g. "volume" in the attribute table of the original road network shapefile.

17) Based on the field "SourceOID" the table obtained in step 15 and the field "FID" in the attribute table of the road network shapefile, join the two tables together.

18) Calculate the values of the 'volume" in the attribute table of the road network shapefile according to the traffic volume in the table obtained in step 15.

19) Classify the road network file based the values of "volume".

B. 2 Procedures for Analyzing External Survey Data

The external survey data contains origins and destinations of trips on an individual-vehicle basis. Therefore, different from the procedures used for Table 0010 from CTPP Part 3 data, the step to calculate traffic volume is not necessary.

Before running the program, please check if the name of the survey locations in the origin and destination files first is defined as "FACNAME". Other name can be used. But the name in the script shall be changed accordingly (the name shows up in line 61 and line 216 in the script). Then please follow the steps below to implement the function.

1) Open Survey_sp.mxd file from folder /Task2_corridor/model in ArcMap

2) Add road network dataset into the data frame

3) Add destination shapefile into the data frame

4) Add origin shapefile into the data frame (Note: please make sure the first layer is the origin shapefile, the second layer is the destination shapefile.)

5) Turn on the network analyst extension

6) Open Visual Basic Editor from tools/macro in ArcMap, make sure the references to ESRI Networkanalyst UI object library, ESRI Network Analyst object library, and ESRI Networkanalysis object library are turned on. Now, the script is shown in the window.

7) Go to line 482 in the script, input/change the path of the folder where the shortest path files will be saved, e.g.

Set pWkSp = pWkSpFactory.OpenFromFile("**C:\TxDOT_0_5345\TxDOT_0_5345_ Mirra\Task2_corridor\External Survey\New Tables\Route_Time_Des"**, 0)

Here, "C:\TxDOT_0_5345\TxDOT_0_5345_ Mirra\Task2_corridor\External Survey\New Tables\Route_Time_Des" is the path of the folder for saving the shortest path files.

8) Save the sp.mxd file.

9) Go to line 2 of the script and run the model.

10) After the program finishes, use merge tool in Arctoolbox to merge all output shortest path files saved under the pre-specified output folder.

11) Summarize and obtain the count of each road segment in the merged road network file obtained in step 10 based on "SourceOID" in the attribute table of the road network shapefile, and output the results to a new table. The count of each road segment is thus served as traffic volume for the corresponding road segment.

12) Create a new field representing traffic volume, e.g. "volume" in the attribute table of the original road network shapefile.

13) Based on the field "SourceOID" the table obtained in step 11 and the field "FID" in the attribute table of the road network shapefile, join the two tables together.

14) Calculate the values of the 'volume" for each record in the attribute table of the road network shapefile according to the trip counts in the table obtained in step 11.

15) Classify the road network shapefile based the values of "volume".