

# Decennial Census Data for Transportation Planning: Case Studies and Strategies for 2000

## Volume 2: Case Studies

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**To James J. McDonnell**

The Conference on Decennial Census Data for Transportation Planning: Case Studies and Strategies for 2000 is dedicated to the memory of James J. McDonnell, who passed away in January 1996. Jim was the leading spokesperson in the U.S. Department of Transportation for improvements in census data for transportation planning, and his colleagues will never forget his many accomplishments in that regard.

Even in retirement, he was an active participant in the Transportation Research Board activities and in various other professional activities. It was at the 1994 conference at the Beckman Center that Jim was the first to recognize the need for this conference in 1996, and while at the 1994 conference, Jim had already lined up the U.S. Department of Transportation financial support for the succeeding conference.

You are remembered, Jim, and we are pleased to dedicate this conference to your memory.

*Conference Proceedings 13—Decennial Census Data for Transportation Planning: Case Studies and Strategies for 2000* consists of two volumes. Volume 1 contains the chairman's introduction, plenary session presentations, summaries of the case studies presented, and workshop reports. Volume 2 contains most of the case studies, organized into the following areas: Large Metropolitan Areas, Transit, Private Sector, Small Metropolitan Areas, and State Departments of Transportation.

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# LARGE METROPOLITAN AREAS

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# Conversion and Use of 1990 Census Transportation Planning Package in the Delaware Valley Region

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Thabet Zakaria, *Delaware Valley Regional Planning Commission*

An analysis of the 1990 Census Transportation Planning Package (CTPP) for the Delaware Valley Region is given, with special emphasis on journey-to-work trips, employment, mode of transportation to work, travel time, vehicle ownership, employed persons, and other socioeconomic data essential to transportation planning and travel forecasting. A review of the CTPP computer tapes and data showed some problems with programming, sampling, and bias, which were resolved before the data were used as a base for trend analysis, travel simulation, highway and transit project studies, strategic planning, and economic development. The CTPP information should be adjusted before it is used for transportation planning. The errors in the 1990 CTPP data are generally small, but the package shows no improvement over the presentation of the 1980 data. Most of the 1990 CTPP problems can be avoided in the future if the recommendations made in this paper are considered in Census 2000.

**I**nformation on work trips, employed persons, employment, and many other socioeconomic variables gathered during the 1990 census is available in the 1990 Census Transportation Planning Package (CTPP). The CTPP is a special tabulation of census data used in transportation planning at the state and regional levels. Funding for the development and production of the CTPP was provided by the states through the American Association of State Highway and Transportation Officials (AASHTO).

On June 22, 1993, the Delaware Valley Regional Planning Commission (DVRPC) received the first three parts

of the CTPP Statewide Element, but the first three parts of the Urban Element were not received until April 21, 1994, more than 4 years after Census Day in 1990. Work was initiated to process and print CTPP data for various levels of geographic units to be used in transportation system planning analysis and evaluation and for project studies. Because the contents of the CTPP are extensive, work on the processing and use of data continued into 1996.

The purpose of this paper is to discuss briefly the experience of DVRPC with the CTPP data, with special emphasis on the journey-to-work information and other socioeconomic information required for transportation planning and forecasting, such as population, households, employed persons, vehicle availability, and employment. The data are evaluated and some figures are presented to illustrate the magnitude of the errors and discrepancies in the data selected. The use of CTPP data in several DVRPC planning projects, both transportation-related and non-transportation-related, is described. This paper is essentially an update of a similar one by the author on the 1990 CTPP published in 1995 (1).

The DVRPC region includes four suburban counties in Pennsylvania (Bucks, Chester, Delaware, and Montgomery), four suburban counties in New Jersey (Burlington, Camden, Gloucester, and Mercer), and the city of Philadelphia. The Delaware Valley includes an area of 9886 km<sup>2</sup> (3,817 mi<sup>2</sup>) and a population of about 5.2 million. There are 352 municipalities, including such major cities as Trenton and Camden in New Jersey and Philadelphia and Chester in Pennsylvania (Figure 1).

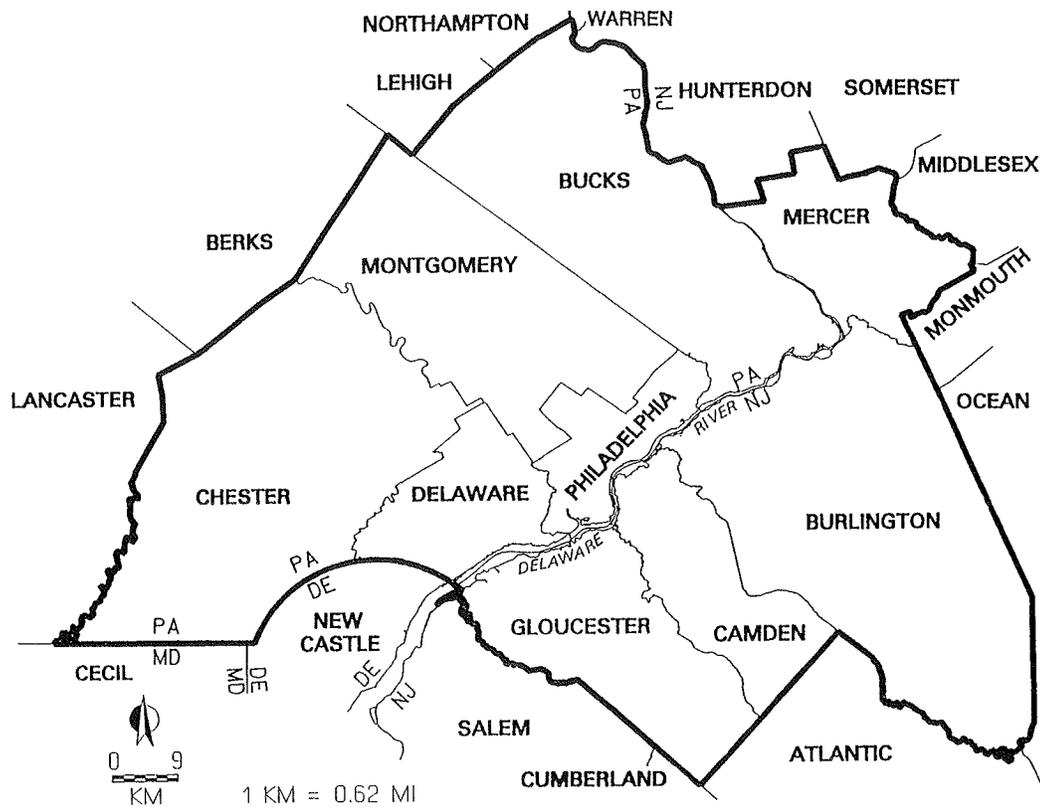


FIGURE 1 Map of the Delaware Valley Region.

## CONTENTS OF 1990 CTPP

The CTPP information was selected from the responses to the 1990 long-form census questionnaire distributed to about 17 percent (1 in 6) of all households. The Bureau of the Census prepared two 1990 CTPP packages: the Statewide and Urban elements. The Statewide Element consists of six parts containing information at the municipal level. These parts are labeled A through F.

The Urban Element provides data at the level of traffic analysis zone (TAZ), which for the most part is equivalent to a census tract. There are 1,395 TAZs in the DVRPC region. Census block groups are used in densely developed areas such as the Philadelphia central business district (CBD) where census tracts are too large for traffic simulation and analysis. There are eight parts in the CTPP Urban Element, labeled 1 through 8. Part 5, however, has been eliminated.

The 1990 data were collected using the following census areal units: block, block group, tract, place, minor civil division (MCD), county, and Metropolitan Statistical Area (MSA). In 1975 the DVRPC zonal system, used for the collection of data in 1960 origin and destination surveys, was converted to the census areal system in order to easily use census data in land use and transportation planning. This conversion has made it

much easier to provide an equivalency table of all tracts, blocks, block groups, and TAZs. The preparation of such a tabulation proved to be tedious, costly, and time consuming because the Delaware Valley region includes more than 74,000 blocks, 1,317 tracts, and 1,395 TAZs. The TAZs are used for travel simulation at the regional level.

In March 1992 DVRPC prepared a correspondence table for use in the tabulation of the Urban Element information. This table includes the following:

- Traffic analysis zone,
- Census block group number,
- Superdistrict,
- Minor Civil Division,
- Census state code,
- County, and
- Census tract number.

In addition to this information, DVRPC specified all external counties with a significant commuting flow from and to the DVRPC region. Because of programming difficulties, this file was not used by the Census Bureau. Instead, DVRPC was asked in 1994 to prepare a revised table (equivalency file), which inserted the TAZs in each census block record.

## REVIEW AND EVALUATION OF 1990 CTPP DATA

A review of the 1990 CTPP data from Parts 1, 2, and 3 for the Delaware Valley region indicated some programming, definitional, and statistical problems. Unlike the 1980 Urban Transportation Planning Package (UTPP), the 1990 CTPP contains data on work-trip destinations not identified by block or tract. The Census Bureau could not allocate all 1990 trips to TAZs because the Topologically Integrated Geographic Encoding and Referencing (TIGER) File does not contain address ranges for some suburban and rural areas in the region. The Census Bureau provided a list of places that failed the census allocation process. Specifically, any place that has less than 70 percent address range coverage and less than 70 percent of the persons working in the place coded to tract and block failed the test. In such places, the Census Bureau allocated the work places to default zones and asked DVRPC to review the list and allocate the default data to the affected TAZs, including water tracts (Figure 2).

### Programming and Format Problems

After receiving the 1990 CTPP tapes from the Census Bureau, DVRPC immediately started to extract the data needed for various air-quality and transportation planning studies. Data on population, households, vehicle

availability, and employed persons were printed for each TAZ, MCD, and county for review and use in several studies. Also, trip origins and destinations were printed to evaluate trip patterns at the zonal level. The format of the tapes was found to be quite complex and confusing. There was no labeling on the tapes, and the names of the tables were puzzling. No documentation of certain record types was available. The variations in recorded content should have been clearly recorded in both the general documentation and the data dictionary.

For example, review of the tapes of the CTPP Urban Element indicated that they do not have the same computer record size and block size at the tract or zonal levels. Part 3 has a record size of 1,180 and block size of 23,600, but Part 2 has a record size of 10,616 and block size of 21,230. These problems have caused some confusion, delay, and duplication of effort.

### Problems of Definition and Statistics

As stated previously, the Census Bureau obtained information on workers and not on trips; the latter information is usually collected in home interview surveys for transportation planning studies. The analysis of workers' trip tables (Part 3) by travel mode indicated that some walk and railroad trips were unrealistic in terms of travel time or distance. It was found, for example, that some workers walked from Philadelphia to places a con-

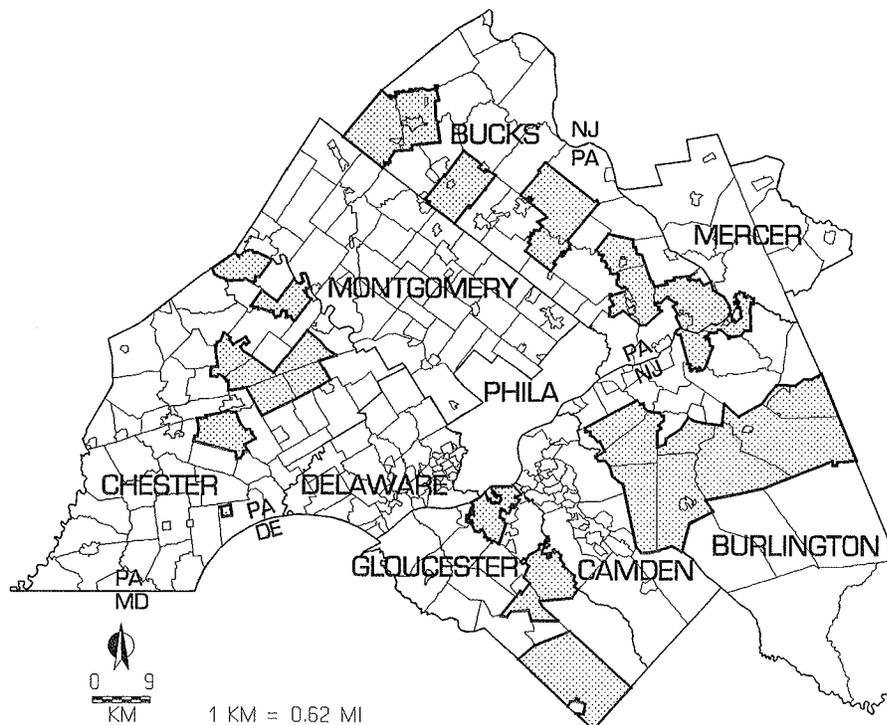


FIGURE 2 Location of default traffic analysis zones.

siderable distance from the city. Similarly, there were railroad trips where no such service existed. These few irrational trips are due to errors in census coding and sampling or to incorrect information returned by respondents who did not understand the census questionnaire. Many respondents confused the access mode with the principal mode of travel.

The evaluation of employment data by industry showed that some respondents misunderstood the census question that used the Standard Industrial Classification (SIC) system (Question 28). Some were not able to identify their industry correctly because some SIC categories are not easily defined and understood. The public administration sector is especially complicated. An employee of a municipal utility authority, for example, may consider himself either a member of the public administration sector or a member of the public utilities sector.

## ACCURACY OF CTPP DATA

### Place-of-Residence Data

Generally, the 1990 CTPP data are very good for transportation planning purposes. The data on population, household, car ownership, employed persons, and other socioeconomic characteristics obtained from Part 1 are quite accurate and do not require any major adjustment because of sampling or nonsampling errors. Part 1 data compare favorably with the 100 percent census counts, Standard Tape File 1 (STF1). Table 1 illustrates the magnitude of difference between the population produced from Part 1 and from the 100 percent counts for a few TAZs, MCDs, and counties selected at random. As can

be seen, the differences in population and resident workers are small and are acceptable for all planning purposes. However, the number of households in the CTPP is slightly lower than that in the total count. Most of the difference, 2,319 out of a total of 2,667, is found in the city of Philadelphia. All household zonal data were adjusted to be consistent with the 100 percent census counts, which are equal to those extracted from the tabulations of the STF3.

### Place-of-Work Data and Development of Employment File

As described previously, Parts 2 and 3 contain worker trip data at the place of work for various geographic units such as TAZs, MCDs, and counties. If trip destinations by resident workers living and working in the region and nonresident workers working in the region are added together, the sum should be approximately equal to the number of regional jobs, or employment. A certain percentage of these work-trip destinations (employment) should be added to account for workers who were absent during the census week because of illness, vacation, or other personal reasons and workers who had more than one job.

Using data from the Bureau of Economic Analysis, Bureau of Labor Statistics, previous DVRPC employment files, and local wage records, the 1990 CTPP work trips (number of workers at the place of destination) were adjusted four times in order to develop the employment file at the zonal level. The first adjustment was made to account for absentee rates reported by the census for each county (2.16 percent for the region) from responses to

TABLE 1 Comparison of 1990 CTPP Population, Households, and Resident Workers with Total Census Counts

Areal Unit	Population			Households			Resident Workers		
	CTPP	Total Count	Diff.	CTPP	Total Count	Diff.	CTPP	Total Count	Diff.
<b>TAZ</b>									
100	1,204	1,205	-1	476	515	-39	557	558	-1
400	9,030	9,030	0	4,279	4,319	-40	3,678	3,678	0
700	3,750	3,750	0	1,459	1,434	25	2,118	2,118	0
990	6,169	6,169	0	1,880	1,881	-1	2,780	2,780	0
<b>Municipality</b>									
New Hope, PA	1,400	1,400	0	811	810	1	964	964	0
Media, PA	5,957	5,957	0	2,876	2,867	9	3,243	3,243	0
Glassboro, NJ	15,614	15,614	0	5,069	5,019	50	7,422	7,422	0
<b>County</b>									
Philadelphia, PA	1,585,577	1,585,577	0	600,740	603,059	-2319	657,389	657,387	2
Mercer, NJ	325,824	325,824	0	116,777	116,941	-164	166,680	166,680	0
<b>Total Region</b>	<b>5,182,705</b>	<b>5,182,705</b>	<b>0</b>	<b>1,891,614</b>	<b>1,894,281</b>	<b>-2667</b>	<b>2,496,292</b>	<b>2,496,215</b>	<b>77</b>

Question 21a on the long-form questionnaire used in 1990. It should be noted, however, that other DVRPC data files indicate that the average rate of employee absenteeism for some companies ranges between 3 and 6 percent.

Second, all employment data were adjusted upward to reflect multiple jobholding based on the results of a survey conducted for the Bureau of Labor Statistics using a national sample of about 60,000 households (2). It was found that the national rate for multiple jobholding was 6.2 percent and varies by employment sector, ranging from 4.7 percent for construction workers to 9.3 percent for those working in government.

Third, employment estimates at many MCDs were examined, and some were adjusted upward or downward to account for coding discrepancies and respondent errors. Such adjustments were necessary at the municipal level to bring the estimates into agreement with data from the Bureau of Labor Statistics, DVRPC files, and municipal tax records. Finally, employment estimates at the TAZ level were examined to allocate the trips coded to default zones and water tracts by the Census Bureau.

All zonal data were factored to county and municipal control totals by employment sector, and a new computer file was prepared for users of these data. DVRPC uses the following 11 SIC sectors to generate trip production and attraction: agriculture, forestry, and fisheries; mining; construction; manufacturing; transportation; wholesale trade; retail trade; finance, insurance, and real estate; service; government; and military.

Table 2 shows a comparison of CTPP employment before and after adjustments for selected TAZs, MCDs, counties, and the total region. It also shows the percent difference between the unadjusted CTPP employment

estimates and those adopted by DVRPC. As the data in Table 2 show, the differences between the two sets of employment estimates are small (about 10 percent). In general, the percent difference between the two sets of employment estimates increases as the size of a geographic unit decreases because of the sampling error and coding problems.

### Means of Transportation

Most parts of the CTPP include information on the worker's mode of transportation to work. Respondents were asked to choose one of 11 travel modes that they usually took to work for most of the distance between the place of residence and work. The travel mode proportions appear to be reasonable because they compare favorably with DVRPC highway traffic counts and transit surveys for large areas and the region. Table 3 shows that the difference between the CTPP data and DVRPC estimates for total public transportation work trips is 1.9 percent. However, such a difference becomes large for travel submodes within smaller areas. In the Philadelphia CBD, the difference between the CTPP and estimated subway-elevated and bus trips is about 35 percent. Such large differences are mainly due to incorrect responses to the questionnaire. It appears that many respondents confused the access mode to a station with the principal mode of travel to work. The Philadelphia CBD highway trips computed by the DVRPC model are underestimated by about 5 percent. This problem will be resolved when the model is recalibrated with the 1990 census data at the subarea level.

TABLE 2 Comparison of 1990 CTPP and DVRPC Adopted Employment Estimates

Areal Unit	1990 Employment Estimates			% Diff. Adopted vs. CTPP Unadj.
	CTPP Unadjusted	CTPP Adjusted	DVRPC Adopted	
<b>TAZ</b>				
100	119	119	-	-
400	1,711	1,719	-	-
700	2,259	2,349	-	-
990	492	493	-	-
<b>Municipality</b>				
New Hope, PA	2,351	2,579	2,351	0.0
Media, PA	10,110	10,993	11,210	10.9
Glassboro, NJ	7,287	7,924	7,924	8.7
<b>County</b>				
Philadelphia, PA	761,244	834,335	836,874	9.9
Mercer, NJ	204,826	224,356	220,592	7.7
<b>Total Region</b>	<b>2,433,682</b>	<b>2,697,229</b>	<b>2,693,879</b>	<b>10.7</b>

**TABLE 3 Comparison of 1990 CTPP and DVRPC Work Trip Estimates by Mode**

Areal Unit	Mode	CTPP Data	DVRPC Estimates	Percent Diff.
Philadelphia CBD	Regional Rail	27.7	25.2	-9.0
	Subway-elevated and Bus	81.5	110.3	35.3
	Highway	117.9	111.5	-5.4
Total Region	Public Transportation	273.2	278.5	1.9
	Highway	1,954.0	1,969.2	0.8

Note: Values are in thousands of trips per day.

Table 4 shows the 1980 and 1990 average travel time of commuters in selected counties and the total region. The regional average travel time has changed slightly since 1980. Despite increasing traffic congestion in the region, regional travel time of work trips declined by 2.8 percent in the 1980s because of the decline of urban areas and the growth of suburbs, where the private automobile is the predominant mode of travel. According to the CTPP data, it takes much longer to commute by public transportation than by automobile. The decline in the share of public transportation in the region contributes to the decrease in commuting time because driving alone takes less time than traveling by public transportation. Commuters in the region have shifted from slower to faster modes of transportation. The 1990 CTPP average regional travel time compares very well with DVRPC average commuting time, which is based on an actual travel survey (24.6 versus 23.8 min).

These problems are similar to those experienced with the 1980 UTPP. For this reason, the CTPP trip information should be adjusted before it is used for transportation planning and travel forecasting. The adjusted CTPP employment and traffic data for the Delaware Valley region are quite reasonable.

### DVRPC USES OF 1990 CTPP

The uses of the 1990 CTPP in the Delaware Valley region are somewhat similar to applications in other metropolitan areas (3-5). DVRPC has already used census data in

various transportation planning studies and will continue to use the CTPP in the future. As mentioned earlier, the CTPP includes many socioeconomic data items and trip information that are invaluable to local and state governments, transit operators, and private corporations for making a variety of transportation and locational decisions, including the locations of shopping centers, industrial parks, banks, and service industries and the estimation of highway and transit travel, parking requirements, transit fleet sizes, and service schedules.

Six major uses of the 1990 CTPP in the Delaware Valley region are described in the following subsections.

### Data Base for Transportation Planning

DVRPC has completed a project to prepare a data bank for transportation planning at the TAZ, superdistrict, municipal, and county levels. This information includes population, vehicle availability, employment, work trips by mode, travel time, household income, and other socioeconomic variables required for traffic simulation and transportation planning and travel forecasting. Such data have been extracted from Parts 1, 2, and 3 of the CTPP. All data items have been edited for reasonableness and adjusted if necessary on the basis of other census data and DVRPC surveys, traffic counts, and data sources as described earlier. These data have been used in most transportation system and project planning studies in the last 3 years.

### Data Summaries and Trend Evaluations

DVRPC has completed three reports on the journey-to-work trends in the Delaware Valley region (6-8). These reports compare the 1970, 1980, and 1990 journey-to-work information, means of transportation for commuting to work, employed persons, and employment at the county and regional levels. They also analyze the commuting flow between the counties of the Delaware Valley region and surrounding counties and cities. The reports were well received by planners and decision makers because they provide factual information about trends in land use development and travel patterns in the region.

**TABLE 4 Average Travel Time of Commuters**

County of Residence	Travel Time (minutes)		
	1980	1990	% Diff
Bucks, PA	24.0	24.2	0.8
Montgomery, PA	21.9	22.5	2.7
Burlington, NJ	24.0	24.1	0.4
Mercer, NJ	21.7	22.1	1.8
Total Region	25.3	24.6	-2.8

For example, Table 5, taken from the regional report (6), gives the 1970–1990 trends in the distribution of Montgomery County resident workers by place of work. Other tables show the trends in employment and mode of travel for all DVRPC counties, cities, and selected municipalities.

Short data bulletins were also published. Each includes one or two information items obtained from Parts 1, 2, or 3 of the CTPP. For example, a bulletin was prepared on vehicle ownership growth between 1970 and 1990 for the counties in the Delaware Valley region. It also includes households stratified by the number of vehicles owned (zero, one, two, or three or more vehicles).

### Update of DVRPC Traffic Simulation Models

DVRPC's staff has used the 1990 census data to update and validate its travel forecasting models. Ten years ago the 1980 UTPP was used to check and validate the DVRPC traffic simulation models (Figure 3). These models follow the traditional steps of trip generation, trip distribution, modal split, and travel assignment, and use the computer programs included previously in the Urban Transportation Planning System (UTPS). In addition to this system, DVRPC is now using the TRANPLAN and TRANSCAD systems for travel forecasting and air-quality analysis.

Generally, the models are similar to those used in other large urban areas that depend on census data for system analysis and project studies. Figure 3 shows the steps followed to update the DVRPC traffic simulation process. A careful review and evaluation of the results of each model were conducted, and necessary adjustments were made to achieve the most accurate calibration. The simulated traffic volumes were compared with actual highway traffic counts and public transportation ridership to ensure that acceptable accuracy of the simulated results is obtained from these models. Specifically, DVRPC used the CTPP data in the following activities:

- Development of accurate inputs on population, households, vehicle availability, resident workers, and employment at the TAZ level;
- Comparison and analysis of DVRPC trip rates for work with the CTPP;
- Comparison and analysis of DVRPC trip length and travel time distribution for work with the CTPP;
- Comparison and evaluation of work trips estimated by the DVRPC model with the CTPP;
- Comparison and analysis of DVRPC automobile occupancy model with the CTPP; and
- Analysis and evaluation of DVRPC external work trips with the CTPP.

TABLE 5 Montgomery County Resident Workers: Distribution by Place of Work (6)

Place of Work	1970	1980	1990	Percent Change	
				'70-'80	'80-'90
Bucks	8,488	14,325	20,986	68.8	46.5
Chester	5,900	10,525	17,920	78.4	70.3
Delaware	5,897	7,773	10,933	31.8	40.7
Montgomery	158,986	204,673	229,923	28.7	12.3
Philadelphia	<u>54,489</u>	<u>55,598</u>	<u>55,956</u>	2.0	0.6
Total PA portion	233,760	292,894	335,718	25.3	14.6
Burlington	1,632	532	1,484	-67.4	178.9
Camden	3,089	1,643	2,808	-46.8	70.9
Gloucester	883	225	474	-74.5	110.7
Mercer	<u>1,877</u>	<u>354</u>	<u>1,024</u>	-81.1	189.3
Total NJ portion	<u>7,481</u>	<u>2,754</u>	<u>5,790</u>	-63.2	110.2
Total Region	241,241	295,648	341,508	22.6	15.5
Berks	2,499	3,070	3,670	22.8	19.5
Lancaster	82	172	162	109.8	-5.8
Lehigh	633	773	1,390	22.1	79.8
New Castle	513	282	580	-45.0	105.7
Northampton	665	196	326	-70.5	66.3
Other	<u>5,504</u>	<u>4,185</u>	<u>5,324</u>	-24.0	27.2
Total External	9,896	8,678	11,452	-12.3	32.0
Total Trips	251,137	304,326	352,960	21.2	16.0

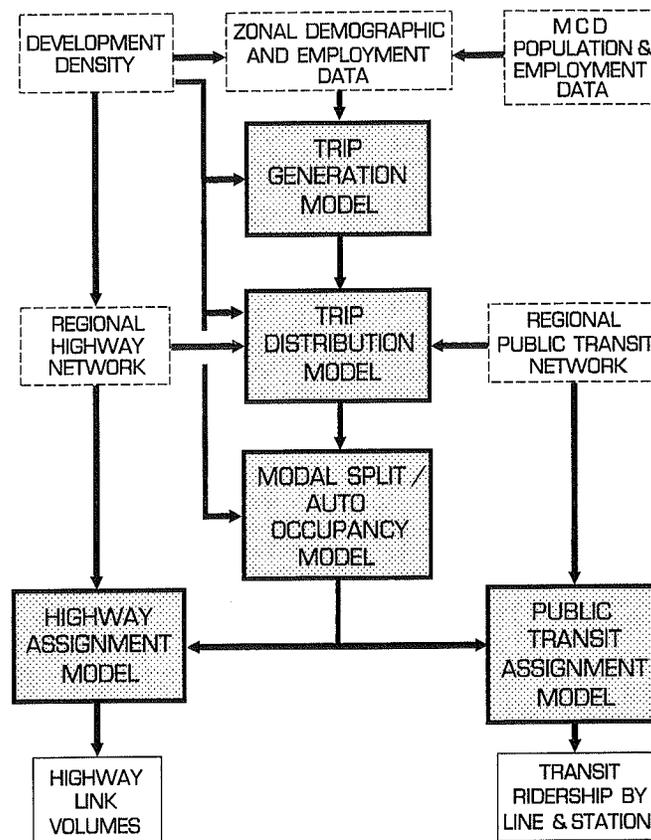


FIGURE 3 DVRPC regional travel simulation process.

In order to convert the CTPP trip data to home-based-work (HBW) productions and attractions internal to the DVRPC region (both trips end within the region), the census trip matrix was multiplied by 1.74 ( $2 \times 0.87$ ). This factor, which accounts for trip chaining, second jobs, absenteeism, and the corresponding work-to-home trips, was needed to convert the census home-to-work data to the average weekday production-attraction format tabulated from traditional home interview surveys for travel simulation. No explicit mode shift factors were used. A factor of 1.76 was used to convert the 1980 census UTPP data.

In 1988 DVRPC conducted a small-sample home interview survey to be used in conjunction with the 1990 CTPP data. Comparison of census-based HBW trips with the 1988 home interview survey indicated that the factor of 1.74 provides reasonable results at the regional level for driving alone and transit travel. The work trip automobile occupancy from the census data (1.09 persons per vehicle) is somewhat lower than the survey result (1.13 persons per vehicle). For Philadelphia CBD attractions, the census data tend to underestimate subway-elevated and bus trips and overestimate drive-alone automobile trips. Commuter rail trip attractions are slightly underestimated by the census data.

### Highway and Transit Corridor Studies

The 1990 CTPP data, especially the journey-to-work information contained in Part 3, have been used in several transit corridor studies to check travel demand or ridership for each transit submode, including high-speed rail, express bus and park-and-ride service, and local bus service in the suburbs.

The 1990 CTPP data are also being used in many proposed highway and transit corridor studies because it is the only information available for transportation planning at the regional level.

### Strategic Planning and Economic Development

DVRPC used the 1990 CTPP information on employment to evaluate the significant changes in the type and location of industries and commercial establishments. This evaluation resulted in recommendations and strategies aimed at attracting new industries and high-technology firms to the Delaware Valley. Also, employment information was useful in the redevelopment of declining urban centers and provision of the required physical improvements for their rehabilitation.

Existing access patterns were examined in terms of origins and destinations and modal split. Access problems for particular labor populations, such as low-wage workers, were identified. Access opportunities were also identified on the basis of data analyses, site analyses, and consultations. Solutions related to both transportation and land use have been proposed to improve access to employment centers, as dictated by findings.

### Provision of 1990 CTPP Data to Public Agencies and Private Corporations

Finally, DVRPC has been providing the 1990 CTPP information to any public or private agency involved in planning or urban studies, including studies for housing, finance, real estate, health facilities, social services, economic base, and economic development. Many planning agencies and private companies in the Delaware Valley region are very much interested in obtaining the CTPP information for their various studies.

### CONCLUSIONS

Generally, the 1990 CTPP for the Delaware Valley region contains good quality data for air-quality and transportation planning, travel forecasting, economic base and employment location studies, urban development analysis, and planning and evaluation of transit services. The use of the CTPP minimizes the need for large-scale data collection in the Delaware Valley and decreases the rising costs of surveys required for transportation planning at the system and project levels. Without census data it would be almost impossible to conduct many transportation studies in the region, and most of the DVRPC applications could not have been accomplished without these data. Under current budget conditions, it is almost impossible to conduct a home interview survey that would provide results similar to those included in the CTPP.

The analysis of CTPP data indicates a few programming, statistical, and bias problems. Most of these problems were resolved before DVRPC used the CTPP as a data base for trend analysis, traffic simulation, highway and transit project studies, strategic planning, and economic development. As with the 1980 data, the 1990 employment estimates must be adjusted before they are used in transportation planning studies because they do not include all jobs.

Most of the 1990 CTPP problems and errors can be avoided in the 2000 census by quality control edits and a careful review of the census questionnaire as well as the computer formats and programs required for processing the information. Specifically, the journey-to-work questions (21, 22, 23, and 28) should be simplified to prevent any confusion on the part of respon-

dents to questions on mode of travel, destination, and industry classification. Many confused the access mode to subway-elevated or railroad lines with the principal mode of travel. The questionnaire should be redesigned to capture multimodal trip information from the place of residence to the place of work and to avoid any error or misunderstanding in the employment sectors.

The format of the 1990 CTPP tapes is rather complex and must be simplified and checked for consistency. The funding and development of two packages in 1990—Statewide and Urban elements—was an excellent idea since they include better coverage of commutershed areas and could be used for checking accuracy and consistency of the census information. AASHTO should again provide the funding for the CTPP 2000. Finally, DVRPC has not as yet received all parts of the CTPP; a more timely release of data is obviously important to all census data users.

### ACKNOWLEDGMENT

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# Census Data Use in Illinois by Research and Academic Community

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Siim Sööt, *University of Illinois at Chicago*

This paper is one in a series of four that document the uses of the Census Transportation Planning Package data by the transportation community in Illinois. The focus in this paper is on the work performed by those conducting basic research or acting as a consultant to a client. Other papers in this series address the work conducted by small and large metropolitan planning organizations and by the transit community. The Census Transportation Planning Package (CTPP) has been used extensively by the research and academic community over the last two decades. The 1970 Urban Transportation Planning Package was used in numerous studies, but the focus of this paper is on the use of the 1990 CTPP. At least one major study is ongoing that examines the changes inherent from the 1970 to the 1990 planning packages, and several studies are discussed that examined the changes from 1980 to 1990. Nine different applications of the CTPP at five different institutions are documented. The applications are quite varied and include studies of Chicago as well as of smaller metropolitan areas throughout Illinois. Most are transportation studies, but there are also numerous uses of the package because of its readily available information on employment by small area. The researchers uniformly indicated that their work could not have been performed in its present form, and in most cases could not have been performed at all, without the CTPP. The CTPP is indeed a very useful source of data for a variety of studies using small-area zones.

**P**lanners and scholars have now used the census transportation planning packages in the Chicago area for well over 20 years. The 1970 Urban Trans-

portation Planning Package (UTPP) was utilized extensively by the staff of Northeastern Illinois Planning Commission (NIPC) and particularly by the Chicago Area Transportation Study (CATS). It was also intensively used by Sen and Sööt at the University of Illinois at Chicago in nearly a dozen studies funded by the U.S. Department of Transportation (DOT) as well as by numerous local agencies. They also spent over half a year in enhancing and modifying the 1970 UTPP to make it more readily usable. Based on the work in the 1970s, the 1980 UTPP was used widely for modeling and descriptive purposes. Most of these efforts were centered on modeling trip distribution and modal split. Several hundred laborsheds were also mapped as a first step in the development of a laborshed model.

In this paper, the focus is on use of the 1990 Census Transportation Planning Package (CTPP). Nine applications for research and planning purposes at five different institutions are discussed. The studies not only addressed transportation questions but also examined employment distributions and concentrations. Several of these studies used both the 1980 and the 1990 packages.

## APPLICATIONS

The CTPP has been utilized by numerous individuals at several universities and research institutes in the Chicago area: the University of Illinois at Chicago,

Northern Illinois University, Loyola University of Chicago, Illinois State University, and the Woodstock Institute. The staff of the Urban Transportation Center at the University of Illinois at Chicago has used the CTPP for three substantial studies. The first was to determine the potential users of the proposed Downtown Circulator System (light rail). The second was to compute the average vehicle occupancy level for the Chicago area. The third was to produce the weights for the CATS Household Travel Survey and to develop a model estimating nonresponse rates. Each of these studies was highly dependent upon the CTPP data.

### Use of Downtown Circulator System

The city of Chicago proposed a network of light rail lines connecting major traffic-generating points and sub-areas in the greater downtown. The study of the potential users of the proposed circulator system made extensive use of the 1990 CTPP (1-3).

A critical factor in garnering political support for the circulator was the demonstration that the Chicago downtown was not just the work destination for wealthy suburbanites and the elite of the city but that it serves nearly all of the Chicago neighborhoods. Figure 1 shows that a high proportion of the workers residing in the upscale neighborhoods along Lake Michigan to the north work in the downtown area, but it also clearly illustrates that the downtown is an important work destination for many of the workers residing in the minority neighborhoods south of the downtown. Figure 1 and the accompanying report (1) were important in understanding the significance of downtown jobs for many minority neighborhoods throughout the city. Conversely, it is evident that the northwestern portion of the city, with a preponderance of single-family homes and upper-middle-income households, is not as dependent upon downtown jobs as most minority areas are.

This application also illustrates the use of the geographic information system (GIS) in working with the CTPP. It was necessary to gather the information by political wards, which are rather irregularly shaped districts and therefore do not conform to the traffic analysis zone (TAZ) geography available in the CTPP. A PC-based GIS was used to aggregate the TAZ data to approximate the city's political wards, as shown in Figure 1.

The CTPP was also used to determine the importance of other employment centers to city residents. In each of these cases the geographic extent of the employment center needed to be delimited. The CTPP was an exceptionally good source of data to accomplish this task. Figure 2 shows how the CTPP was to be used to define employment hubs in a direct cartographic manner. Although the limits of the hubs are not shown,

it is evident that with spatial data such as these, the hub can be defined using a minimum employment density criterion as well as a contiguity requirement. This task can be accomplished more readily by visual inspection than by the development of an extensive computer code.

Other techniques could clearly be used, but the visual statement of what constitutes the employment hub is important in establishing the credibility of the method. Seven major employment hubs, including the central business district (CBD) were defined using this method (Table 1). The commuting patterns to each of these seven hubs and other destinations were then determined. Using the geographic detail provided in the CTPP (TAZ-to-TAZ work trips), the number of individuals commuting from each of the city's 50 political wards was tabulated.

The amount of traditional and reverse commuting could also be seen. The first four destinations in Table 1 are within the city (O'Hare International Airport is partially in the city). It also showed that in some employment hubs, such as the University of Chicago/Hyde Park, residents find more jobs in the Chicago downtown than they do in their own local employment hub. In general the importance of downtown jobs is very evident.

Without question, this study could not have been conducted at this level of detail without the CTPP, nor could it have been conducted at a much more aggregated level with the ease made possible by the CTPP. The study clearly demonstrated that the Chicago CBD was critical to many inner-city minority neighborhoods as a job destination, and it was used to refute conventional wisdom about the significance of the downtown for many low-income neighborhoods.

### Average Vehicle Occupancy

The Statewide Element of the CTPP was utilized to determine the average vehicle occupancy (AVO) rates for the city of Chicago and suburban Chicago (4). By examining the CTPP work-trip data by time of day it was possible to determine the number of workers commuting during the critical morning peak period. Drivers could be distinguished from automobile passengers.

Table 2 shows some of the results of this work. With the CTPP files it was possible to compute the target for the Employee Commute Option (ECO) program. The city AVO was 1.07 and the corresponding AVO for suburban work places was 1.12. The highest levels were achieved by Chicago workers working in Chicago (city-city trips). Some county-to-county levels were as low as 1.05. The CTPP data allowed an examination of AVO data by both place of residence and place of work.

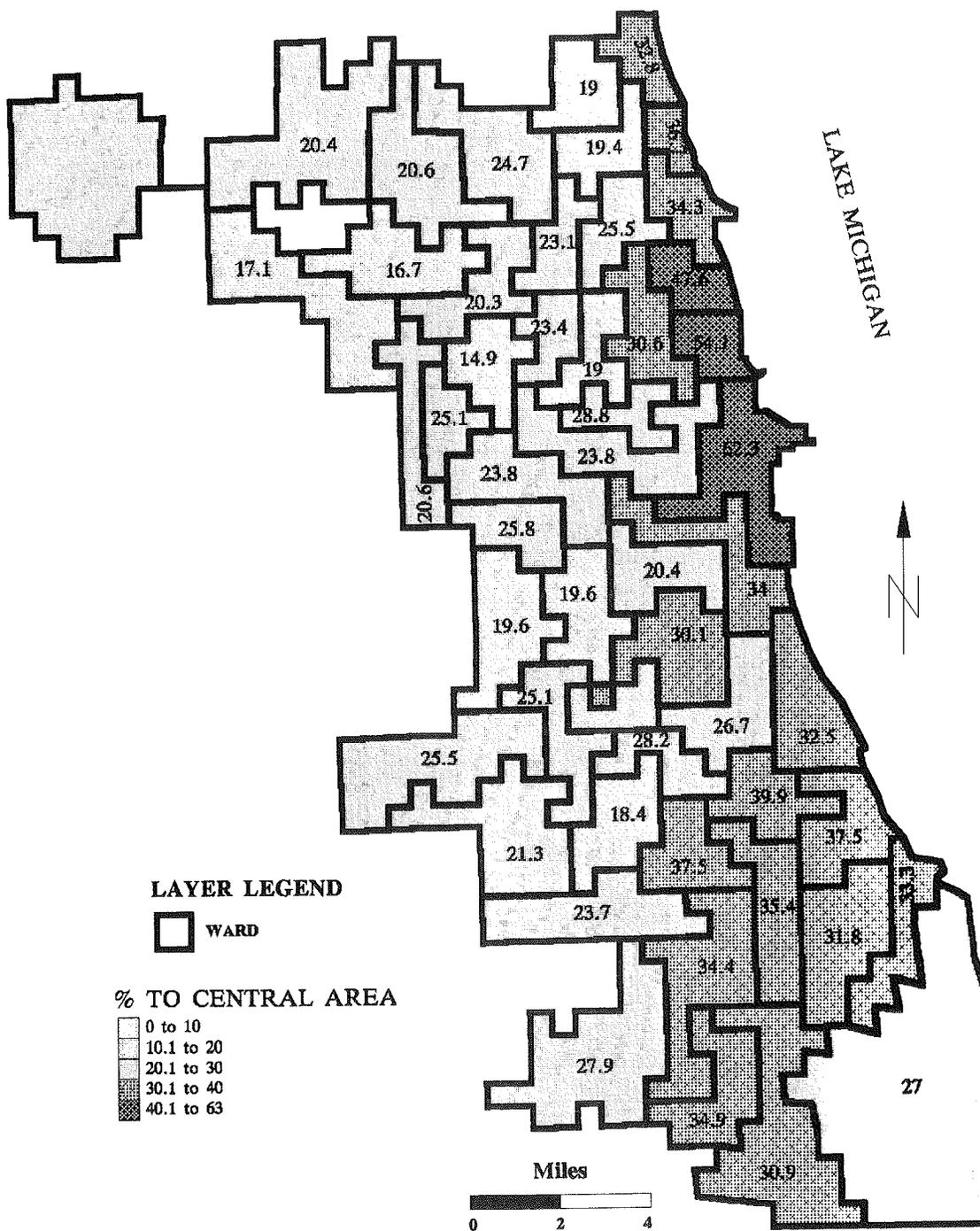


FIGURE 1 Percent of work trips from Chicago wards to the central area (city of Chicago wards generalized to quarter sections). Source: 1990 CTPP.

### Household Travel Survey

The 1990 CTPP was used in two different studies relating to the CATS 1990 Household Travel Survey: to help establish the weights for each survey instrument (5) and to establish a model to estimate the nonresponse rates in a mail-out, mail-back surveying procedure (6).

The 1990 CATS Household Travel Survey was weighted for the purposes of tabulating the raw data into summary tables and other descriptive reports. The survey responses were weighted to the data on number of workers and household size available by TAZ geography used in the CTPP aggregated to factoring zones (5). Figure 3 illustrates a basic step in the weighting process. The re-

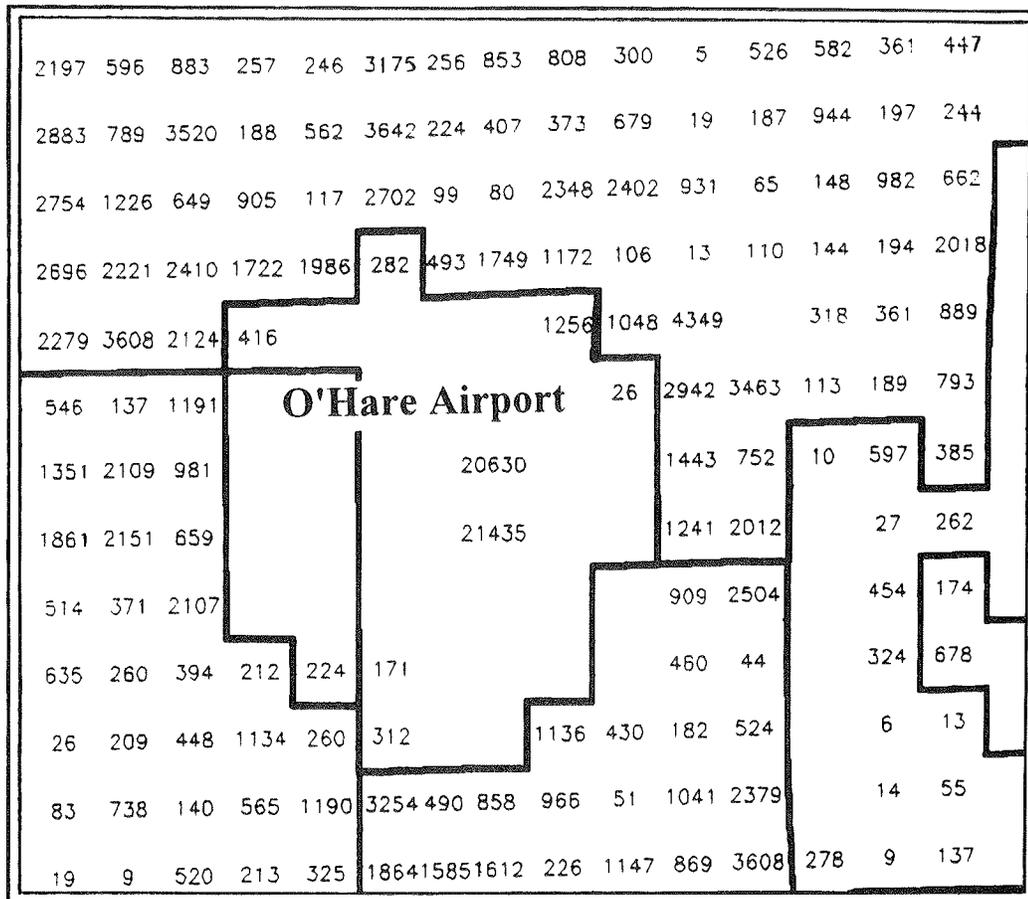


FIGURE 2 Employment in the O'Hare area by TAZ.

TABLE 1 Major Employment Hubs and Workers Living in Chicago

Employment Hub	Area sq.mi.	Employment	From Chicago	% From Chicago
Central Area	4.75	542,387	333,431	61
O'Hare East	7.00	81,030	29,627	37
Near North	6.50	79,469	57,067	72
Med Complex	6.25	69,266	45,044	65
UC Hyde Park	4.50	29,489	21,613	73
Schaum/Wdflid	6.00	49,971	4,062	8
I-88 East	13.00	70,512	6,212	9

Source: Census Transportation Planning Package, 1990.

TABLE 2 Number of Work Trips by Automobile

Residential Location	Automobile Work Trips 6:00-10:00 (1000's)	Percent of These Trips to Chicago	Percent of * of all Work Trips
Suburban Cook	793	20.9	68
DuPage County	302	9.1	73
Lake County	188	5.5	72
Will County	116	6.0	69
McHenry County	67	2.5	74
Kane County	111	1.9	72
Kendall County	15	1.6	75
Subtotal: Suburban Chicago	1,592	13.5	70
City of Chicago	524	68.2	45
Seven County total	2,116	27.0	62

\*Automobile work trips (drivers plus passengers) between 6:00 and 10:00 AM as a percentage of all work trips.

Source: Household Travel Survey and CTPP (which uses 5:30 AM - 9:30 AM, here assumed to be 6:00 - 10:00 AM).

turn rates shown indicate where the standard large zones need to be disaggregated to compensate for especially low returns from some square-mile-sized neighborhoods. It should be noted that near Waukegan there are a large number of zones with low return rates. On the basis of these rates, this area was designated a separate factoring zone. Other factoring zones are much larger.

The CTPP was also used in estimating the nonresponse to the CATS Household Travel Survey. It is apparent that response rates for survey instruments were much higher for some neighborhoods than for others. Since in most surveys a target number of responses is desired from each neighborhood, it is necessary to have a reasonable estimate of the response expectations. The sociodemographic information from the CTPP was used as independent variables in a regression analysis of response rates (6).

### Analysis of Employment Concentrations

Richard Greene of Northern Illinois University and Richard Forstall of the Population Division of the Bureau of the Census have worked on several joint efforts between the two agencies; one was in the Chicago area. The Chicago study used both the 1980 and 1990 trans-

portation planning packages to define employment concentrations and to examine the shifts in employment (7). Greene and Forstall cooperated in a similar study for Los Angeles and noted that the size of the average census tract (the TAZ) in the Los Angeles area is 0.62 mi<sup>2</sup>, whereas in the Chicago area TAZs are approximately a quarter of a square mile. In the Chicago metropolitan region the average census tract is several square miles in area; therefore the TAZ provides data for a much smaller area than the census tract.

Since the Chicago metropolitan area (the Chicago CMSA) now includes 13 counties in three states, the authors focused on the three central counties—Cook, DuPage, and Kane. Cook is the central county (Chicago) and the other two are directly west of Chicago. Other counties were excluded because each had problems associated with coding place-of-work data by TAZ.

As part of their analysis they mapped several variables, including the number of resident workers and jobs by place of work. The distribution of resident workers is largely concentrated in the city of Chicago and close-in western and northern suburbs. The distribution of jobs, however, is much more clustered, with several TAZs having more than 5,000 jobs. Although

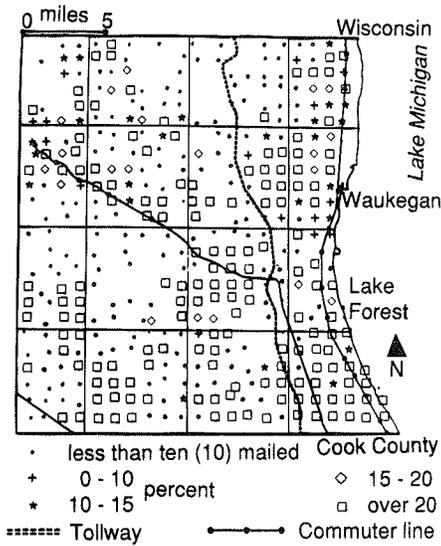


FIGURE 3 Lake County return rate by square-mile zones.

large numbers of workers reside on the south side of Chicago, the concentrations of jobs are found elsewhere. It is very evident from their maps that there is an imbalance of workers and jobs on the south side of Chicago. For many of these south-side communities, average work trip travel times are in excess of 45 min in contrast to the metropolitan average of 28.1 min. This imbalance in travel times continues to be a problem that defies a short-term solution.

The jobs are concentrated in and near the Chicago CBD and in the near north side. In the suburban area the greatest cluster is at O'Hare International Airport and in the industrial parks and mixed office and hotel land uses in the northern suburbs. There are other major employment areas such as the I-88 corridor, the Schaumburg/Woodfield area and the western suburbs.

Some of these patterns can be more readily seen in Figure 4, which covers only the three counties of special interest in their study. With the CBD area removed, some of the remaining clusters can be more readily seen,

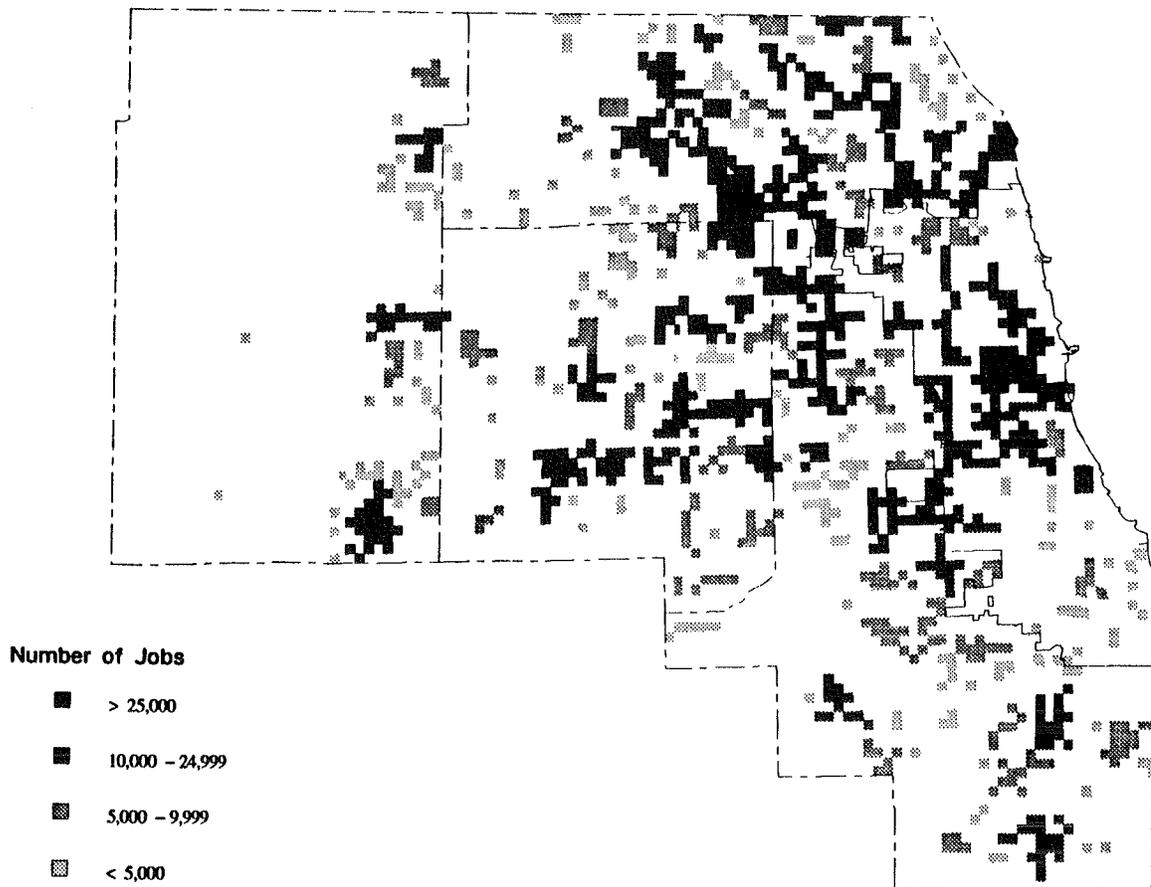


FIGURE 4 Employment concentrations outside Chicago's CBD (7).

including the North Branch (River) industrial area and the ones mentioned in the previous paragraph.

Last, Greene and Forstall examined the changes inherent from 1980 to 1990. These maps clearly indicated that employment growth is in the suburban areas, principally in the western and northwestern suburbs.

### Examination of Congestion and Air-Quality Relationships

Currently Audrey Clark and Andrew Kremenc at Northern Illinois University are participating in a promising study of changes in travel behavior and how these are contributing to congestion in the Chicago area. The study is the first step in congestion mitigation analysis. The goal is to achieve air-quality improvements by first better understanding current travel behavior and the changes since 1970. Because 1980 was a period of unusually high energy costs, the 20-year time horizon is particularly useful. The 1970 and 1990 planning packages represent the centerpiece of this research. It is the first serious long-term effort using both the 1970 and 1990 CTPP to track changes in travel behavior in the Chicago area. The work is ongoing and the results should be available near the end of 1996.

### Decentralization and Suburbanization of Employment

David Merriman, in the Department of Economics at Loyola University of Chicago, found the CTPP indispensable in completing the paper *Location, Location, Location?*, currently in draft form (8). The study examines to what degree location is important in determining employment growth. He uses the 1980 and 1990 transportation packages to examine empirical evidence for the role of location in light of the traditional urban economic theories that indicate the importance of access to amenities and other economic activities in locating new employment. Merriman's early findings suggest that location is not as important as many would suggest.

Merriman examined the employment distribution by industry for the 4,244 TAZs that are found in both the 1980 and 1990 packages. No other census product would have given him this level of geographic detail. For the emphasis on the spatial aspect of changes in employment distribution, the small-area geography provided by the 1980 and 1990 packages is ideal. Also, the 1980 and 1990 packages readily lend themselves to longitudinal analysis. The 1970 package is more difficult to use because of the varied sizes of employment zones (TAZs, ZIP codes, municipalities, and counties as well as work place not reported). Merriman computed the center of gravity for

each of 14 employment categories by industry and found that most centers moved west and north of the Chicago CBD during the decade studied. He also used an economic model to examine the decentralization of employment from the existing employment cores, which suggests that decentralization forces are active since large clusters of employment are not growing but smaller ones are.

### Redefinition of Metropolitan Areas

The 1990 CTPPs for Bloomington-Normal, Springfield, Kankakee, and Chicago in Illinois and Clarkville in Tennessee were used to explore the possibilities of providing an alternative to the current practice of designating one or more cities as the central city of a metropolitan region. The study by Treadway at Illinois State University (9) concludes that the CTPP is an ideal source for identifying small subareas used to define a "more suitable multi-nodal 'metropolitan core' than central cities" (9, p. 13). He also points to several methodological problems associated with other procedures.

Treadway's procedure is based on initially allocating default-zone employment (employment that is not assigned to a TAZ) to existing TAZs. In his five metropolitan areas this ranges from a low of 4 percent of the work trips in Chicago to a high of 33 percent in Kankakee. After the allocation of default-zone employment to TAZs, the resulting employment is divided by the number of resident workers to obtain employment-residence ratios (Figure 5). Areas with ratios less than 1.0 are interpreted as principally residential and not part of the employment core of the metropolitan area. These areas account for a high of 78 percent of the TAZs in Chicago to a low of 60 percent in Springfield (the state capital).

Treadway mapped several ratio levels and interpreted the bounds of these respective TAZs as possible limits for the central core of the metropolitan area as an alternative to the central-city concept. He mapped the distribution of the major employment concentrations with employment-residence ratios over 5.0. The other ratios over 1.0, mapped separately in the study, need to be added to obtain the final results. In summary, this procedure is analogous to procedures exercised in the New England states where metropolitan areas have definitions different from those for the rest of the country. Clearly this approach is only feasible if there are employment data by the same geography as resident worker data, which is currently only available in a single source, the CTPP.

### Intercounty Work-Trip Flows

The Statewide Element was also used to study the work-trip flows in central Illinois. The eight-county area in the

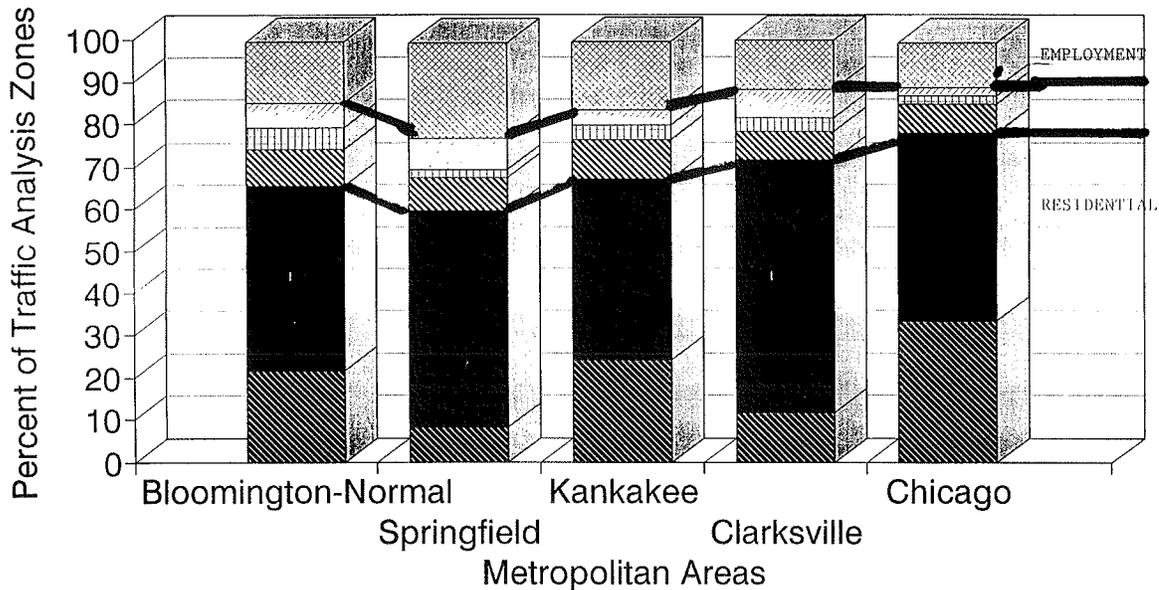


FIGURE 5 Percent of TAZs by employment-residence ratio, metropolitan areas, 1990.

vicinity of Peoria showed which counties exported workers and which counties imported them (10). Peoria County is the work destination for over 100,000 workers, only about 68 percent of whom live in the county. McLean County also imports workers.

Studies such as these are important in assessing the draw that each central county exerts on surrounding residents. This information is important for prospective employers in determining the size of the potential labor pool when siting a new facility. Data such as these are also useful in longitudinal studies of commutersheds and for transportation planning.

### Inner-City Jobs Accessibility

The Woodstock Institute in Chicago is a public interest research organization that has studied a variety of problems confronting inner-city residents. Currently one of the major focus areas is the loss of jobs in manufacturing and related industrial sectors near the core of city. The CTPP has been used in several studies (11, 12) to examine how residents are adjusting to job losses in the central city and job gains in the suburbs. In one study the Institute focused on a select neighborhood (Noble) and studied both the source of workers and the work places of local residents using pie charts. The study area was found to be much more important as a source of workers than as a destination for local resident workers. In this study area traditional commuting from the suburbs to the city is still much more prevalent than is reverse commuting.

Robert Gray of Gray Data, who has used the 1970, 1980, and 1990 packages for a variety of studies, per-

formed much of the data processing for the Woodstock Institute. He is currently beginning another effort utilizing the CTPP, but it is too early to report his preliminary findings.

### CONCLUDING REMARKS

In Illinois there has been a long tradition of CTPP use, starting with extensive utilization of the 1970 UTPP. The 1980 UTPP was used more extensively, and the 1990 CTPP is being used to address a wide variety of questions. There now is also the opportunity to use the census packages in longitudinal studies. Several of the studies cited here focused as much on the current patterns inherent in the 1990 data as they did on the changes since 1980. A major study is currently in progress examining the changes in travel patterns from 1970 to 1990. This study is especially promising since the 1980 UTPP data reflect a period of unusually high energy prices and therefore a mix of mode choices, particularly carpooling, which was not reflected in either the 1970 or 1990 travel behavior.

The planning packages represent the only data bases available in most metropolitan areas that use a consistent method of data collection and provide detailed travel and sociodemographic information on a small-area basis (TAZs). The next decennial census will add to the potential to conduct longitudinal studies.

Since the CTPP also includes sociodemographic information, it has been used by a large number of persons in the academic and research community. It has been used in two thorough studies of laborsheds in the

Chicago area, both of which used the 1980 and 1990 packages. It has been used to produce weights for the CATS Household Travel Survey and to produce a procedure for estimating survey response rates. In smaller metropolitan areas in Illinois, it has been used to study intercounty work trips and to assist in developing new definitions for metropolitan areas.

The CTPP has even been used by a not-for-profit organization to study target neighborhoods and the flow of workers in and out of these neighborhoods. Discussion of these efforts with the researchers indicated that their work would not have been possible without the availability of the CTPP or that their work would have had to be very different and would not have had the level of detail that allowed many of the conclusions to be drawn in these studies. The 1990 CTPP has been an exceptionally useful data source.

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# Census Data Use in Illinois by a Large Metropolitan Planning Organization

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Ed J. Christopher, *Chicago Area Transportation Study*

This paper is the second in a series of four that document the uses of census data by the transportation community in Illinois. It focuses on the use by the largest metropolitan planning organization (MPO) in the state—the Chicago Area Transportation Study (CATS)—of the Census Transportation Planning Package. The other papers in this series discuss the uses of the census data by smaller MPOs, transit planners, and the research and academic community. CATS has had a rich history working with the census data, specifically the journey-to-work data. However, unlike smaller MPOs, CATS has used the census data as an adjunct to supplement its own travel surveys. In general terms, these uses have included factoring and adjusting other surveys, producing descriptive reports, conducting special studies and analyses, and developing models.

Planners and scholars have now used the census transportation planning packages in the Chicago area for almost 30 years. The 1970 Urban Transportation Planning Package (UTPP) was utilized extensively by the staff of Northeastern Illinois Planning Commission (NIPC) and particularly by a large metropolitan planning organization (MPO), the Chicago Area Transportation Study (CATS). It was also intensively used by several local universities that produced a variety of different analyses at the request of public agencies. In fact, the transportation agencies in northeastern Illinois contracted with a local university to en-

hance and modify the 1970 census data base to make it more readily usable.

Stemming from the momentum created by the 1970 work-related questions and fueled by the prospect of a separate journey-to-work tabulation, CATS purchased the 1980 UTPP. Since the agency already had conducted its own travel survey for modeling purposes in 1970, the 1980 UTPP was used primarily for the production of transportation statistics for northeastern Illinois. As soon as the package was received, in 1985, CATS staff began the publication of data bulletins entitled *Transportation Facts* (T-Facts). The 1980 UTPP was also used for a variety of planning studies.

As the decade of the 1980s advanced, so did CATS staff expertise with the use of the package. Toward the end of the decade when funding for the MPO's activities was in short supply, CATS staff devoted their time to providing and charging for the production of custom tabulations serving a variety of different types of outside clients. The most commonly sought-after products were summaries of the daytime population as well as the commuting patterns of workers. This information was solicited by banks, loan institutions, and prospective business entrepreneurs. The package was also used to a lesser degree in support of a 1979 effort of CATS staff to update the agency's 1970 Home Interview Survey.

Presented in this paper is a review of the CATS use of the 1990 package, which is now called the Census Transportation Planning Package (CTPP). As is evi-

dent, the 1990 package has received more use than the 1980 package, which in turn was used more than the 1970 package. In effect, the journey-to-work data are becoming more widely used and their application for planning-related questions is growing.

CATS has had a substantial history with the use of all the census planning packages. The uses of the 1990 CTPP are summarized in the following sections, which cover factoring and adjusting surveys, descriptive reporting, special studies, and model development.

It should also be pointed out that when the 1990 CTPP was first received by CATS, the data were examined and checked against other local data. The purpose of this step was to determine the validity of the package. CATS staff specifically checked the data on employment in Chicago's central business district (CBD) for various levels of geography against other known sources of employment. The employment levels were also checked in terms of trends (1980 to 1990). As a result of these checks, which are documented in internal agency memorandums, it was concluded that the CTPP was valid and indeed usable.

### FACTORING AND ADJUSTING SURVEYS

A basic but many times overlooked use of the census data is to factor and adjust other surveys. A prime example of this is the factoring that was done with the CATS 1990 Household Travel Survey. The CATS factoring, which has been described by Kim et al. (1), was a two-tiered process. The first tier consisted of an adjustment for the response rate followed by the development of weights based on the 1990 census. The census variables included were persons per household or household size and the number of vehicles available. Although these variables were used because of their consistency with CATS travel demand models, other variables could be used as well. For example, with its household travel survey conducted in the fall of 1995, the Northwestern Indiana Regional Planning Commission used age and income from the census as their adjustment variables.

Aside from their use in direct factoring and adjusting, the census data have also played an important role in conducting reasonableness checks of locally collected survey data. Local agencies are continually collecting data to answer specific questions. As a result, CATS staff have been strong proponents of including on every survey one or two control questions that match the data collected by the census. In this way the survey administrator can compare the data from the control question with the census data and make a determination as to the quality or reasonableness of the survey.

### DESCRIPTIVE REPORTING

After receiving the CTPP and assessing its reasonableness, CATS undertook the publication of summary reports for the Chicago metropolitan area (2-8) and for the state of Illinois (9-11). One-page statistical bulletins were produced such as the one shown in Figure 1 for each of the approximately 250 census places in the metropolitan area. The tabulations were also produced for the 77 community areas that make up the city of Chicago. The statewide package was used to produce a similar one-page summary for each of 102 counties in Illinois. Two Illinois county reports were produced, one by place of residence and the other by place of work. Figure 1 summarizes the data by place of residence for residents of the city of Chicago.

Many of these reports also include maps such as the one in Figure 2, which effectively illustrates the wide regional variations in travel times. From Figure 1 it is apparent that the median travel time to work in the city of Chicago is 31.5 min; the areas with the lightest shading in Figure 2 largely represent areas where the local median is lower than the city median. This map clearly indicates that most of these communities with short travel times are in the northern two-thirds of the city. The University of Chicago/Hyde Park area (Community Area 41) is unique. Of greatest concern to local planners is the large area of minority residents on the far south side, which lacks local jobs and therefore has unusually high median travel times. A map such as the one in Figure 2 is particularly informative and underscores the utility of the CTPP.

CATS has also produced county-level work-trip flow tables for northeastern Illinois (Table 1). Using data from the last three censuses, Table 1 is a concise summary of the county-to-county work-trip flows and how they have changed. It clearly shows the growth of reverse commuting during the last 20 years by the increase in trips from Cook County (the central county). In particular, it should be noted that the number of reverse trips to DuPage County has grown from approximately 32,000 in 1970 to almost 117,000 in 1990. The number of trips to all collar counties has grown by more than 120,000.

This work-trip flow table is from the bulletin *Transportation Facts* (6), which includes a multitude of other information. Figures 3 and 4 are typical of the data presented in this bulletin. Figure 3 shows the substantial shift from carpooling to driving alone. The greatest percentage increase in driving alone is predictably in the smallest county (McHenry), but the percentage increases in driving alone are in excess of 20 percent for all suburban counties. Conversely the carpooling declines in all collar counties exceed 20 percent.

Persons 2,783,726			Households 1,020,911			Workers 1,181,677		
<b>Where Residents Work</b>			<b>Population Summary</b>					
In Chicago city	900,550	( 76.2%)	Urban Area					
Worked outside place	281,127	( 23.8%)	Urbanized			2,783,726 (100.0%)		
Total Workers 1,181,677 (100.0%)			Non-Urbanized			0 ( 0.0%)		
Total Households by Vehicles Available			Male			1,332,653 ( 47.9%)		
			Female			1,451,073 ( 52.1%)		
			<b>Spatial Summary</b>					
0 Vehicle Households	340,460	( 33.3%)	Land Area			Sq. Mi.	Sq. Km.	
1 Vehicle Households	421,276	( 41.3%)	Water Area			227.2	588.5	
2 Vehicle Households	200,495	( 19.6%)				6.8	17.7	
3 Vehicle Households	45,025	( 4.4%)	<b>Travel Time to Work</b>					
4 or more Vehicles	13,655	( 1.3%)	<b>(Workers not Working at Home)</b>					
Vehicles per Household = 0.98			0 - 4 Minutes			16,853 ( 1.5%)		
Mode Used to Travel to Work			5 - 9 Minutes			59,007 ( 5.1%)		
Car, Truck, or Van	721,983	( 61.1%)	10 - 14 Minutes			98,565 ( 8.5%)		
Drive Alone	546,955	( 46.3%)	15 - 19 Minutes			128,656 ( 11.1%)		
Carpool	175,028	( 14.8%)	20 - 24 Minutes			151,754 ( 13.1%)		
Public Trans	342,737	( 29.0%)	25 - 29 Minutes			62,387 ( 5.4%)		
Bus	228,222	( 19.3%)	30 - 34 Minutes			227,716 ( 19.6%)		
Streetcar/Trolley	2,932	( 0.2%)	35 - 39 Minutes			40,828 ( 3.5%)		
Subway or Elevated	93,824	( 7.9%)	40 - 44 Minutes			63,618 ( 5.5%)		
Railroad	17,759	( 1.5%)	45 - 59 Minutes			160,602 ( 13.8%)		
Other	96,968	( 8.2%)	60 - 89 Minutes			117,958 ( 10.2%)		
Taxicab	8,289	( 0.7%)	90 or more Mins			33,744 ( 2.9%)		
Bicycle	3,307	( 0.3%)	Total			1,161,688 (100.2%)		
Motorcycle	593	( 0.1%)	Mean Travel Time to Work = 31.4 Minutes					
Walked	76,041	( 6.4%)	Median Travel Time to Work = 31.5 Minutes					
Other Modes	8,738	( 0.7%)	<b>Time Leaving Home to Go to Work</b>					
Work at Home	19,989	( 1.7%)	<b>(Workers not Working at Home)</b>					
Work at Home	19,989	( 1.7%)	12:00 a.m. - 4:59 a.m.			36,441 ( 3.1%)		
Total Workers 1,181,677 (100.0%)			5:00 a.m. - 5:29 a.m.			41,407 ( 3.6%)		
Occupancy of Private Vehicles (Car, Truck, or Van) Used for the Work Trip			5:30 a.m. - 5:59 a.m.			53,395 ( 4.6%)		
Vehicles with 1 Worker	546,955	( 87.7%)	6:00 a.m. - 6:29 a.m.			121,119 ( 10.4%)		
Vehicles with 2 Workers	62,716	( 10.1%)	6:30 a.m. - 6:59 a.m.			113,543 ( 9.8%)		
Vehicles with 3 Workers	9,401	( 1.5%)	7:00 a.m. - 7:29 a.m.			177,508 ( 15.3%)		
Vehicles with 4 Workers	2,923	( 0.5%)	7:30 a.m. - 7:59 a.m.			140,233 ( 12.1%)		
Vehicles with 5 Workers	864	( 0.1%)	8:00 a.m. - 8:29 a.m.			141,091 ( 12.1%)		
Vehicles with 6 Workers	384	( 0.1%)	8:30 a.m. - 8:59 a.m.			59,751 ( 5.1%)		
Vehicles with 7 or more	439	( 0.1%)	9:00 a.m. - 9:59 a.m.			56,958 ( 4.9%)		
Workers per Private Vehicle = 1.16			10:00 a.m. - 10:59 a.m.			24,618 ( 2.1%)		
			11:00 a.m. - 11:59 a.m.			12,591 ( 1.1%)		
			12:00 p.m. - 3:59 p.m.			103,087 ( 8.9%)		
			4:00 p.m. - 11:59 p.m.			79,946 ( 6.9%)		
			Total			1,161,688 (100.0%)		

Notes: 1. Workers include those persons 16 years old and over.  
2. Percentages may not add up exactly to 100 due to rounding.  
Data Sources: 1990 Census of Population and Housing; Summary Tape File (STF3A) and Census Transportation Planning Package (CTPP).  
Prepared by Chicago Area Transportation Study (CATS) October 1993.

FIGURE 1 1990 transportation facts for residents of Chicago city.

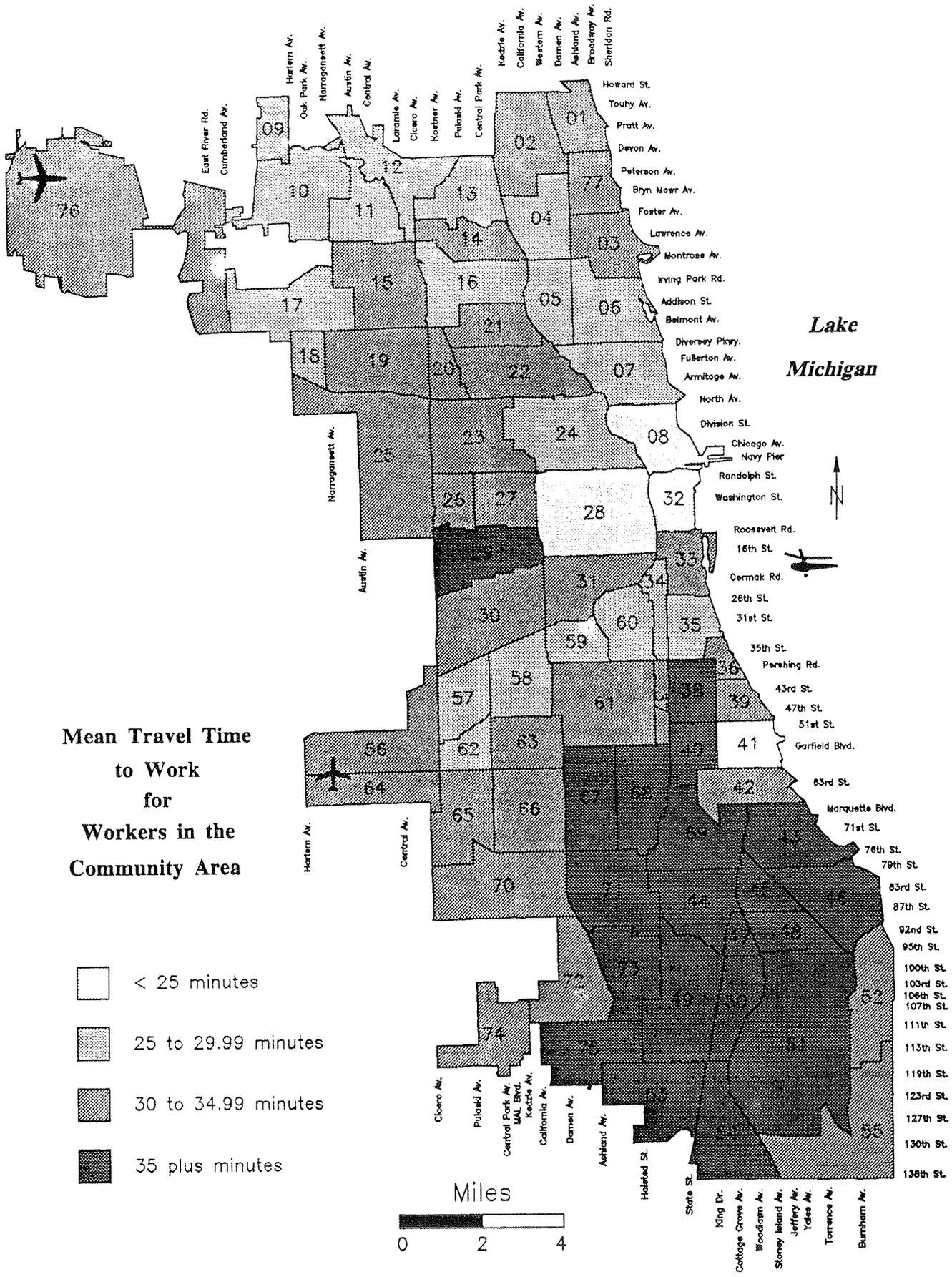


FIGURE 2 Chicago community areas: mean travel time to work (source: 1990 Census STF 3A).

TABLE 1 Census Work-Trip Summary (County-to-County): 1970 to 1990

		Place of Work						Outside Six County Region
		Cook County	DuPage County	Kane County	Lake County	McHenry County	Will County	
County of Residence	<b>Cook County</b>							
	1990	2,147,598	116,776	16,107	39,641	3,283	15,806	30,413
	1980	2,150,111	60,197	8,389	19,760	1,506	9,441	31,446
	1970	2,105,178	32,624	9,056	18,624	951	4,299	43,076
	<b>DuPage County</b>							
	1990	155,655	244,898	10,805	3,655	566	4,092	5,613
	1980	142,824	178,473	6,705	1,270	353	1,835	3,500
	1970	90,663	97,226	3,670	960	76	1,092	3,589
	<b>Kane County</b>							
	1990	28,017	24,325	94,614	1,548	3,193	1,018	4,767
	1980	19,952	11,649	90,702	832	2,118	437	3,100
	1970	14,956	5,505	76,982	1,532	803	294	3,863
	<b>Lake County</b>							
	1990	82,767	5,771	1,423	171,535	3,514	425	4,809
	1980	57,067	1,834	328	145,550	2,346	48	4,300
	1970	37,180	1,040	891	121,183	1,345	72	3,963
	<b>McHenry County</b>							
	1990	24,599	2,899	5,196	10,942	47,757	161	2,322
	1980	16,078	1,147	3,007	5,797	40,354	24	1,500
1970	9,192	469	1,785	3,366	28,076	41	1,676	
<b>Will County</b>								
1990	55,224	26,333	2,361	613	50	78,614	7,050	
1980	40,975	12,177	1,627	78	26	75,175	5,300	
1970	20,273	3,533	1,133	247	7	63,957	3,073	
<b>Outside Six County Region</b>								
1990	78,493	12,248	13,255	17,231	6,635	10,115	N/A	
1980	29,000	2,500	10,100	5,900	3,000	5,500	N/A	
1970	27,329	1,264	8,510	4,961	2,001	4,395	N/A	
Transportation Facts	<b>Total Work Trips to County of Work</b>							
	1990	2,572,353	433,250	143,761	245,165	64,998	110,231	N/A
	1980	2,456,007	267,977	120,858	179,187	49,703	92,460	N/A
	1970	2,304,771	141,661	102,027	150,878	33,259	74,150	N/A

\* Trips from outside the region were rounded to the nearest 100 for the year 1980.

The changes in public transportation use are shown in Figure 4. Regionwide bus use is declining more rapidly than for all the rail modes combined, and both experienced declines in market share. The greatest bus use declines are in the areas closest to Chicago, and conversely there are increases in three counties distant from the metropolitan core. The percentage increases appear impressive (e.g., almost 40 percent in Will County), but in light of their small base levels in 1980, these increases are small in contrast to the declines in the closer-in large counties. Regionwide the decline in bus use is more than 10 percent.

## SPECIAL STUDIES

CATS is frequently presented with requests regarding information in the CTPP. It is not always feasible to meet these requests, but Figures 5 and 6 are typical of what is uniquely available in the CTPP and how requests for information can be packaged. Both maps portray the job destinations of workers residing in designated study regions. Figure 5 shows that most of the workers residing in the Austin Community Area (Area 25 in Figure 2) work in one of two general areas—in the vicinity of Austin and in the Chicago downtown. Since the down-

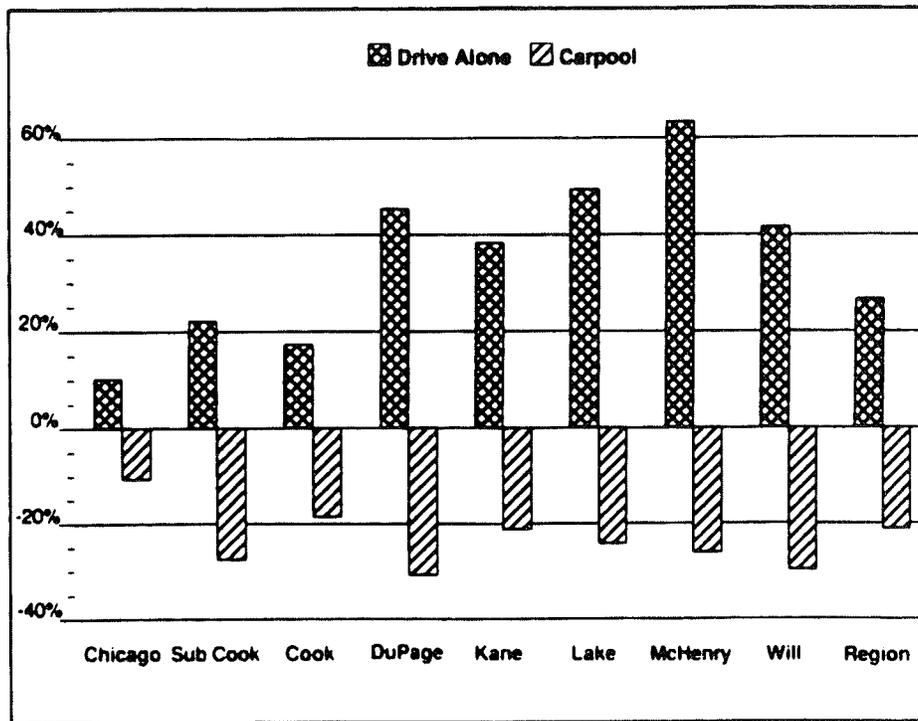


FIGURE 3 Change in private passenger vehicle trips, 1980 to 1990, by mode.

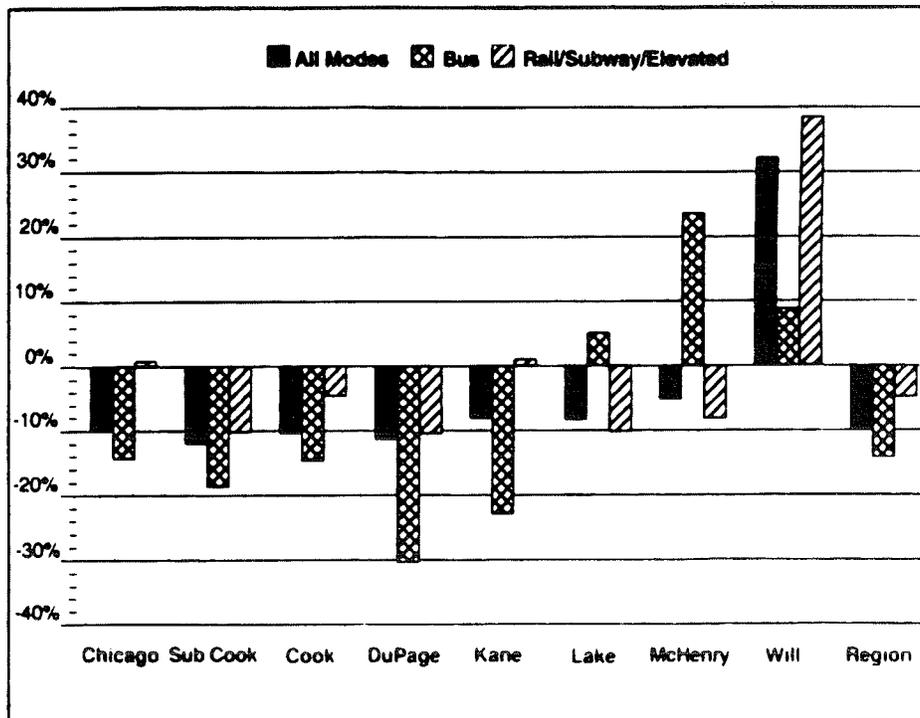


FIGURE 4 Change in census work trips via public transportation, 1980 to 1990, by mode.

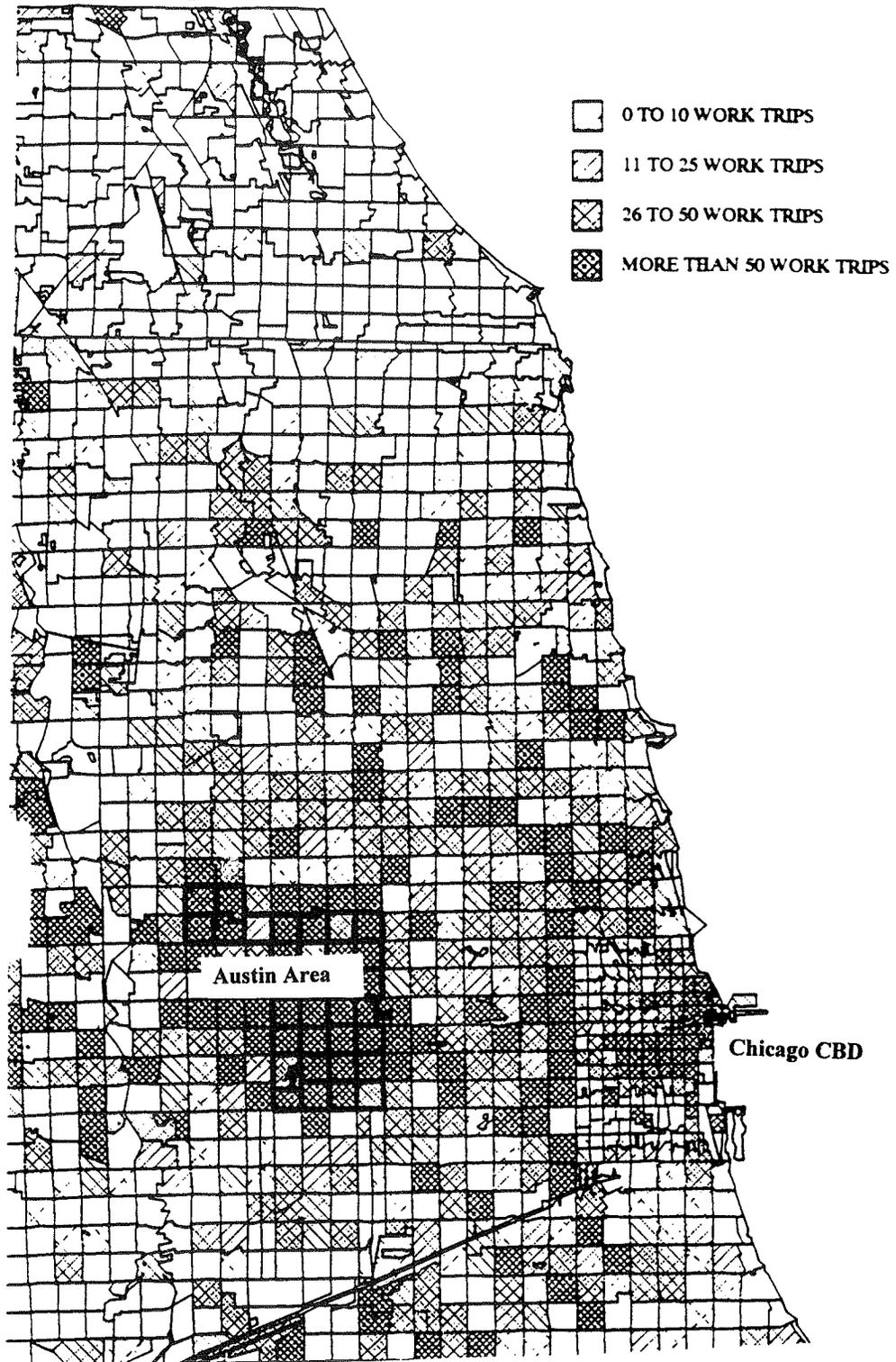


FIGURE 5 Work-trip flows from Austin area by TAZ.

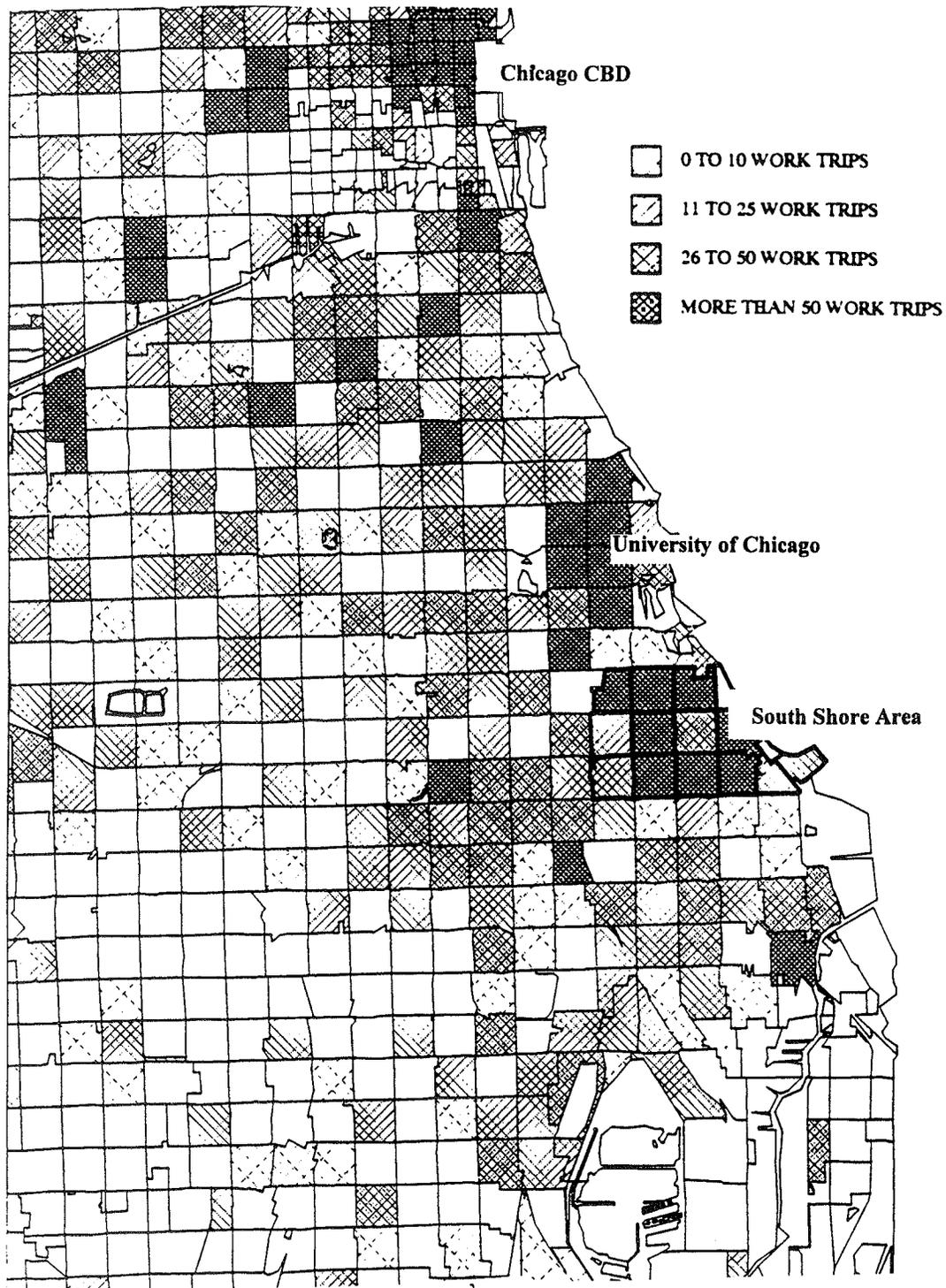


FIGURE 6 Work-trip flows from South Shore area by TAZ.

town traffic analysis zones (TAZs) are smaller than those in the rest of the study area, the pattern seems out of phase with the rest of the map. In addition, with a mapping convention such as this, it is impossible to tell how large the numbers are once they extend beyond the highest category, over 50 workers, as would be true for sev-

eral CBD TAZs. Still, the map effectively shows the diverse work locations of Austin residents.

Figure 6 is an analogous map, but for the South Shore Community Area (Area 43 in Figure 2). Again the origin-destination (O-D) file, Part C of the CTPP, was used, but in this case 14 origin zones (quarter-square-mile

zones) were added into one residential origin. The job destinations (workplaces) were kept at the original zonal level. The scatter of workplaces includes three basic areas: the home community of South Shore, the University of Chicago/Hyde Park area to the north, and the Chicago downtown on the northern perimeter of the map. By contrast it is remarkable how few workplaces there are in zones immediately to the south and north.

Only the CTPP is capable of presenting data on such a fine level of geography. Even the CATS Household Travel Survey, extensively used for travel modeling, cannot provide the detail shown in Figure 6. The nearly 20,000 households in the CATS Household Travel Survey would only average 2 per TAZ. Even though the number of responses is higher in the city than in the suburb TAZs, they still are inadequate except in very limited cases.

CATS has also used the Indiana portion of the CTPP, in which the TAZs follow a different geography. Figure 7 provides an indication of traffic generation by combining the number of households and employment by TAZs. It shows where residential populations are concentrated and where employment dominates. This work was undertaken to help with the development of a new zone system for modeling Indiana trips.

## MODEL DEVELOPMENT

The CTPP and other census products play a varied but important role in CATS modeling and model development. Their use ranges from providing direct inputs for CATS trip generation rates to producing work-trip flows and descriptive statistics used to check the data model quality. Presented in this section is a brief overview of some instances in which the CTPP is used in the CATS modeling process.

With the passage of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), the Clean Air Act Amendments (CAAA), and subsequent regulations, CATS has embarked on a series of efforts to redefine and enhance its travel forecasting process. This effort has drawn from a variety of data sources, including the family of census products. The process itself is ongoing, and the enhancements will be brought online as they are fully developed, tested, and validated.

Throughout this paper and within the transportation planning community, references are routinely made to the need for the CTPP and its specialized geography in transportation planning. There is also a need for locally collected travel survey data. CATS is currently in the almost ideal situation of having both products to draw from. One of the areas in which these two products most clearly come together is the trip generation process. Figure 8 is a flow diagram of this process. As can be seen, the CTPP plays an important role at the beginning of the

process. Working in concert with the CTPP is the CATS Household Travel Survey. According to the process, the actual trip rates are derived from the CATS survey, whereas the classification cells for each zone use the demographic data from the CTPP. How these two data sources come together within trip generation is detailed elsewhere (12).

The CTPP data are also used in the CATS process in many other ways. Table 2, created as part of a developing document that details the current CATS enhancements within its modeling applications, identifies many of the specific variables from the package that are used for different components of the trip generation process. At this point the documentation is composed as a series of in-house memorandums that will be published as part of future air-quality conformity analyses.

The last item in Table 2 pertains to a vehicle ownership model, which is one of the latest improvements to the CATS process. Like the trip generation model improvements, the vehicle ownership model is still under development and will be documented as part of future conformity analyses. The model uses two variables from the CTPP: the average automobile work-trip mode share and what CATS staff has dubbed the "pedestrian environmental factor."

In the development of the vehicle ownership model, a measure was needed as a surrogate for pedestrian and bicycle facilities in each zone. Since there was no existing measure, CATS staff created the pedestrian environmental factor. The number of census blocks in a zone was used as the surrogate. Since census blocks are, for the most part, bounded by streets and each time a street intersects another street a new block is formed, CATS staff reasoned that the more blocks that are located in a particular zone, the more streets it had and the more conducive it would be to both walking and bicycling. Although this exercise was not a direct application of the CTPP output, the equivalency file used to generate the TAZs was most useful.

Besides its use in the CATS trip generation process, the CTPP also provides data that are used with the mode split process. Supporting the mode split models is a zonal-level data base containing many of the variables used by the process. The CATS files that contain the relevant data are known as MO1 and MO23. Although these files contain many of the transit-related infrastructure variables like route miles, parking costs, and bus wait times, they include two CTPP variables—automobile occupancy and median income. The documentation for this file can be found in a CATS Working Paper (13).

The foregoing are just some of the areas in which the CTPP is a necessary and vital component in the CATS forecasting process. The CTPP also plays a less-than-subtle role in the modeling process since it is a good independent source of information on mode split,

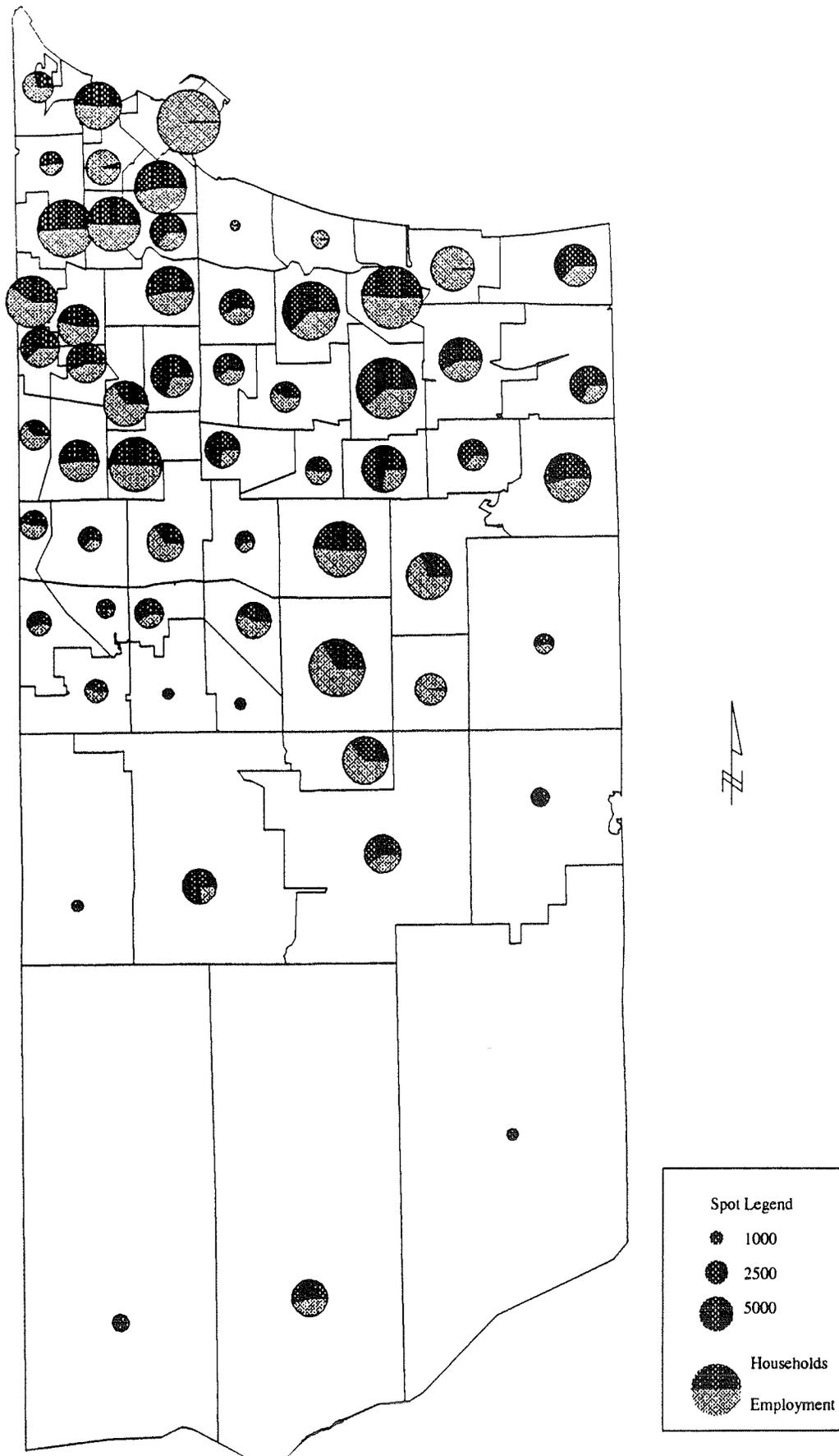


FIGURE 7 Distribution of households and employment by combined Northwestern Indiana Regional Planning Commission TAZs for proposed 1995 CATS zones for Indiana.

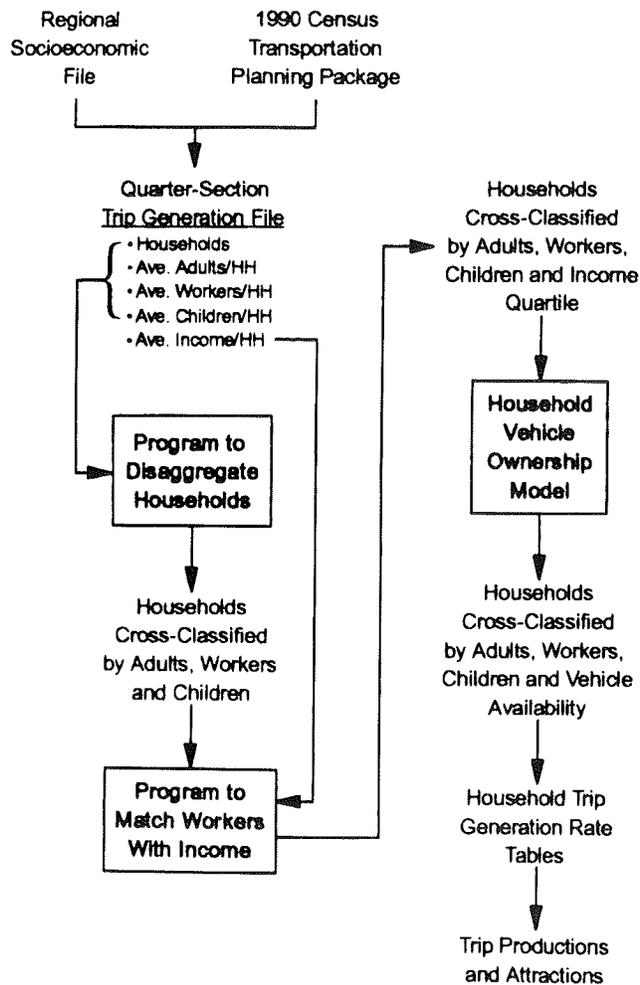


FIGURE 8 Overview of CATS household trip generation process.

travel time, and O-D information. Also, as CATS continues to improve its modeling and forecasting ability, it is certain that the CTPP will be considered a vital source of new data items. The fact that the CTPP is aggregated down to the geography used in the model process makes it an invaluable source.

## CONCLUDING REMARKS

Within CATS there is a great deal of activity surrounding the use of the CTPP. There has been a long tradition of CTPP use, starting with extensive utilization of the 1970 UTPP. The 1980 UTPP was used more extensively, and now the 1990 CTPP is used in addressing a wide variety of questions. CATS has the opportunity to use the census packages in longitudinal studies. Several studies just now getting under way will examine the changes in travel patterns from 1970 to 1980 to 1990.

TABLE 2 Variables Required for Trip Generation: Census CTPP Variables

Variable	Description
Persons Total in Households in Group Quarters	Table 1-1 Table 1-11 Table 1-12
Households	Table 1-4
Workers in Households in Group Quarters	Table 1-49 Table 1-50
Non-Workers 16 Years and Older in Households in Group Quarters	Table 1-11 Minus Table 1-49 Table 1-12 Minus Table 1-50
Children in Households Total Younger Than 16 Only Ages 12 Through 15	Table 1-11 Table 1-8 (12 to 17 Years) Minus Table 1-11 (16 to 17 Years)
Mean Household Income	Table 1-16
Total Vehicles Available in Households	Table 1-17
Workers Commuting to TAZ Government Manufacturing Retail Service TCUW Other	Table 2-3. Accumulated by SIC Code to Match NIPC Definitions
Vehicle Ownership Model Variables Average Pedestrian Environmental Factor Average Auto Work Trip Mode Share	Both Are Obtained From Vehicle Ownership Model Calibration Data Set

In northeastern Illinois CATS has used the package in four distinct ways. First, it was used to provide the benchmark data from which to factor and adjust the CATS 1990 Household Travel Survey. The other uses include providing descriptive summaries that feed into a whole host of questions related to planning information; performing special studies; and supporting the modeling efforts of the region.

Although this paper has addressed the many uses of the CTPP, it should be acknowledged that this MPO could survive without the package. In fact, among CATS staff it is possible to find divergent opinions as to the absolute utility of the package. From a planning perspective, CATS has had a rich tradition of collecting localized data to support its travel demand modeling work. However, as the package gets easier to use and is more readily available, this perspective may change.

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# Improvement of Decennial Census Small-Area Employment Data: New Methods To Allocate Ungeocodable Workers

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The Southeast Michigan Council of Governments (SEMCOG), like any other agency involved in general and transportation planning, makes extensive, continuous use of decennial census data products. Standard products meet most of SEMCOG's data needs. When they do not, special tabulations have been purchased from the Census Bureau. In connection with SEMCOG's latest forecast, special tabulations of 1980 and 1990 census data were obtained, each including a tabulation of housing units and households by traffic analysis zone (TAZ) of residence and a tabulation of workers by TAZ of work. The worker data included a cross-tabulation by industrial class and occupational class. In response to puzzling industrial class mixes at the TAZ level found earlier in the Census Transportation Planning Package (CTPP), the special tabulations separated geocoded workers from allocated workers. (The Census Bureau uses worker allocation to assign tract and block numbers to workers whose workplace addresses cannot be geocoded to tract and block.) Subsequent mapping of geocoded workers by TAZ evidenced high quality, but allocated workers showed questionable distributions. SEMCOG decided to develop its own reallocation method that accepted Census Bureau county assignment, geocoded or allocated, and place geocoding. The method was applied to workers needing allocation, using as a base the workers geocoded to tract and block by detailed industrial class and occupational class. A comparison of TAZ employment by detailed industrial class demonstrates that workers reallocated by SEMCOG replicate the Census Bureau geocoded pattern much better than do workers allocated by the Census Bureau.

A new, comprehensive allocation method is proposed for the 2000 census. The new method would combine features of the current Census Bureau allocation and SEMCOG reallocation methods, and add the demarcation of commuting origin and destination areas.

The overall purpose of this paper is to discuss worker allocation, the method used by the Census Bureau to assign tract and block numbers to workers whose workplace addresses cannot be geocoded to tract and block, and to present the reallocation method developed by the Southeast Michigan Council of Governments (SEMCOG) to deal with locational inaccuracies found in the allocated census numbers.

## DECENNIAL CENSUS PRODUCTS AND SEMCOG'S DATA NEEDS

SEMCOG, like any other agency involved in general and transportation planning, makes extensive, continuous use of decennial census products. These include printed reports, summary tape files (STFs), other computer files, maps, and various other products. Decennial census data are indispensable. Without such data, many planning applications that are now commonplace would become impossible.

There is no other data source with the combination of data dimensions provided by the decennial census: a

wide variety of data items about population and housing, spatially organized in a system of geographic areas that range from the nation as a whole down to individual city blocks, occurring as a data time series represented by the name "decennial."

Standard decennial census products meet most of SEMCOG's needs for demographic data, and meet them very well. However, in preparing data inputs for a recently completed Regional Development Forecast (RDF), two areas were encountered in which the standard products were inadequate: data availability and data quality.

Regarding availability, certain data combinations were needed that had not been produced by small-area geography corresponding to traffic analysis zones (TAZs). For example, such data were needed as input to SEMCOG's demographic forecasting process in order to group the households in each TAZ into income quartiles, each quartile subdivided into portions with children and portions without children. In addition, for the input required by SEMCOG's method of assigning land use classes to decennial census small-area employment data, cross-tabulations of worker data and industrial class by occupational class and by TAZ of work were needed.

In the past, SEMCOG had overcome such problems of data availability by using one of the cost-reimbursable "special services" provided by the Census Bureau, that is, a special tabulation of data collected in the decennial census. Because of the interest in data from both the 1980 and 1990 censuses, SEMCOG needed two tabulations for each year, one of housing unit and household characteristics by place of residence, the other of worker characteristics by place of work.

Questions of data quality related to place-of-work data in the Census Transportation Planning Package (CTPP). SEMCOG's TAZs had been demarcated wherever possible to isolate individual major facilities and establishments, including large shopping centers, hospitals, colleges and universities, major government buildings, corporation headquarters, and large industrial plants. It was anticipated that most, if not all, of the CTPP's place-of-work employment counts for such TAZs would be either of a single industrial class (for example, transportation, communications, and utilities in the TAZ that contained only the telephone company's headquarters office building) or of a characteristic combination of related industrial classes (e.g., a shopping center TAZ that would have mostly retail trade employment, but also small numbers of workers in such industrial classes as services, and finance, insurance, and real estate).

However, many such TAZs were found in which, although the expected industrial class made up the majority of workers, there was a substantial minority of workers in a variety of other industrial classes. These unexpected workers were a puzzle that could not be

solved using only the CTPP data. In addition, it could not be determined to what extent the industrial class mix of workers given in the CTPP represented the actual situation or reflected geocoding errors or shortcomings in the allocation procedure for nongeocodable workers.

Through discussions with the Census Bureau staff, it was agreed that a special tabulation of workers' characteristics by place of work could be structured in a manner that would separate geocoded workers from allocated workers. Ultimately, agreement was reached that the Census Bureau would produce special tabulations of 1980 and 1990 census data, one by place of work and one by place of residence.

## REALLOCATION: METHOD AND RESULTS

### Census Worker Special Tabulation

SEMCOG's 1990 census worker special tabulation is like the CTPP in that it

- Was derived from the same "parent file" as the CTPP—the Sample Edited Detail File,
- Includes the key employment-related variables of the CTPP,
- Includes household characteristics, and
- Includes TAZ of work.

However, the special tabulation is different in that it

- Is more detailed (e.g., 75 industrial classes and 40 occupational classes compared with 18 and 14, respectively, in the CTPP), and
- Includes flags indicating whether or not the workers were geocoded to tract as well as to place.

### Necessity of Allocation

In 1990 the Census Bureau geocoded workers to tract and block provided that the workplace addresses reported were sufficiently complete and that either the Topologically Integrated Geographic Encoding and Referencing (TIGER) File could identify the address or the Workplace File included the specific worksite. In 1980 the procedure for the Urban Transportation Planning Package (UTPP) was similar, although some of the details were different. However, some tract and block geocoding errors still occur. Such errors in the UTPP and CTPP are difficult to recognize and correct because geocoded workers and allocated workers are mixed.

Because the special tabulation included a flag that indicated whether or not the workers had been geocoded

to tract (in most cases such workers had also been geocoded to block), SEMCOG could not produce computer-generated maps of tract-geocoded employment by any of the 75 industrial classes of the special tabulation. Upon examination, the overall quality of tract and block geocoding appeared to be quite good. There were relatively few recognizable major errors, and these were corrected, resulting in an improved base for subsequent reallocation.

In the Census Bureau procedure for creating small-area employment data, workers who could not be geocoded to tract and block were instead assigned to tract and block by an allocation procedure (1, 2). In 1990 a considerable percentage of workers needed to be allocated. In the four most urban counties of Southeast Michigan, an average of over 30 percent of all workers needed to be allocated to tract and block. In Detroit City, nearly two-thirds of the tracts had more than 40 percent of their workers allocated by the Census Bureau. Some sort of allocation procedure is absolutely necessary so that workers with ungeocodable addresses can be assigned to an appropriate small area. However, the Census Bureau allocation procedure was believed to se-

riously reduce the overall accuracy of small-area place-of-work employment data. Therefore, it was decided to develop a reallocation procedure. That procedure accepted the Census Bureau's state and county assignments, as well as their geocoding to place, and then used the special tabulation's detailed breakdowns of industrial class and occupational class to match workers needing to be reallocated to TAZ with workers who had been geocoded to tract and block and thereby to TAZ by the Census Bureau.

### SEMCOG Reallocation Method

The reallocation method used by SEMCOG is illustrated in Figure 1. The procedure begins by grouping the workers to be reallocated by their workplace destination area, which is the county to which the Census Bureau assigned the worker (through either geocoding or allocation), subdivided into places for those workers who were so geocoded by the Census Bureau.

Next, to identify all tract-geocoded workers in the destination area who match the worker being reallo-

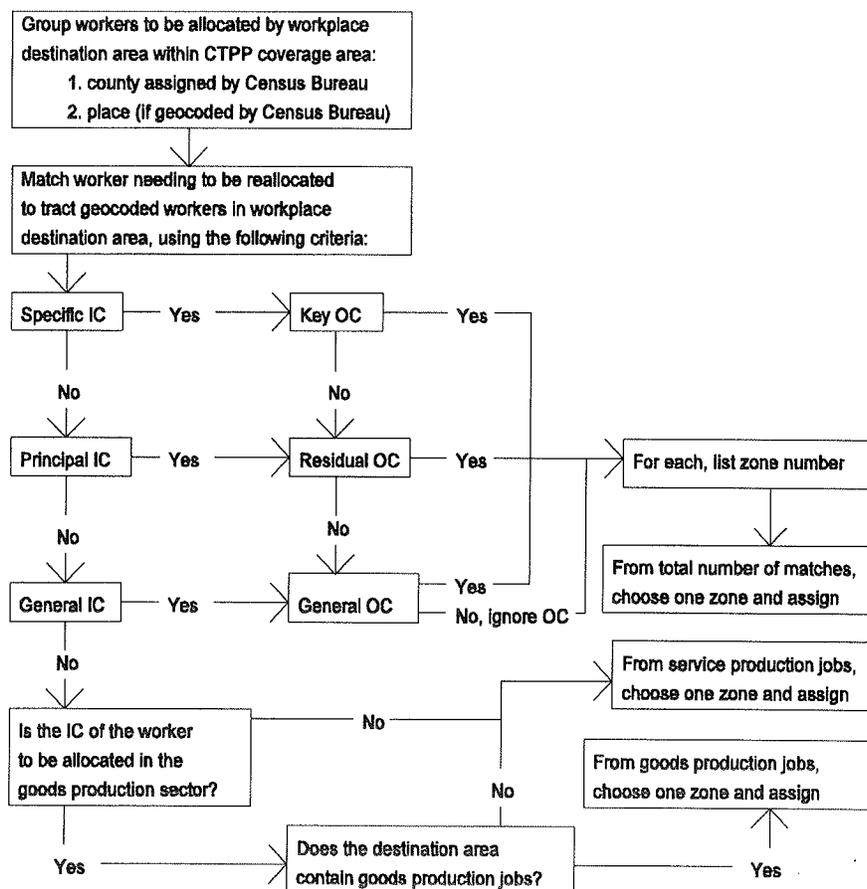


FIGURE 1 SEMCOG reallocation method.

cated, a decision tree consisting of a series of questions about industrial class followed by a series of questions about occupational class is run for each worker. These questions are based upon a four-tier system of industrial classes and a three-tier system of occupational classes, both systems going from less general to more general.

The system of industrial classes (ICs) consists of the following:

1. **Specific IC:** These are the 75 classes used in the 1980 and 1990 special tabulations obtained from the Census Bureau. The Specific ICs were designed to recognize ICs that made up at least 1 percent of Southeast Michigan's employment plus some smaller industries having distinctive land use characteristics.
2. **Principal IC:** These are the 18 ICs used in the 1990 CTPP. Specific ICs combine to form Principal ICs.
3. **General IC:** These are the 11 ICs used in Census Bureau printed reports to summarize employment by industry. The principal ICs combine to form General ICs.
4. Finally, if no match can be made by General IC, one is made using a distinction between goods-producing and services-producing classes.

The system of occupational classes (OCs) consists of the following:

1. **Key OC:** These are Specific OCs that form at least 10 percent of the region's employment within a Specific IC. (The 1990 special tabulation included 40 Specific OCs, whereas the 1980 tabulation had 39 because of the absence of military occupations.) It turns out that in 1990 every Specific IC has at least one Key OC and that the range extends up to six. Key OCs are used to identify those Specific OCs that occur relatively frequently in a Specific IC, and therefore can be expected in many zones, where they will provide potential matches. Conversely, OCs that are uncommon to a Specific IC will tend to occur in relatively few zones. If the reallocation procedure did not use Key OCs, workers of a given Specific IC and a given uncommon Specific OC needing to be allocated would be matched only to those few tract-geocoded workers.
2. **Residual OC:** To prevent such a biased allocation, Specific OCs that do not qualify as Key OCs within a given Specific IC are grouped into Residual OCs. A Residual OC consists of the Specific OCs of the special tabulations that occur within a given OC of the CTPP (that is, the OC equivalent of a Principal IC) less any relevant Key OCs of the given Specific IC.
3. **General OC:** These are the six OCs used in Census Bureau printed reports to summarize employment by occupation. The Key OCs plus the Residual OCs form General OCs.

The procedure begins with Specific IC and if necessary moves down the IC sequence until matches are found. It then moves over to the appropriate box in the OC sequence and down until a match on OC has been made. If no match can be made even on General OC, OC is ignored and all the IC-matching geocoded workers are used. Finally, a random process is used to choose a single matching tract-geocoded worker. That worker's zone of work is assigned to the worker needing reallocation, completing the process for that worker. The process is repeated for each worker needing reallocation.

## Reallocation Results

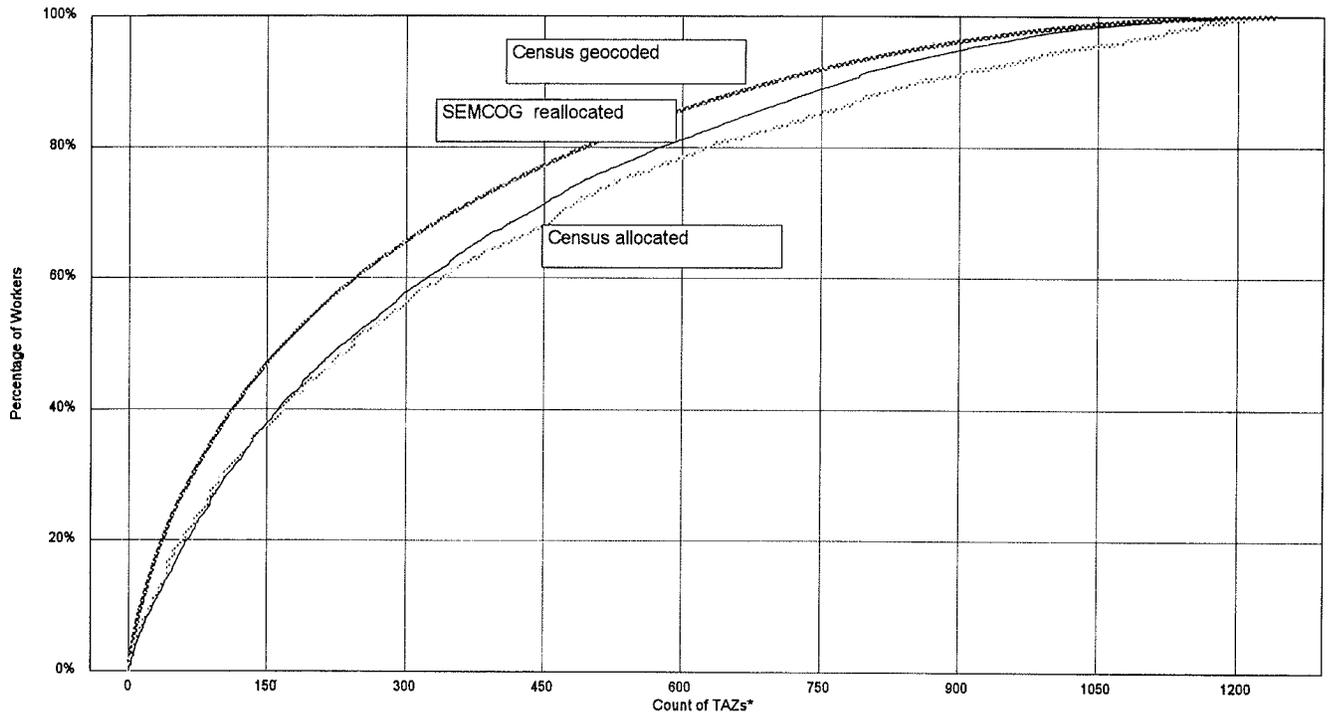
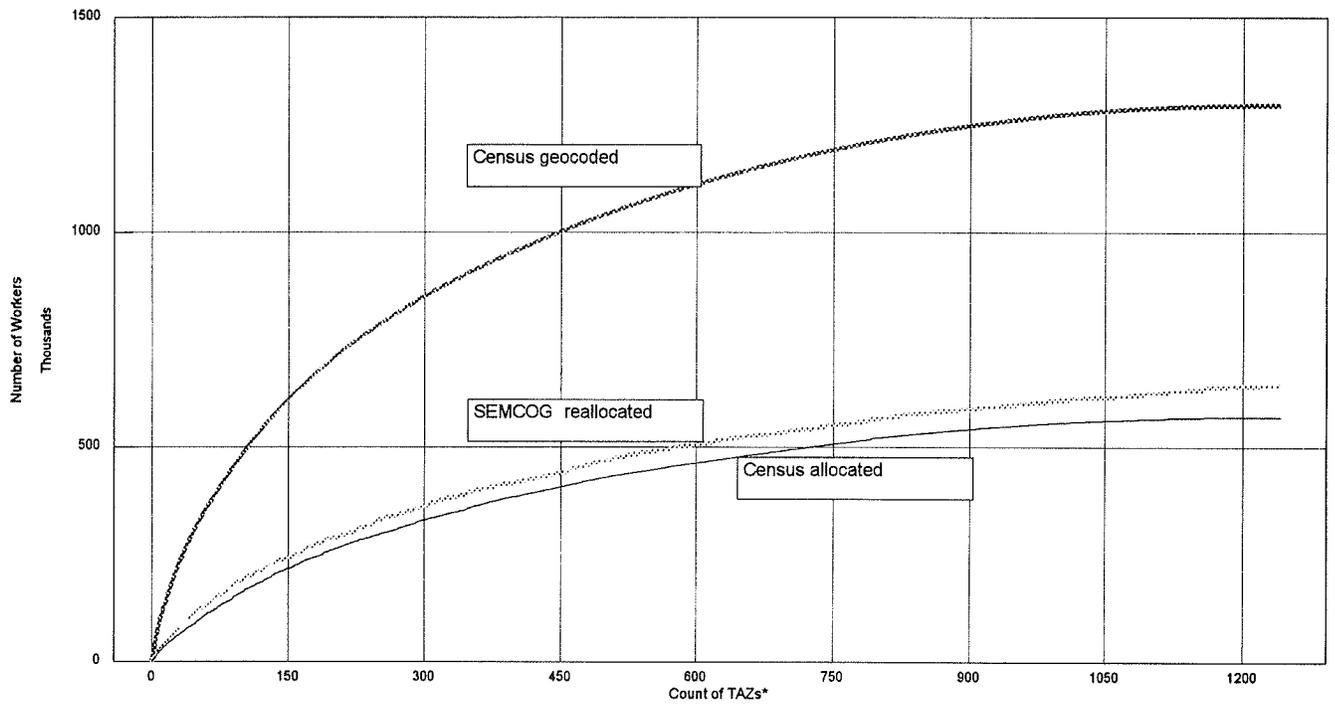
The results of applying the SEMCOG reallocation method to those workers who could not be geocoded to tract are illustrated in Figures 2 through 9. Figure 2 includes all workers, and the others present data on a selection of the specific ICs of the special tabulation. Each is divided into two graphs, the upper numerical graph giving a count of workers and the lower percentage graph giving a percentage distribution, both along the Y-axis.

The X-axis gives a count of TAZs arranged in an order that corresponds to the occurrence of Census Bureau tract-geocoded workers in the specified IC. The leftmost TAZ has the greatest number of workers in that IC; the other TAZs are arranged in descending order.

Each graph shows three curves representing Census Bureau geocoded, Census Bureau allocated, and SEMCOG reallocated workers. The curves are cumulative, each corresponding to the distribution (either numerical or percentage) of workers of its type of workplace coding procedure. (It is important to keep in mind that the Census Bureau allocated and the SEMCOG reallocated curves both follow the X-axis TAZ sequencing established by the Census Bureau geocoded workers: descending order, highest TAZ first).

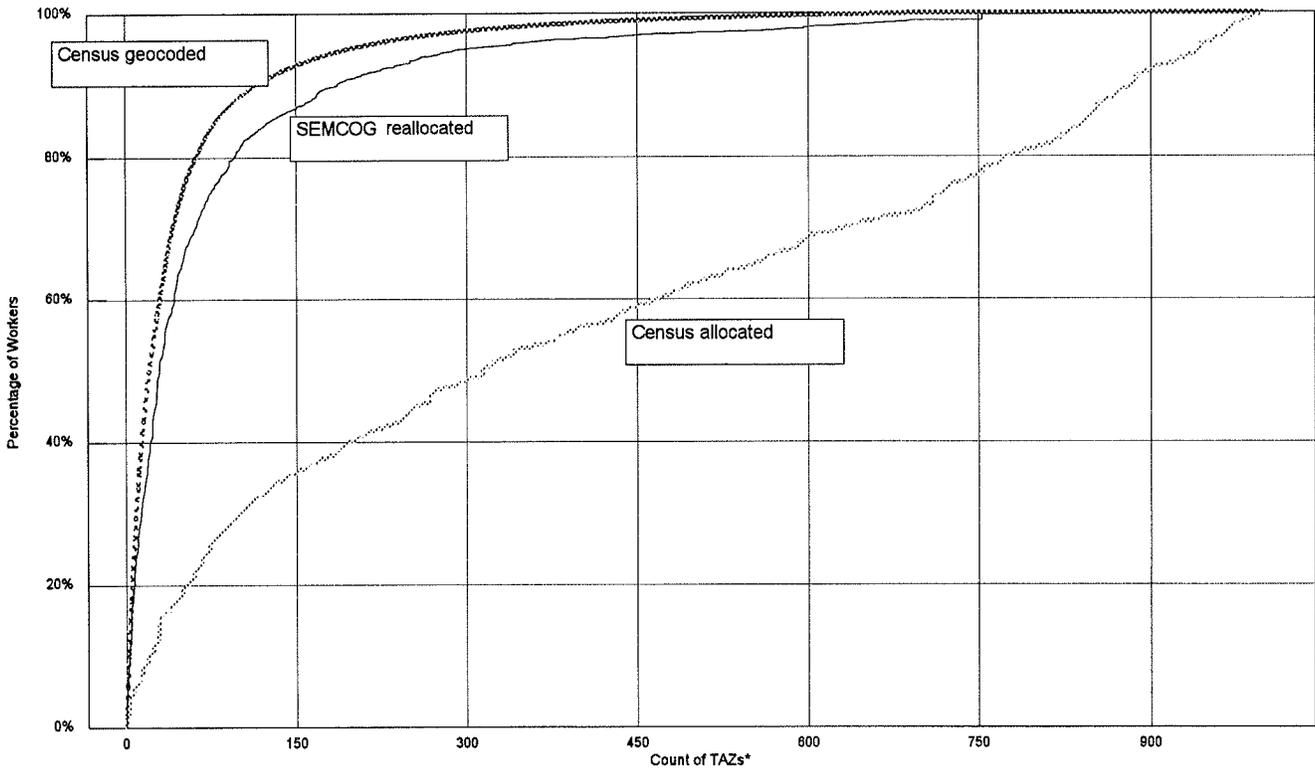
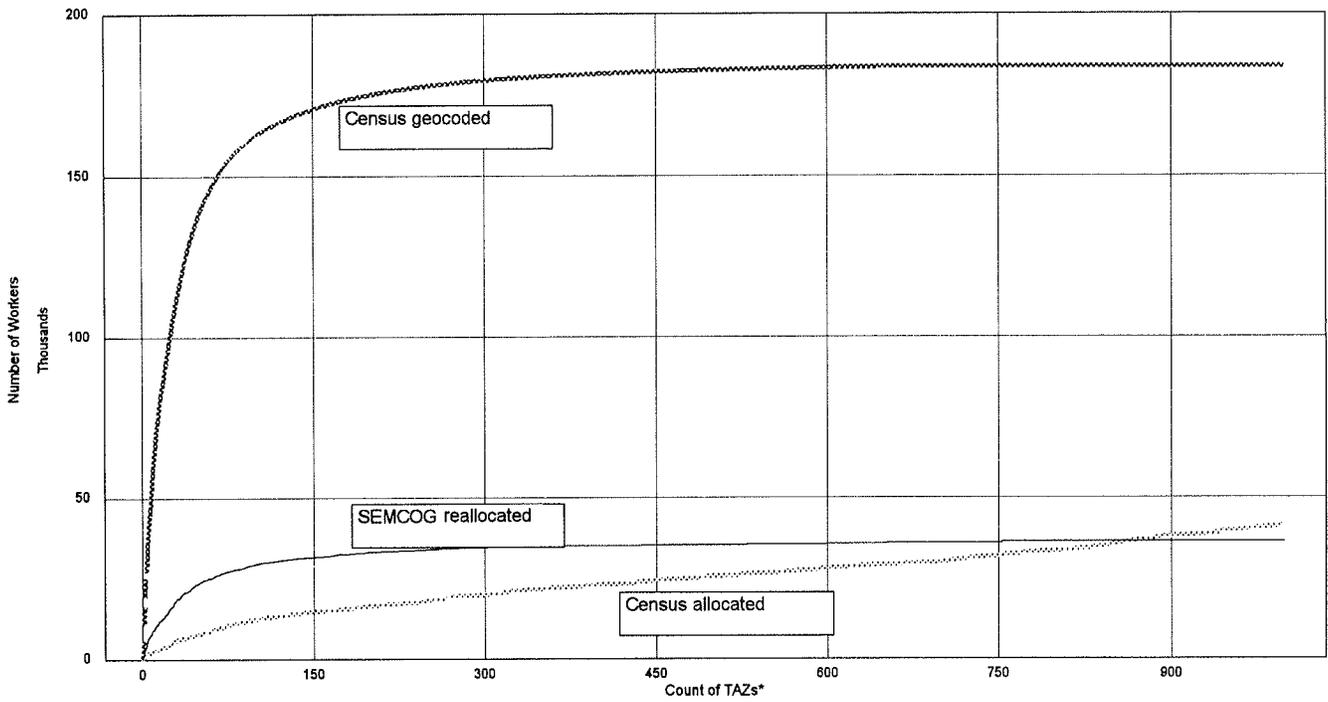
The curves demonstrate four key aspects of the specified IC:

1. **Number of workers:** Using the top graph, sum the Census Bureau geocoded plus the Census Bureau allocated. (Note that the SEMCOG-reallocated total tends to be somewhat lower than the Census Bureau allocated because of a difference in the two allocation procedures.)
  2. **Degree of concentration:** Using the lower graph, note that the steeper the curve, the higher the portion of workers located in a relatively few TAZs. The air transportation IC (Figure 4, *bottom*) shows an extremely high degree of concentration.
  3. **Geocoding rate:** Using the top graph, approximate the number of Census Bureau geocoded workers as a
- (text continues on page 45)*



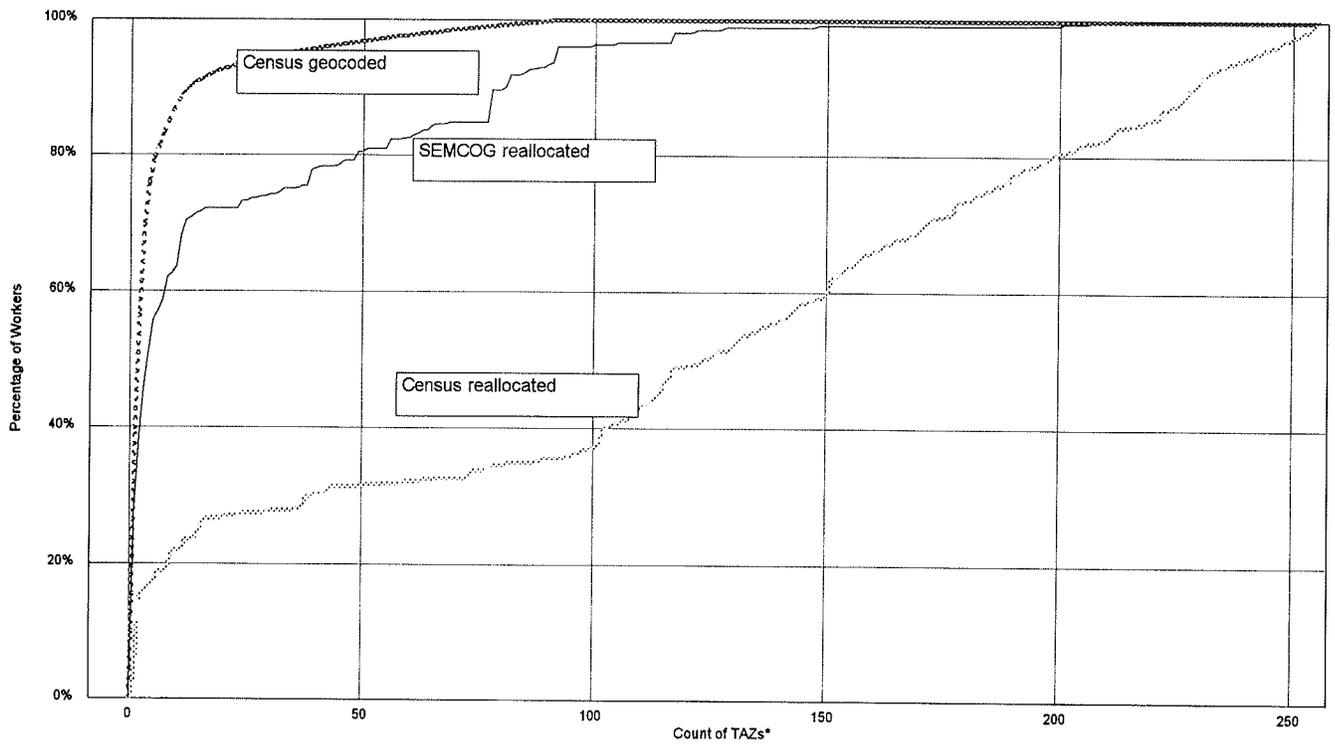
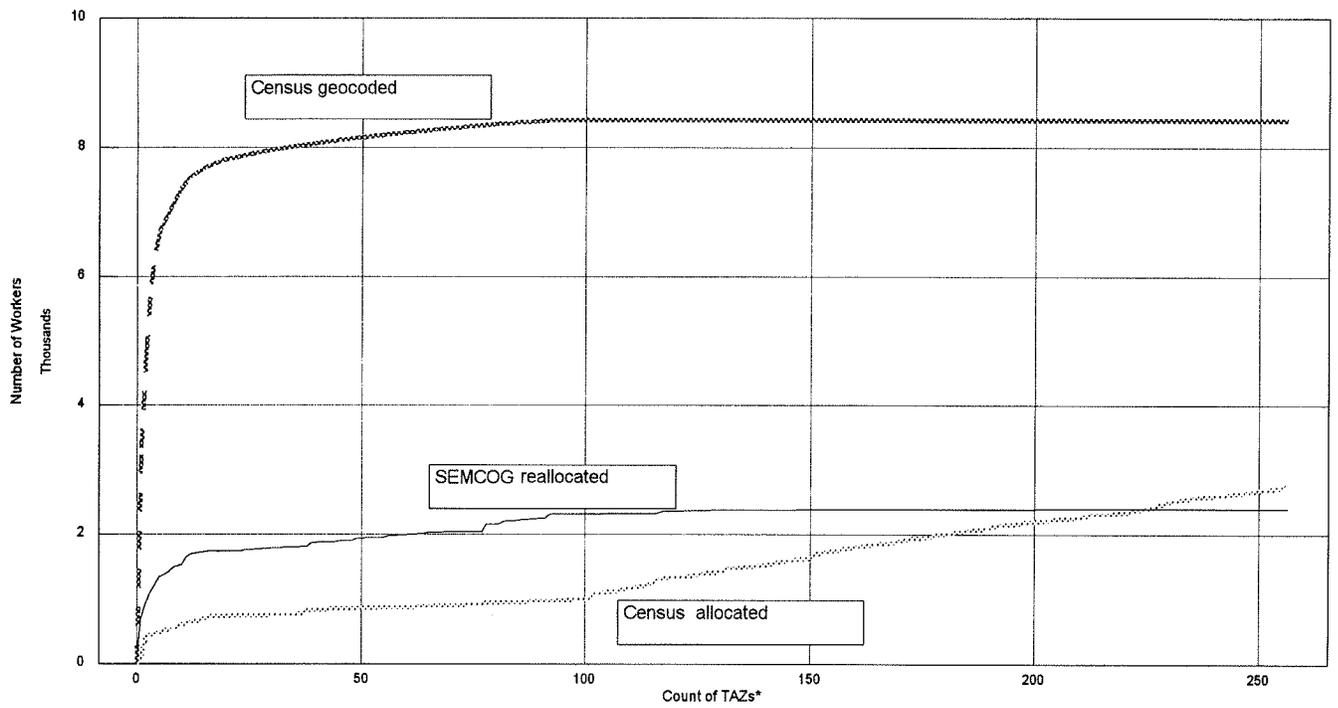
\*Note: TAZs are sorted by number of Census geocoded workers, largest first.

FIGURE 2 Cumulative distribution of workers by workplace coding procedure by TAZ, Southeast Michigan, 1990—all industrial classes.



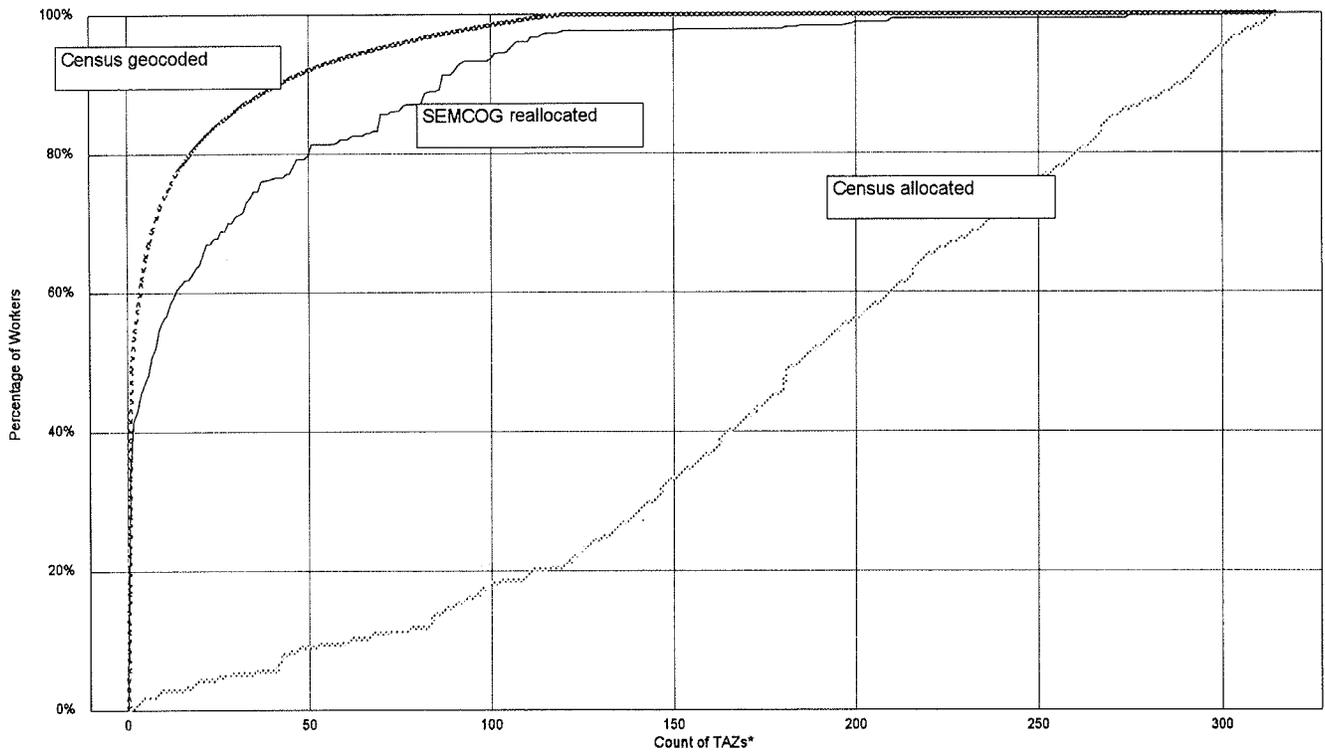
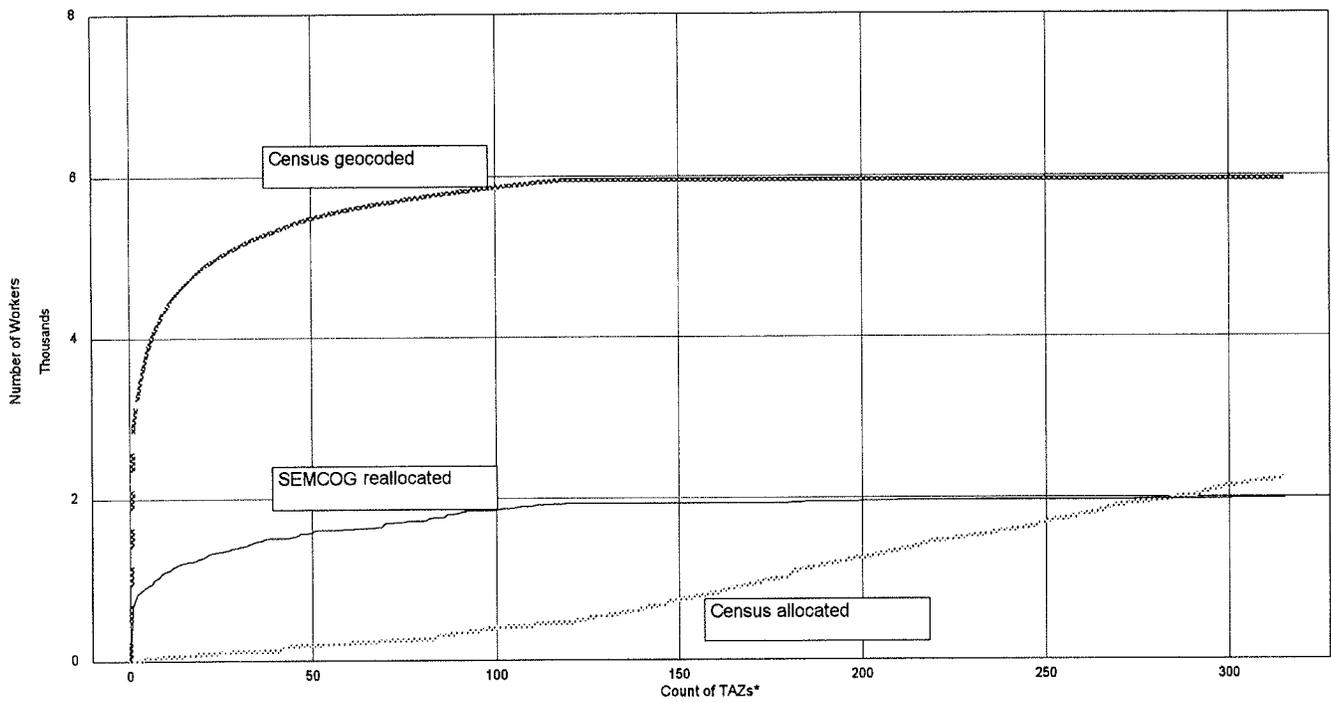
\*Note: TAZs are sorted by number of Census geocoded workers, largest first.

FIGURE 3 Cumulative distribution of workers by workplace coding procedure by TAZ, Southeast Michigan, 1990—manufacturing: transportation equipment.



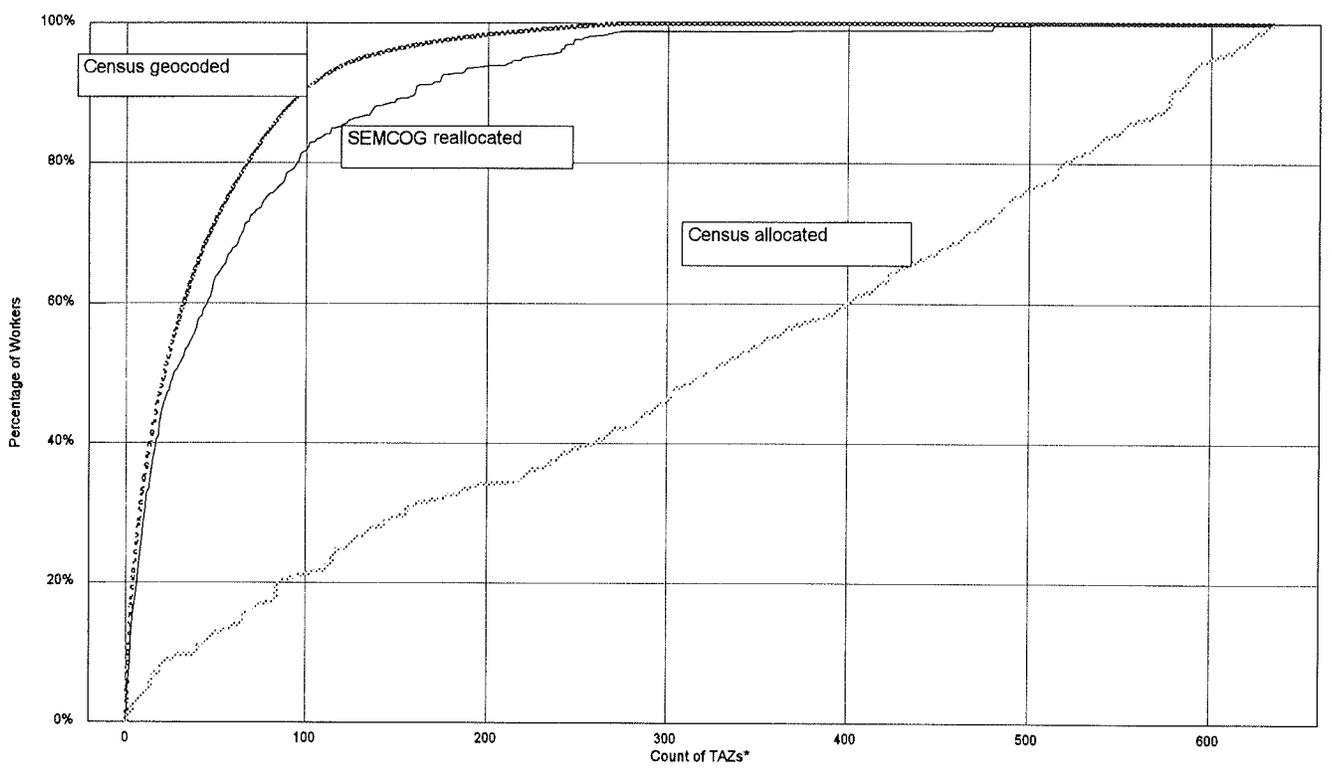
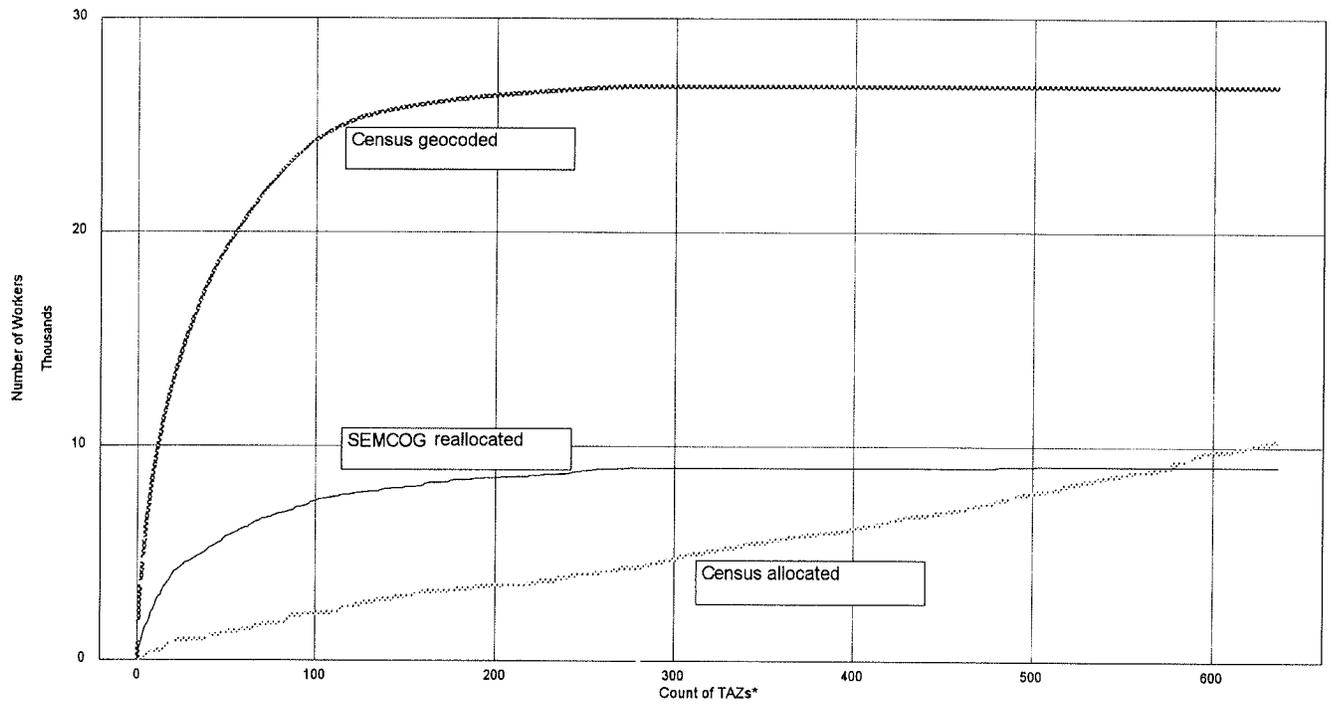
\*Note: TAZs are sorted by number of Census geocoded workers, largest first.

FIGURE 4 Cumulative distribution of workers by workplace coding procedure by TAZ, Southeast Michigan, 1990—transportation: air.



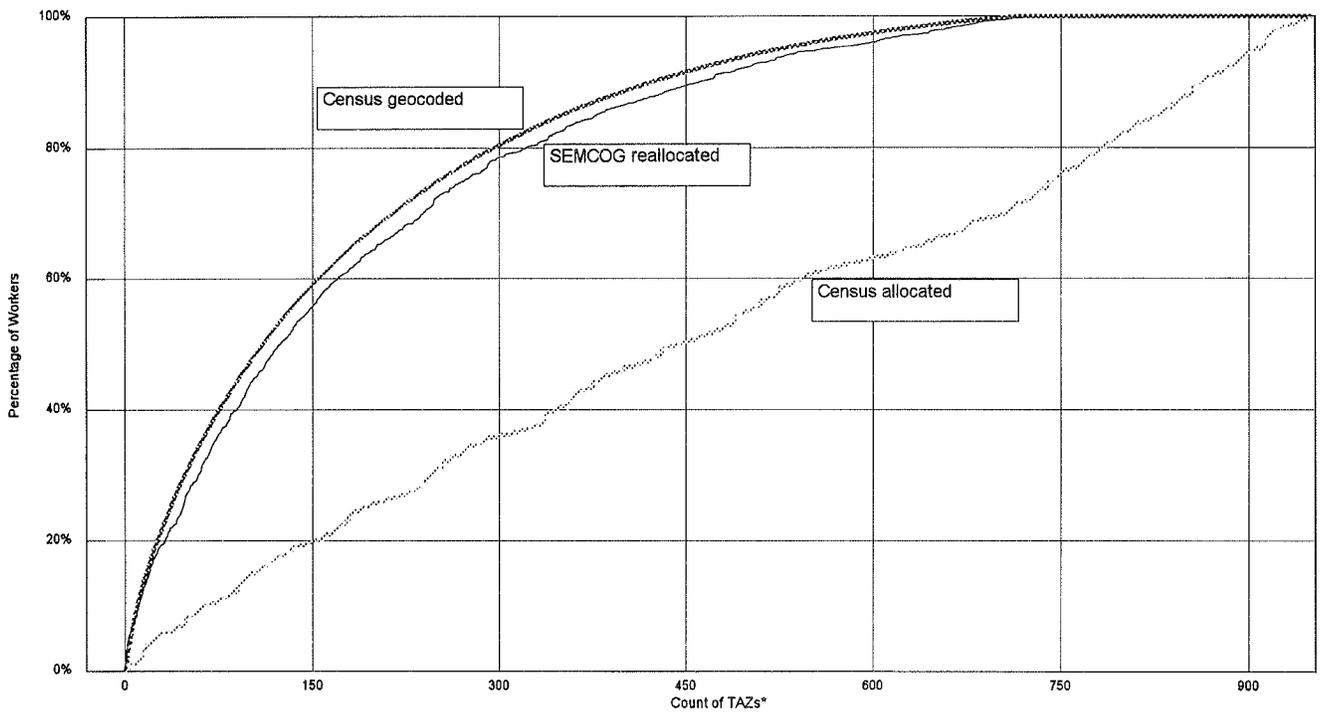
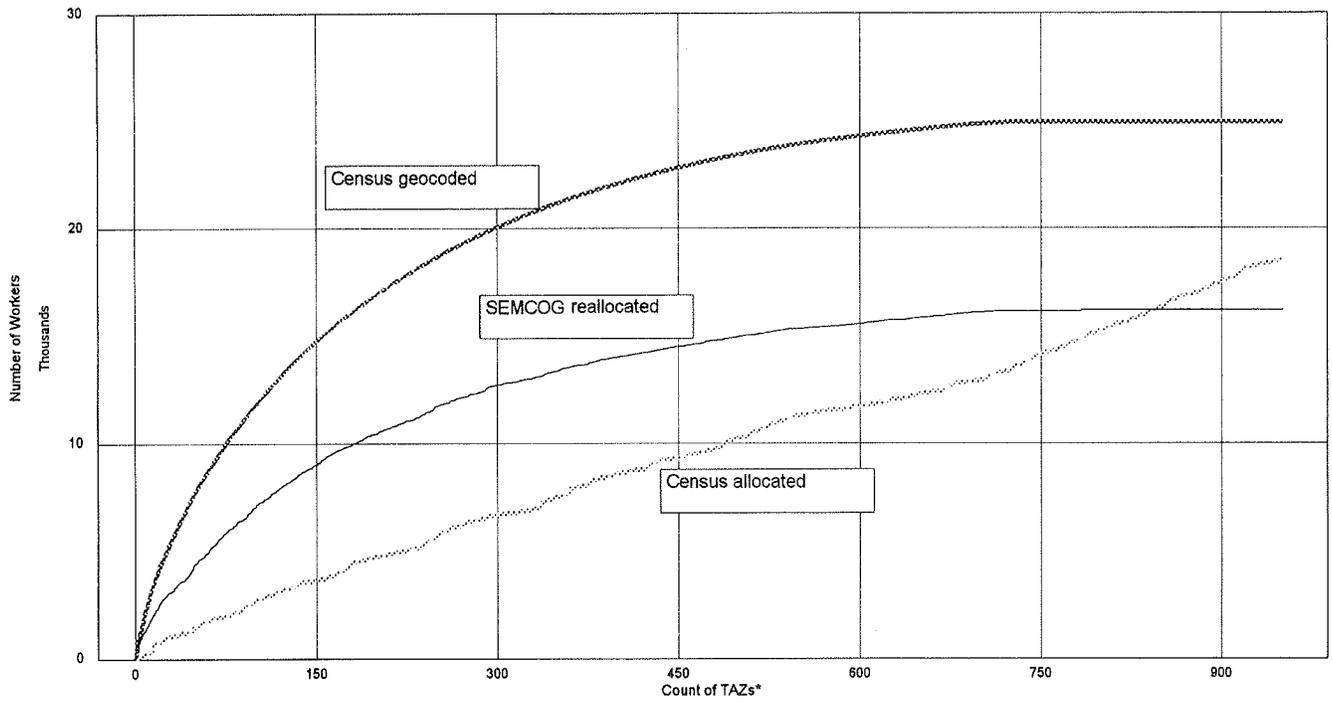
\*Note: TAZs are sorted by number of Census geocoded workers, largest first.

FIGURE 5 Cumulative distribution of workers by workplace coding procedure by TAZ, Southeast Michigan, 1990—utilities: electric.



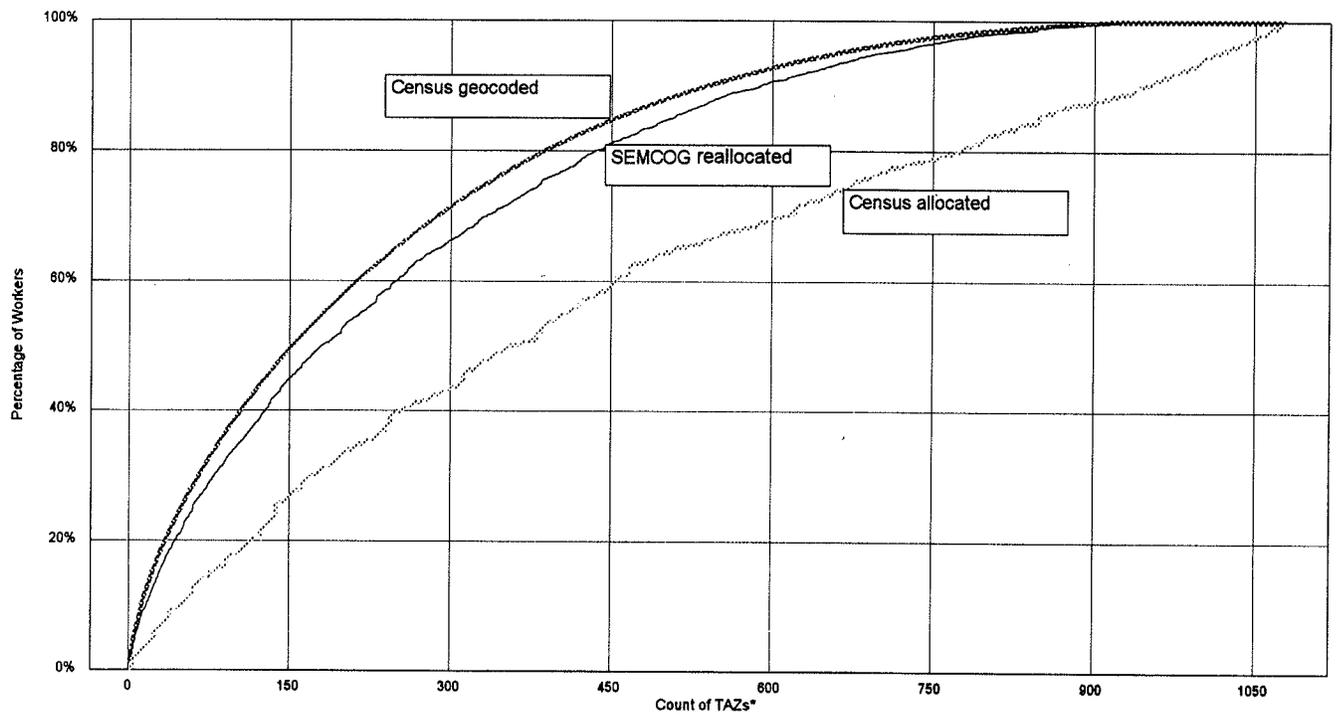
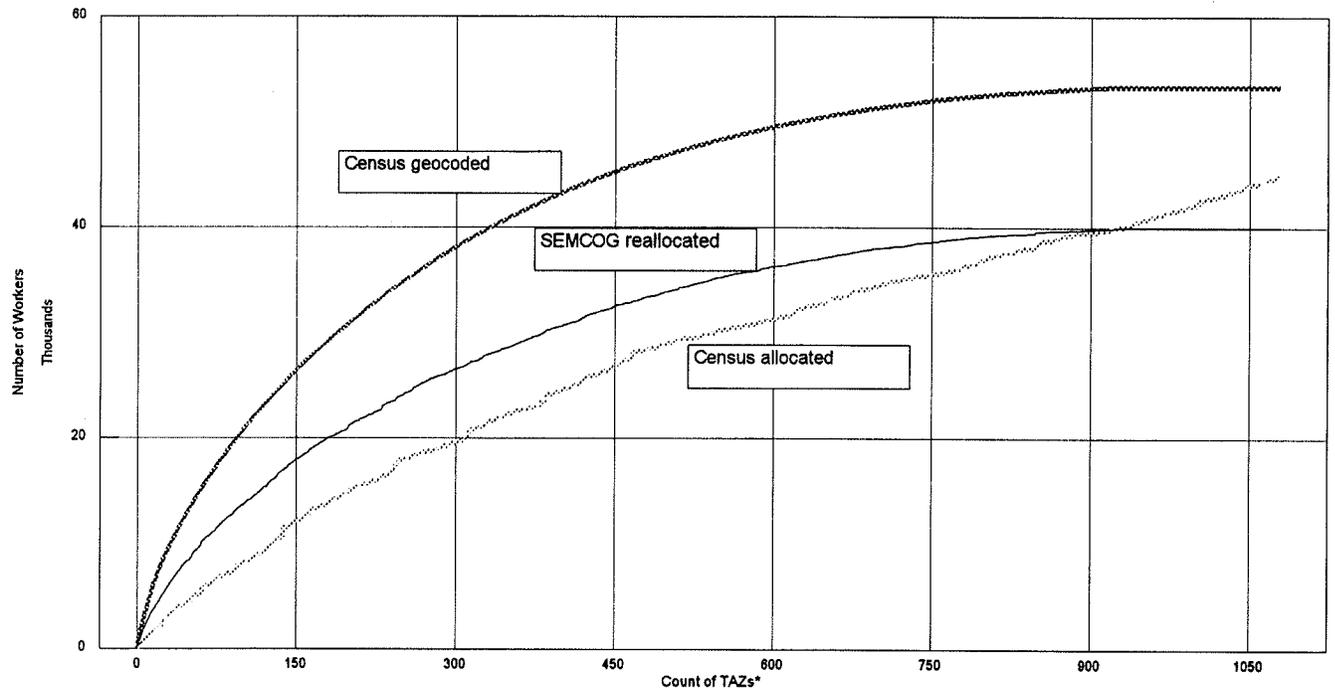
\*Note: TAZs are sorted by number of Census geocoded workers, largest first.

FIGURE 6 Cumulative distribution of workers by workplace coding procedure by TAZ, Southeast Michigan, 1990—retail trade: general merchandise stores.



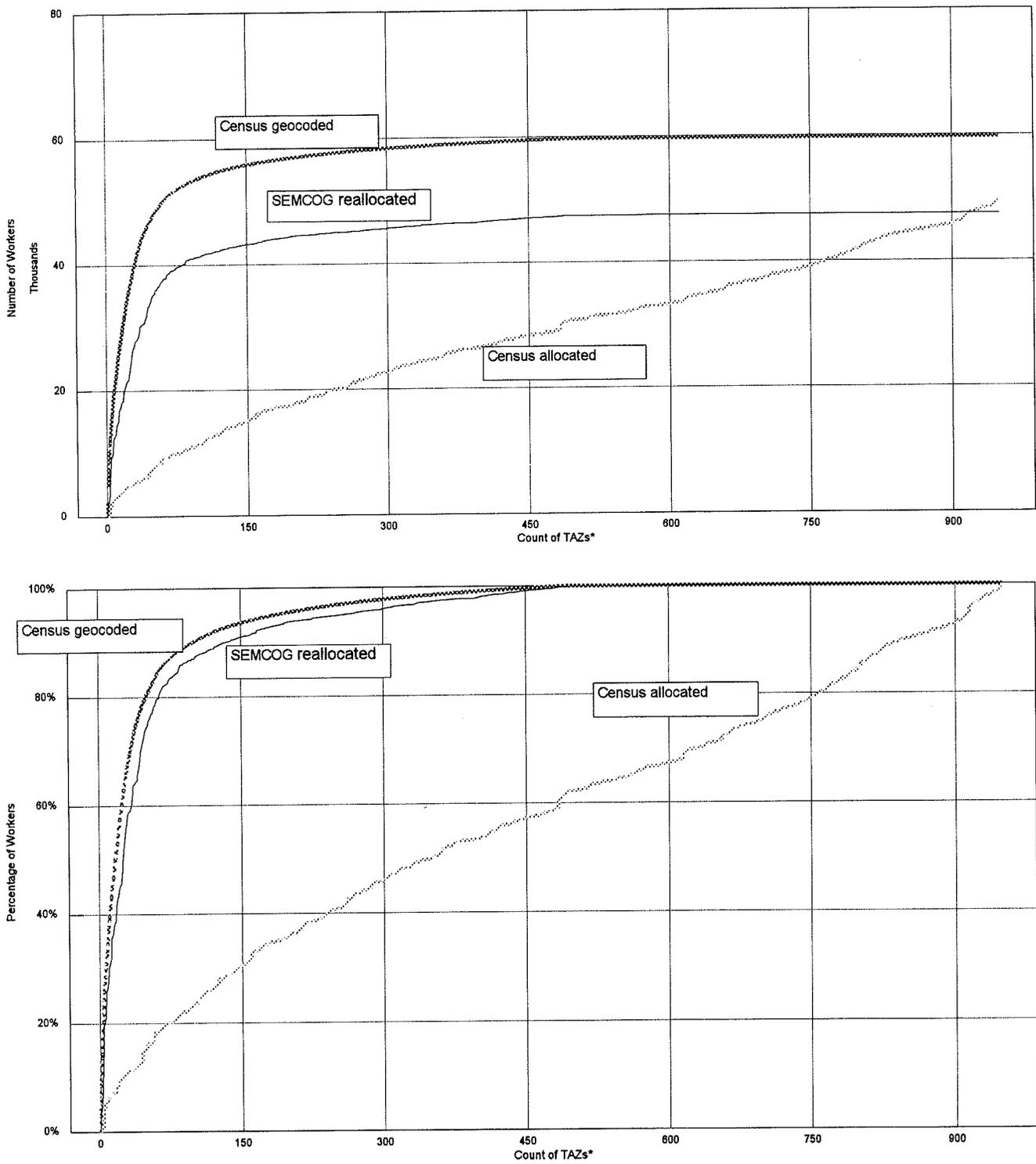
\*Note: TAZs are sorted by number of Census geocoded workers, largest first.

FIGURE 7 Cumulative distribution of workers by workplace coding procedure by TAZ, Southeast Michigan, 1990—retail trade: food stores.



\*Note: TAZs are sorted by number of Census geocoded workers, largest first.

FIGURE 8 Cumulative distribution of workers by workplace coding procedure by TAZ, Southeast Michigan, 1990—retail trade: eating and drinking places.



\*Note: TAZs are sorted by number of Census geocoded workers, largest first.

FIGURE 9 Cumulative distribution of workers by workplace coding procedure by TAZ, Southeast Michigan, 1990—hospitals.

portion of total workers (geocoded plus allocated). The transportation equipment manufacturing IC (Figure 3, *top*) shows roughly 185,000 geocoded and 40,000 allocated workers, equal to a geocoding rate of roughly 82 percent. In contrast, the graph for retail trade: eating and drinking places (Figure 8, *top*) shows roughly 55,000 geocoded and 45,000 allocated, giving a geocoding rate of only 55 percent. If the allocation procedure does have the problems that it appears to have, it is obvious that the lower the IC geocoding rate, the greater will be the negative impact and the greater the percentage of workers who will be assigned to TAZs that are inappropriate for that industry. Further, it should be borne in mind that incorrect workplace assignments produce incorrect home-to-work commuting trips.

4. **Degree of replication:** This is the central concern of this paper, namely, how well do Census Bureau allocated workers replicate the small-area locational pattern of Census Bureau geocoded workers? Further, can there be a better way to allocate ungeocodable workers? To answer both these questions, examine the percentage graphs (Figures 2 through 9, *lower graphs*).

The graph of all ICs (Figure 2, *bottom*) shows that both the Census Bureau allocated and the SEMCOG reallocated curves track the Census Bureau geocoded curve fairly well. However, such is not the case with the selected Specific ICs; the Census Bureau allocated curve does not do a good job of tracking the Census Bureau geocoded curve. For example, the Census Bureau allocated curve of the electric utilities IC (Figure 5, *bottom*) has allocated less than 20 percent of its workers by the first 100 TAZs, whereas by that point the Census Bureau geocoded curve has accounted for 98 percent of its workers. That geocoded curve hits 100 percent at around the 130th TAZ, but at that point the allocated curve still has 80 percent of its jobs yet to be assigned to TAZs. In other words, that 80 percent will go into TAZs that have no geocoded workers for that industry, or into TAZs where, for the most part, they do not belong. The SEMCOG reallocated curve replicates the geocoded curve well, but not exactly. Some degree of discrepancy is to be expected. For one thing, if a worker in a given IC was geocoded to place but the place had no geocoded workers for that industry, the reallocation method accepts the Census Bureau's geocoding and then matches on Principal IC or, failing that, General IC, as illustrated in Figure 1.

A comparison of the Census Bureau geocoded and SEMCOG reallocated curves by Specific IC demonstrates that the reallocation method, even without using means of transportation and travel time, produces a better replication of the small-area pattern of geocoded workers than does the current Census Bureau allocation method. However, a full allocation method should include both means of transportation and travel time. Time demands

plus the complexity of the task kept SEMCOG staff from attempting to include them in their reallocation method. In the final section of this paper a proposal for a comprehensive allocation method is presented.

## RECOMMENDATION FOR CENSUS 2000

An improved allocation method for use in Census 2000 could combine features from both the current Census Bureau allocation method and the SEMCOG reallocation method, and in addition could incorporate several new features. Means of transportation and trip duration would be adopted from the Census Bureau method. However, there would be at least four separate means, namely, walk, bicycle, car/truck/van, and transit (with transit being split into separate types in metropolitan areas in which transit types other than bus are significant). Walk and bicycle are recognized as separate means because their reach is so restricted compared with car or transit. The current Census Bureau method uses only two means of transportation: transit and all other.

Both existing methods use ICs. However, the Census Bureau method uses up to 11 classes, whereas the SEMCOG method uses up to 75. In addition, the improved method would adopt OCs from the SEMCOG method. The Census Bureau method makes no use of OCs, whereas the SEMCOG method uses up to 40. The improved method would use detailed breakdowns for both industry and occupation, with the exact number of classes to be determined.

The new method would introduce the concepts of "commuting origin areas," representing areas of residence, and "commuting destination areas," representing areas of workplace. Each TAZ would have an origin area, consisting of the TAZ itself as a central zone plus a ring of immediately surrounding TAZs. Place-of-work data for tract-geocoded workers residing in each origin area would be used to demarcate a set of destination areas, which would then be assigned to the origin area's central TAZ. (By assigning the destination areas of the entire origin area to the central TAZ, the sample size of each central TAZ is increased.)

There would be a separate destination area for each travel time interval of the car/truck/van and the transit means of transportation. Each particular destination area would represent the TAZs that were the work ends of commuting trips made by workers residing in the origin area who were geocoded to tract and block of workplace and who made a trip of the specified length by the specified means. The allocation of workers whose workplaces had been geocoded to a place but not to a tract would be restricted to the portion of the commuting destination area that fell within that place.

Because walk and bicycle trips are relatively infrequent, their destination areas should not be demarcated

using data for tract-geocoded workers residing in the origin area. Instead, the destination area representing the first or shortest travel time interval would always include the entire origin area, plus any other TAZs that could be reached within the time interval. It would be assumed that there was one average travel speed for walk trips and another for bicycle trips, and straight-line centroid-to-centroid distances, central TAZ to each TAZ beyond the origin area, would be used. Subsequent travel time intervals for walk and bicycle trips would also use average travel times and zone-to-zone straight-line distances. In the improved allocation method, following the demarcation of an origin area and destination area for each central TAZ, workers needing to be allocated would be assigned to tract and block using the previously described procedure illustrated in Figure 1.

The proposed allocation method represents a systematic effort to make maximum use of all that is known about workers needing to be allocated so that they can be assigned to a tract and block that best correspond to their place of residence, their work-trip characteristics, and their specific industry and occupation. The nationwide TIGER File and the current capabilities of geographic information systems bring such an improved allocation system within reach.

#### ACKNOWLEDGMENT

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Department of Transportation; through the Michigan Department of Transportation; and through local membership contributions. The specifications of the worker data file were developed through consultation with Census Bureau staff, who then created the special tabulation. Phillip Salopek of the Census Bureau and Philip Fulton of the Bureau of Transportation Statistics both provided valuable information and advice throughout this project. Processing and manipulation of the special tabulation data were performed by former SEMCOG staff member George Janes, planning analyst, and current SEMCOG staff member Ming H. Tsai, planning analyst. In addition, Tsai did additional analytical work, designed and produced the figures, and gave other important assistance in the production of the final paper.

Finally, special thanks are due the Southeast Michigan Council of Governments for generous willingness to provide financial and staff support for this project. Without SEMCOG's allocation, there would be no reallocation.

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# Improvement of Decennial Census Small-Area Employment Data: Method To Assign Land Use Classes to Workers

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The 1990 census collected data on a wide variety of demographic characteristics, including employment. The census recognized three dimensions of kind of work or job activity: industrial class, the overall purpose of the employing organization; occupational class, the kind of work done in the individual job; and class of worker, the relationship between the organization's ownership and the employed person. However, there is a fourth dimension of job activity, land use, which is not recognized by the decennial census. Non-residential land use classes describe the nature of economic activities and facilities occurring as individual establishments. Major land use classes include office, commercial, institutional, industrial, as well as others. SEMCOG has obtained a special cross-tabulation of 1990 census data on workers by zone of work. A method has been developed at SEMCOG that uses industrial class and occupational class in conjunction to assign land use class to workers. This method allows the linking of census demographic characteristics to the land use class of the workplace, and thereby to noncensus data on land use characteristics; to the spatial distribution of nonresidential land uses that these data describe; and to the locational determinants that underlie these patterns. SEMCOG has used the method to assign land use classes to 1990 census employment data. Testing and improvement of the method are continuing. The indispensability of decennial census data on employment for analytical and planning purposes is emphasized, and a proposal is made to incorporate the land use assignment method into the procedures for Census 2000.

The purpose of this paper is to present a method for adding land use classes to decennial census employment data. There are four major objectives: to discuss the ways in which the job activity or kind of work aspect of employment is classified, especially in the decennial census; to describe the special tabulation of 1990 census worker data that the Southeast Michigan Council of Governments (SEMCOG) has obtained from the Census Bureau and to contrast it with the Census Transportation Planning Package (CTPP); to present a procedure that uses the special tabulation to add a land use "tag" to decennial census employment data; and to discuss the current status of this work.

In this paper, the term "land use" is used in a restricted sense. It does not include all the "land use" inputs—employment, households, population, developed and vacant land, etc.—that transportation models require nor is it the inclusive, umbrella concept implied in the phrase "land use and transportation." Rather, land use in this discussion means the nature and characteristics of the activities occurring at specific individual locations and usually also the buildings and associated open land that the activities occupy. Land use is site specific. Land use class describes the general activity performed by a particular establishment. Commonly recognized types or classes of land use include residential, office, commercial, institutional, and industrial, as well as others.

The following sections of the paper discuss the classification of job activity by the decennial census, the de-

velopment of a method for adding a land use class to existing census data on employment, the current status of this work, the indispensability of decennial census data on employment, and last, a proposal to incorporate the land use assignment method into the procedures for Census 2000.

## DECENNIAL CENSUS DATA AND CLASSIFICATION OF JOB ACTIVITY

### Decennial Census Data on Employment

The 1990 census collected data on a wide variety of employment characteristics, including

- Labor force status (employed, unemployed, or not in labor force; year last worked);
- Complete address of workplace;
- Travel to work (means of transportation, departure time, trip duration);
- Number of hours worked (last week and during 1989); and
- Job activity (industrial class, occupational class, class of worker).

For persons who held more than one job, data were collected only for the principal job, defined as the job at which the person worked the most hours. Workplace location and hours worked last week were determined only for employed persons who were actually at work some time during the week preceding April 1, Census Day (1).

### Dimensions of Job Activity in Decennial Census

The decennial census recognizes three dimensions of job activity. These are industrial class, occupational class, and class of worker.

Industrial class refers to the overall, predominant purpose of the business, agency, or governmental department for which the person works. This purpose corresponds to the major product or service of the organization. The 1990 census used 236 separate industrial categories grouped into 13 major groups to code industrial class. Examples of the categories (with the corresponding major group in parentheses) are petroleum refining (manufacturing), hardware stores (retail trade), hotels and motels (personal services), and hospitals (professional and related services).

Occupational class describes the kind of work done in the individual job. The 1990 census used 501 separate occupational categories grouped into 6 summary and 13 major groups to code occupational class. Examples of the categories (with the corresponding major groups in

parentheses) are architects (professional specialty), computer programmers (technical, sales, and administrative support), aircraft engine mechanics (precision production, craft, and repair), and hoist and winch operators (operators, fabricators, and laborers).

Class of worker describes the relationship between the ownership of the organization and the employed person. The 1990 census used eight such classes: wage and salary (subdivided into private for profit and private not-for-profit); government (local, state, federal); self-employed (not incorporated, incorporated,); and unpaid family worker (2).

### Land Use Class as Fourth, "Missing" Dimension

Industrial class and class of worker relate the employed person to the dominant nature—purpose and ownership, respectively—of the employing organization. Occupational class relates the employed person to the nature of the work performed in his or her own job. But there is a fourth dimension to job activity, a dimension that is not included in the decennial censuses: land use. Land use as a concept relates to what is happening site by site in establishments on the land. It relates the employed person to the nature of the individual establishment, the workplace, in which he or she works. These establishments—the stores, shops, restaurants, theaters, lodging places that form commercial areas, factories and warehouses that form industrial areas, schools, churches, and hospitals that form institutional areas, etc.—are the building blocks of nonresidential land use patterns.

In a paper presented at the 73rd Annual Meeting of the Transportation Research Board, Putman, the developer of the DRAM and EMPAL demographic forecasting models, discussed the use of employment types. He noted that many of the agencies forecasting with DRAM and EMPAL use up to eight employment types based on slight aggregations of the one-digit Standard Industrial Classification (SIC) industrial classes. However,

the problem with this is the S.I.C. categorization of employment, which often does not match what might be termed a land use based categorization. For example, the office staff of a manufacturing firm will often be located in a central city area, but it will be classified, by S.I.C., as heavy manufacturing. The actual manufacturing facility for that same firm might be located in a suburban area. When the calibration is done for manufacturing, the model will encounter two zones containing manufacturing employment, but with apparently very different location determinants. While this would argue for the use of employment categorizations based on land use classifications, there is a further complication. An im-

portant component of the linkage between EMPAL and DRAM is the employment-to-household (EMP/HH) conversion process. In this, the employees, by type and by place of work, are converted to implicit heads of households by type, still at place of work. Adjustments for unemployment and workers per household are subsumed into this conversion. The data for the conversion are based on U.S. Census data, now generally obtained from the PUMS (Public Use Microdata Sample) data involving a cross tabulation of S.I.C. of employment and household income. The preparation of the EMP/HH conversion matrix for land use based employment categories would be extremely difficult if not impossible. Finally, the data for employment by place of work are amongst the most difficult data for regional agencies to obtain, and they often have no choice as to the categorization in which they get it. (3, p. 5)

In short, there is a double problem. First, decennial census employment data do not include a land use classification. Second, even if employment by land use class were obtainable from a source other than the census, it would not be linkable with decennial census data on employee characteristics. Land use class is a "missing dimension" in decennial census data. Its absence severely limits the possibility of interrelating physical data on land use, such as building type, floor space, and acreage, of both existing and planned development with census data on the demographic characteristics of workers by place of work.

A solution is offered in this paper in two basic steps. Beginning with a cross-tabulation of decennial census data on the employment and household characteristics of workers by zone of work, in Step 1 each zone's number of workers cross-tabulated by industrial class and occupational class is input into a procedure that assigns a land use class to the workers in each industrial class. In Step 2 assigned land use class is cross-tabulated with the workers' household characteristics, for example, household income, that are part of the original cross-tabulation.

## CLASSIFICATION OF EMPLOYMENT BY LAND USE

### Overall Procedure

The overall procedure used to assign land use classes to small-area decennial census employment data is illustrated in Figure 1. There are three major phases. Phase I involves the design, creation, and subsequent improvement of the census special-tabulation data. Phase II consists of the creation of an industrial class by occupational class matrix, followed by the assignment of land use classes to the cells of the matrix. Phase III assigns land use classes to the workers of the special tabulation.

These phases are described in detail in following sections of the paper.

### Basic Land Use Classes

The current version of the land use assignment procedure classifies workers by small-area place of work into six basic land use classes: office; commercial; institutional; industrial; transportation, communications, and utilities (TCU); and residential. These basic land use classes are defined in the following paragraphs.

#### Office

Workers in the office land use class fall into three general groups. One group consists of those industrial classes whose workers are in mostly white collar occupations and work in office floor space, including finance, insurance, and real estate; business services, such as advertising, collection and credit reporting, direct mailing, computer programming, and data processing; and professional services, such as offices and clinics of physicians and dentists, membership organizations (business, professional, labor, etc.), and legal, engineering, architectural, accounting, research, and management services.

The second group of workers that is found in office land use occurs in industrial classes whose workers are predominantly not white collar. Using Putman's example, a large, multiestablishment manufacturing firm, in addition to industrial facilities such as factories and warehouses in which blue collar workers predominate, will typically also have one or more offices at separate locations that are primarily engaged in performing management and other general administrative functions. Such separate office establishments are called central administrative offices in the *Office of Management and Budget Standard Industrial Classification Manual* (4). Such central office establishments, along with research laboratories and warehouses, are called auxiliary establishments; they serve the other establishments of the same enterprise, called operating establishments, which produce the goods and services that are the business of the enterprise (4, pp. 13-15).

Third, there are industrial classes in which blue collar occupations might predominate but which include operating establishments staffed mainly by white collar workers. A firm in the construction industrial class can have a majority of workers in blue collar occupations and working at temporary construction sites and at the same time maintain a permanent office location at which the firm is headquartered. Within the wholesale trade industrial class, some firms maintain inventories of goods and therefore require establishments that are designed for goods storage and so fall into the industrial land use class. Other wholesale trade firms, however, do

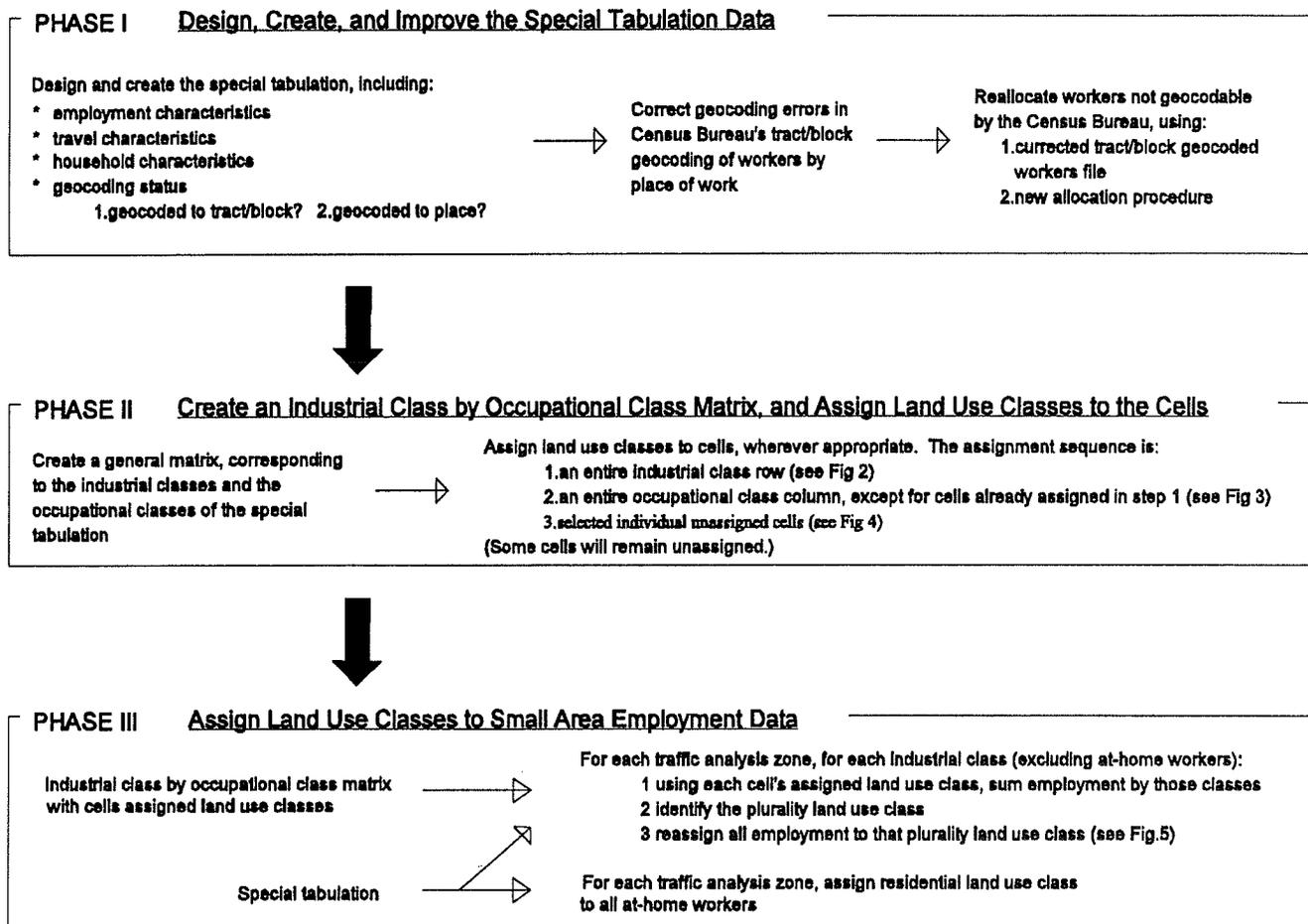


FIGURE 1 Overall procedure for assigning land use classes to decennial census small-area employment data.

not maintain their own inventories but instead act as middlemen who arrange and direct deliveries of goods from manufacturers directly to retailers. Workers of such wholesale trade firms occur solely in office land use.

### *Commercial*

Workers in the commercial land use class are found in such establishments as stores, restaurants, theaters, hotels and motels, gasoline stations, and repair shops. Typically, commercial land use establishments deal directly with the final consumers of products and services. In a very broad sense, commercial land use is "retail" in its orientation. It should be noted, however, that this group includes not only establishments in the retail trade industrial class, but also others in a wide variety of service industrial classes.

### *Institutional*

The institutional land use class includes establishments that provide services of a public, educational, or chari-

table nature. Employees of these establishments are, in terms of class of worker, mostly governmental or private not-for-profit. Industrial classes in the institutional land use class include hospitals, elementary and secondary schools, libraries, museums, and houses of worship. The SEMCOG assignment method also includes correctional facilities in the institutional class; government offices, conversely, are included in the office land use class. Hospitals and colleges and universities are treated as campuses that are entirely institutional land use. Therefore, an administrative office building belonging to a hospital or a university will be called institutional rather than office land use.

### *Industrial*

The industrial land use class includes those establishments whose industrial class is manufacturing and that are engaged in converting raw materials into new products or in assembling component parts into finished products. Plants, factories, and mills are the usual names of such establishments. Industrial land use also includes warehouses in which goods and materials are stored. Ware-

houses are used not only by firms of the manufacturing industrial class, but also by firms of other industrial classes, especially wholesale trade and retail trade, when firms maintain storage facilities separate from their other establishments. Industrial land uses, for the most part, do not deal face to face with the final consumer for the goods that are produced and stored within this land use.

### *Transportation, Communications, and Utilities (TCU)*

The TCU land use class has as its unifying characteristic a concern for the maintenance of flows. The flows can consist of persons, goods, energy, or information. TCU land use includes a wide variety of specialized establishments, such as air, rail, bus, truck, and ship terminals; post offices; broadcasting stations; electric generating stations; water supply treatment plants; and sewage treatment plants.

### *Residential*

Residential land use includes all workers who work at home, regardless of their industrial class or occupational class. In addition, the residential land use class includes all other workers in four industrial classes that involve residential-type services: private households (that is, persons doing domestic work in others' residences), child daycare services, nursing and personal care facilities, and residential care facilities without nursing.

### **Census Special Tabulation**

The CTPP is a 1990 census product. It consists of a series of data tabulations oriented to transportation planning. The CTPP has two components. The Statewide Element includes data on all places having populations of 2,500 or more, plus all counties. The Urban Element covers only metropolitan-area counties. Within those counties, the Urban Element gives data by small area [traffic analysis zone (TAZ) and census tract].

Both components give data by three types of location: place of residence, place of work, and residence-to-work commuter flows. The 1970 and 1980 censuses had a similar product called the Urban Transportation Planning Package (UTPP).

SEMCOG's 1990 census worker special tabulation is like the CTPP in that it

- Was derived from the same "parent file" as the CTPP, the Sample Edited Detail File,
- Includes the key employment-related variables of the CTPP,
- Includes household characteristics, and
- Includes TAZ of work.

However, the special tabulation is different in that it

- Is more detailed (e.g., 75 industrial classes and 40 occupational classes compared with 18 and 14, respectively, in the CTPP) and
- Includes flags indicating whether or not the worker was geocoded to tract as well as to place.

### **Improving Special-Tabulation Data**

Before applying the land use assignment method to the special-tabulation data, SEMCOG staff conducted a separate project the purpose of which was to make improvements to the census data. The improvements addressed two problems in the data, geocoding errors and allocation inaccuracies.

In 1990 the Census Bureau geocoded workers to tract and to block provided that the workplace addresses reported were sufficiently complete and either the Topologically Integrated Geographic Encoding and Referencing (TIGER) File could identify the address or the Workplace File included the specific worksite. (In 1980 the situation was similar, although some of the details were different.) However, some tract and block geocoding errors still occur. Such errors in the UTPP and CTPP are difficult to recognize and correct because geocoded workers and allocated workers are mixed.

Because the special tabulation included a flag that indicated whether or not the workers had been geocoded to tract (in most cases such workers had also been geocoded to block), SEMCOG was able to produce computer-generated maps of tract-geocoded employment by any of the 75 industrial classes of the special tabulation. Upon examination, the overall quality of tract and block geocoding appeared to be quite good. There were relatively few recognizable major errors and these were corrected, resulting in an improved base for the workers who needed to be allocated.

In the Census Bureau procedure for creating small-area employment data, workers who could not be geocoded to tract and block were instead assigned to tract and block by an allocation procedure. A considerable percentage of workers needed to be allocated. In the four most urban counties of Southeast Michigan, an average of over 30 percent of all workers needed to be allocated to tract and block. In Detroit City, nearly two-thirds of the tracts had more than 40 percent of their workers allocated by the Census Bureau. Some sort of allocation procedure is absolutely necessary so that workers with ungeocodable addresses can be assigned to an appropriate small area. However, the currently used allocation procedure was believed to seriously reduce the overall accuracy of census small-area place-of-work employment data. Therefore, SEMCOG developed its own reallocation procedure.

That procedure accepted the Census Bureau's geocoding to county and to place, and then used the special tab-

ulation's detailed breakdown of industrial class and occupational class to match workers needing to be reallocated to zone with workers who had been geocoded to tract and block and thereby to zone by the Census Bureau. SEMCOG's reallocation greatly increased the accuracy of the zone-of-work geocoding and thereby elevated the quality of the subsequent assignment of land use classes to employment.

### Assigning Land Use Classes to Industrial Class by Occupational Class Matrix

In drawing up the specifications for the special tabulation, it was decided to group the 236 industrial classes and 501 occupational classes by which the parent census data file is coded. For industrial classes, separate identification of those industries that in actuality occurred mostly, if not completely, in a single land use class was requested. For example, the finance industrial class was identified as an industry that occurred overwhelmingly within office land use, the hospital industrial class as occurring overwhelmingly within institutional land use, and so on. In addition, it was requested that each industrial class that equaled at least 1 percent of the region's total employment be separately recognized. Finally, industrial classes that had unique physical land use characteristics—for example, wholesale trade in scrap and waste materials—were given separate recognition even though they had relatively few employees.

For occupational classes, separate identification of occupations that in actuality occurred mostly if not completely in one particular type of floor space was requested, with floor-space types corresponding to land use classes. In effect, this question was to be answered: "If an entire building was totally occupied by workers of this one occupational class, what kind of building would it be?" So, for example, the occupational class of financial records processing was assigned to office floor-space land use, whereas the occupational class of teachers, counselors, and librarians was assigned to institutional floor-space land use. Some occupational classes could not be assigned, in their entirety, to a single land use class. In some instances, individual occupational classes were assigned to one of several land uses on the basis of the particular industrial class. For example, the occupational class of motor vehicle mechanics and repairers was assigned to commercial land use when the industrial class was automobile repair, services, and parking and to TCU land use when the industrial class was road transportation. In addition, when grouping occupational classes (as for industrial classes), the amount of employment in the class was considered as well as unique relationships between occupational class and land use class that would require special treatment. The result of this work was a general matrix of industrial classes by occupational

classes. The cells themselves had no identification beyond an industrial class and an occupational class.

The next task to be performed was to assign a land use class to each cell wherever that was judged to be possible. First addressed were the industrial classes in which all employment could justifiably be assigned to a single land use class, for example, finance or hospital. For each such industrial class, each of the cells forming that industrial class's matrix row would be assigned to office land use or institutional land use, as was appropriate (Figure 2). Next, for each occupational class that was assigned entirely to one land use class, all cells in that occupational class column of the matrix would be assigned to that land use class except where the cell had already been given a land use class because of its industrial class. For example, the computer programmers occupation was assigned to office land use except for cells belonging to an industrial class—for instance, hospitals—that already had an overall land use class, in that case, institutional. Figure 3 illustrates that step. The third step assigned a land use class to each matrix cell that was yet unassigned but that could be assigned a land use class on the basis of the characteristics of that particular industry-occupation combination. Motor vehicle mechanics and repairers is an example of this cell-by-cell assignment. Figure 4 shows this step. The remaining cells of the matrix had no assigned land use class.

### Assigning Land Use Classes to Small-Area Decennial Census Employment Data

The resulting general matrix was still a cross-tabulation of industrial classes by occupational classes. However, the majority of cells in the matrix had now been assigned land use classes. The matrix was then used to assign employment to land use classes by individual TAZ. The assignment was made separately for each industrial class. (However, workers of any industrial class who worked at home were assigned to residential land use. Such workers played no further role in the land use assignment procedure.) Within each industrial class, the employment in each cell for which a land use class had been assigned was summed by land use class, and the plurality land use class was identified. All employment in the given industrial class, including that in cells for which a land use class had not been assigned in the general matrix, was then reassigned to that plurality land use class. The result is shown in Figure 5. The special tabulation made it possible to assign the plurality land use class of the given industrial class of the given zone to workers in that industrial class in that zone. Land use class became an additional dimension of the cross-tabulation. All data items that were part of the cross-tabulation then could be cross-tabulated by land use class. For example, it is now possible to create an employment-to-household conversion matrix using land-use-based employment

	OC1	OC2	...	...	...	...	...	...	OC39									
IC1																		
IC2																		
...																		
...																		
Finance										Office								
...																		
...																		
...																		
...																		
Hospital	Institutional																	
...																		
IC74																		

FIGURE 2 Assignment of land use class by industrial class.

classes, which Putman characterized as “extremely difficult if not impossible.” Use of the census special tabulation in conjunction with SEMCOG’s land use class assignment procedure adds the missing land use dimension to census data. In a sense, it is as if the decennial census had included a question on the land use class of the employed person’s workplace.

**CURRENT STATUS OF WORK**

**Application of Method**

Some general results of applying the land use classification method to decennial census employment data are

shown in Table 1. The industrial classes are the eight that SEMCOG has used in its current Regional Development Forecast (RDF). Construction employment is excluded. The land use classes are the six described in this paper.

Among the noteworthy points are the following:

- All eight industrial classes include employment in office land use;
- Office land use is the single most important class, comprising about two-fifths of all employment;
- Commercial, industrial, and institutional land use each equal roughly one-fifth of total employment;
- Aside from the finance, insurance, and real estate (FIRE) industrial class (which except for at-home workers is assigned to office land use), all seven other indus-

	OC1	OC2	...	Financial records processing	...	Teachers, counselors & librarians	...	...	OC39
IC1				Office		Institutional			
IC2				Office		Institutional			
...				Office		Institutional			
...				Office		Institutional			
...				Office		Institutional			
...				Office		Institutional			
...				Office		Institutional			
...				Office		Institutional			
...				Office		Institutional			
...				Office		Institutional			
IC74				Office		Institutional			

FIGURE 3 Assignment of land use class by occupational class.

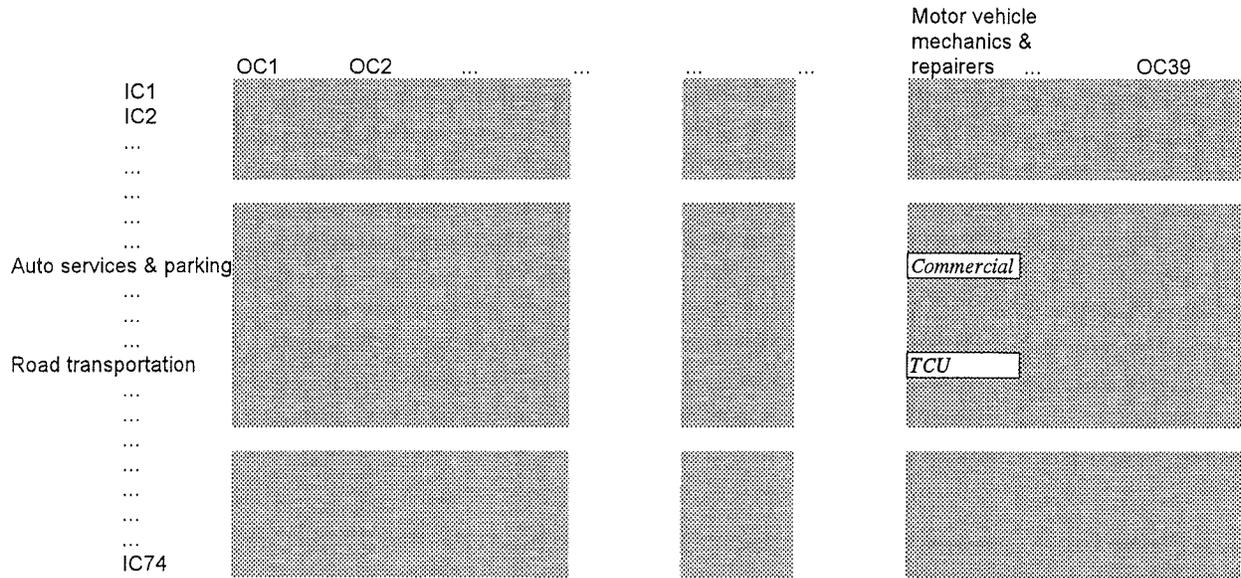


FIGURE 4 Assignment of land use class by individual cell.

trial classes contain significant portions of employment in more than one land use class.

The last point is especially significant in that it illustrates the serious distortions that can be involved in assigning all the employment in a given industrial class to a single land use class; for example, manufacturing to industrial, retail to commercial, services to office. In addition, because establishments of a given land use class tend to gather together and at the same time avoid establishments of unlike land uses, the percentage distributions of Table 1 cannot, of course, be applied to small-area data on employment by industrial class. In actuality, most employment in a given nonresidential land use class will be concentrated within a minority of

zones. Such spatial concentrations reflect the locational needs, compatibilities, and incompatibilities of the basic nonresidential land use classes and have very little to do with industrial class per se.

Multitenant office buildings provide a striking example of the primacy of land use class in the locational patterns of jobs. Such buildings can contain workers of any and all industrial classes, and the mix of industrial classes changes as some tenants move out and others move in. However, as long as overall occupancy rates stay about the same, the functioning of the buildings, including their traffic-generating characteristics, remains basically the same.

For the just-completed forecast, SEMCOG used the EMPAL model to project changes in employment by in-

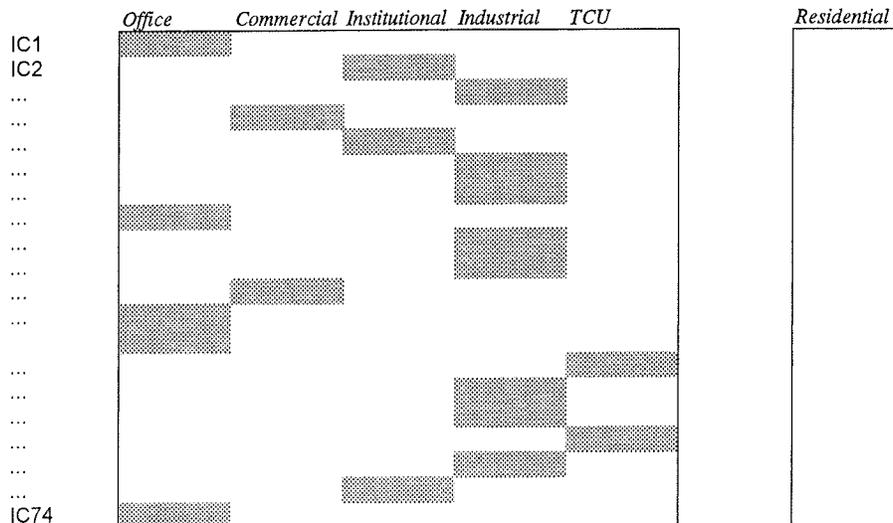


FIGURE 5 Reassignment of plurality land use class to small-area employment.

TABLE 1 1990 Census Place-of-Work Employment Data by Industrial Class Assigned to Land Use Class

Industrial Class	Employment (%) by Land Use Class						Totals
	Office	Commercial	Institutional	Industrial	TCU <sup>a</sup>	Residential	
Natural Resources	21.0	53.9	0.0	3.1	0.0	21.9	100.0
Manufacturing	31.6	--- <sup>c</sup>	0.0	67.6	0.0	0.8	100.0
TCU <sup>a</sup>	42.1	--- <sup>c</sup>	0.0	0.3	56.7	0.9	100.0
Wholesale Trade	71.7	0.1	0.0	26.0	0.0	2.2	100.0
Retail Trade	9.1	88.9	--- <sup>c</sup>	0.7	0.0	1.2	100.0
FIRE <sup>b</sup>	98.0	0.0	0.0	0.0	0.0	2.0	100.0
Services	32.3	16.7	42.2	0.1	--- <sup>c</sup>	8.6	100.0
Public Administration	65.2	0.0	34.4	0.0	0.0	0.5	100.0
All Industries	36.0	23.8	17.3	15.6	3.0	4.3	100.0

<sup>a</sup> Transportation, Communications, and Utilities.

<sup>b</sup> Finance, Insurance, and Real Estate.

<sup>c</sup> Less than 0.05 percent.

Note: Row percentages may not add to 100.0, due to rounding.

Source: Southeast Michigan Council of Governments

dustrial class for the period 1990 to 2020. Job changes were forecast by medium-sized areas called forecast districts. A separate procedure was then used to allocate these changes to the TAZs into which the districts are subdivided. Vacant holding capacity, the number of jobs that can be accommodated on currently vacant land planned for future nonresidential uses, is one of the inputs to the allocation method. However, plans for the future development of land are of course in terms of land use classes rather than industrial classes. By transforming census employment data at the zonal level into industrial class by land use class matrixes, it has been possible to translate the EMPAL forecast of change in employment by industrial class into a forecast of demand for future development by land use class. Currently SEMCOG is investigating the possibilities of directly forecasting employment by land use class subsequent to a conversion of census employment data from industrial class to land use class.

### Testing of the Method

Concerning the testing of the method, the greatest problem is that no other set of small-area employment data by land use class exists for Southeast Michigan with which to compare the results. The one quantitative comparison that has been possible to date is with data on employment by land use class collected in SEMCOG's 1994 household travel survey. Table 2 compares the two data sets. Considering the differences in data collection method, date, and coverage area, the two sets of numbers are quite close. In addition, visual comparisons have been made using maps of 1990 existing physical land use; generally excellent correspondence was found between those patterns and zone-level census employment data by land use class. Other possibilities for testing and improving the method using Southeast Michigan data

are being explored. However, full testing and refining of the assignment method would require the creation of special tabulations of census data in several other metropolitan areas. Ideally, these selected areas would have circa-1990 lists of establishments (by name, address, SIC code, and number of employees) to which land use class had been or could be added.

The major apparent limitation of SEMCOG's land use assignment method involves the occurrence of establishments of the same industrial class but different land use class within the same zone, for example, one or more restaurants and the administrative office of the restaurant chain. In its current form, the assignment method would identify the plurality land use class and then assign all employment in the industrial class (eating and drinking places) to either commercial land use or office land use. With further work, it should prove possible (in instances of larger employment numbers) to use the occupational distribution to disaggregate the restaurant employment from the office employment and assign them to separate land use classes. With smaller numbers, the "usual" land use class, for example, commercial for the industrial class of eating and drinking places, would be automatically assigned without reference to the occupational mix. In the meantime, this limitation appears to cause no more than minor misclassification.

In summary, SEMCOG has obtained a special tabulation of 1990 census data on employment by zone of work. A method has been developed that uses the industrial class in conjunction with the occupational class of workers in this file to assign the workers to a land use class and to make this land use class a dimension of the cross-tabulation. This in turn allows other demographic data items contained in the cross-tabulation to be organized and analyzed by land use class. The special tabulation used in conjunction with the land use assignment method represents a significant extension of the usefulness of decennial census employment data.

**TABLE 2 Comparison of Employment by Land Use Class,  
1990 Census and 1994 SEMCOG Household Travel Survey**

<u>Employment (%) by Land Use Class</u>		
Land Use Class	1990 Census	1994 Travel
Survey		
Office	36.0	33.4
Commercial	23.8	19.8
Institutional	17.3	18.8
Industrial	15.6	18.8
TCU <sup>a</sup>	3.0	2.4
Residential	4.3	6.9
Totals	100.0	100.0

<sup>a</sup> Transportation, Communications, and Utilities.

Note: Percentages may not add to 100.0, due to rounding.

Source: Southeast Michigan Council of Governments

## INDISPENSABILITY OF CENSUS EMPLOYMENT DATA

### Impetus for Creating Employment-Land Use Classification Method

A method to assign land use classes to decennial census employment data has been described. The impetus to create such a method was the desire to extend census data via a new dimension, land use class, and thereby connect census data with both the spatial distribution of nonresidential land uses and the locational determinants that underlie these patterns.

The decennial census is by far the single most important source of information on employed persons and jobs and their interrelationships. First, the census describes the nature of the employment itself: labor force status, workplace location, travel to work, hours worked, and kind of job activity. Second, the census contains data on a multitude of other, non-job-related characteristics of workers. These characteristics include basic facts not only about individual persons (including age, sex, race, marital status, and educational attainment), but also about the workers' households (size, relationships, presence of children, income, among others) and housing (structure type, size, cost, vehicles available, etc.).

But because census data do not include the land use class of the employed person's workplace, it has been impossible to link this unmatched wealth of demographic data with the variety of noncensus physical data about workplaces, including building type, floor space, acreage, and assessed value. Furthermore, as Putman

has explained, the lack of a land use dimension in decennial census data has meant that demographic forecasting for a variety of applications, including transportation planning, has been seriously handicapped. Demographic forecasting, of course, cannot be done without census data, the richest source of information on both workers and nonworkers. However, the absence of a land use dimension has meant that worker characteristics in census data cannot be connected to a prime locational determinant of jobs, that is, the land use classes of the establishments that contain the jobs. The land use classification method described in this paper provides the link between workers, with all their census-determined characteristics, and establishments by land use class.

### Recommendations for 2000 Census

To conclude, a proposal for incorporating land use class assignment into the procedures for the 2000 census has been presented. As illustrated in Figure 6, this work would be done in three phases. First, census place-of-work data would be improved through the correction of geocoding errors and the use of a new procedure to allocate ungeocodable workers. This phase would combine efforts of the Census Bureau and urban and transportation planning agencies. Second, the Census Bureau would use an improved version of the assignment method to give each individual worker a workplace land use class. Third, the Census Bureau would incorporate this land use attribute into a variety of census files and products, including the parent file and the CTPP.

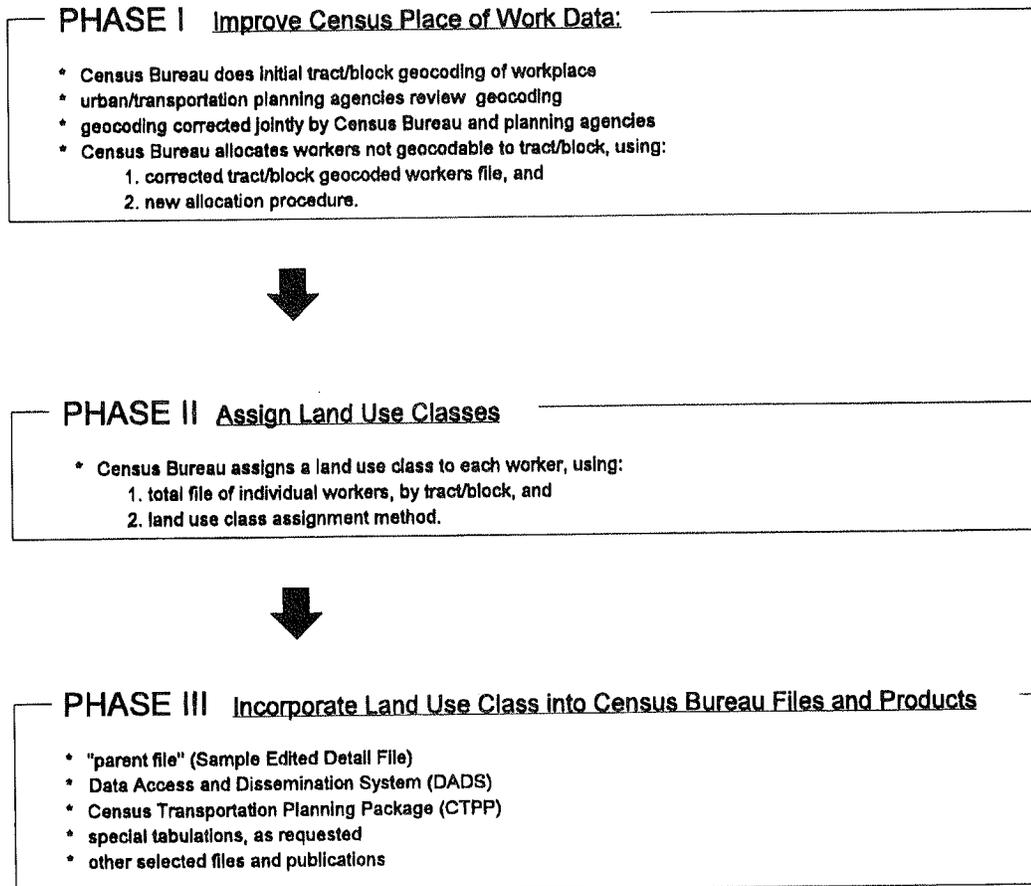


FIGURE 6 Proposal for incorporating place-of-work land use class into procedure for 2000 census.

The 2000 census would ask no question about the land use of the workplace. Nevertheless, through the incorporation of the land use assignment method into the overall census procedure, land use class would become a 2000 census answer.

#### ACKNOWLEDGMENT

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In addition, special thanks are due the Southeast Michigan Council of Governments for their generous support of this project.

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# Uses of Census Data in Transportation Planning: San Francisco Bay Area Case Study

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This case study is an update of a resource paper prepared for the 1994 Conference on Decennial Census Data and Transportation Planning. It focuses on the uses of census data in transportation planning activities in the nine-county San Francisco Bay Area. Attention is paid to the use of decennial census data in various planning analysis activities, including general descriptive analyses, estimation of disaggregate and aggregate travel demand models, market segmentation in travel demand model forecasting systems, and the validation of demographic and travel model simulations. The discussion covers where the census data are critical for the application and where the census data are desirable but perhaps not required for the application. The various census products that are used in the Bay Area—the standard Summary Tape Files, the Public Use Microdata Sample, the Census Transportation Planning Package, and special tabulations—are discussed within the context of the various planning analysis activities occurring in the Bay Area. Recommendations and expectations for Census 2000 are provided.

In this case study the uses of census data in transportation planning activities in the nine-county San Francisco Bay Area are discussed. From an institutional perspective, this covers the uses of census data in the Metropolitan Transportation Commission (MTC), a metropolitan planning organization (MPO); the Association of Bay Area Governments (ABAG); state agencies such as

the California Department of Transportation (CalTrans); various transit operators in the region; and local county and city planning, public works, and congestion management agencies. The primary focus is on census activities at MTC and ABAG, with reference to other creative work under way at the county and transit operator levels.

This study also serves as an update of a resource paper (1) for the 1994 Conference on Decennial Census Data for Transportation Planning that examined the use of census data in several major metropolitan areas, including the Bay Area, using published reports covering 1970 through 1994. This paper will focus on Bay Area applications as well as new uses of census data in the region between 1994 and 1996.

In terms of census products used in the Bay Area, the case study will cover the use and application of data from standard Census Bureau products such as the Summary Tape Files (e.g., STF1A, STF3A); the Public Use Microdata Sample (PUMS); special products from the Census Bureau and the U.S. Department of Transportation such as the Census Transportation Planning Package (CTPP), including the Statewide Element (CTPP/SE) and the Urban Element (CTPP/UE); and special Census Bureau data files purchased by the MTC and the Santa Clara County Center for Urban Analysis.

Following this introduction, the application of census data in several categories will be reviewed, including descriptive analysis, model estimation, market segmentation for travel forecasting systems, model validation,

and miscellaneous transportation applications. The paper concludes with a set of recommendations and expectations for Census 2000. This last section is essentially a strategic assessment of the decennial census in terms of the strengths and weaknesses of census data, the opportunities for improvement, and the danger of not getting what is needed to maintain analytical tools and data bases for transportation planning.

## DESCRIPTIVE ANALYSIS

In the context of this paper, the term "descriptive analysis" refers to the reports, working papers, summary data files, spreadsheets, maps, press releases, trend reports, newsletters, and so on, related to the dissemination of information from the decennial census. In the Bay Area these analyses have traditionally been in the form of place-level or county-level profile reports (all the information from certain census files, say, STF1A, STF3A, or CTPP/SE) or working papers (more in-depth discussion and trend analysis of census data).

Information systems and technology is a rapidly evolving field, and it is apparent that a new era of data dissemination is also evolving. Although in the past the most common means of dissemination was the hard copy or "dead tree-and-ink" issuance of census data re-

ports, the future (and current) nature of data dissemination involves online, perhaps even real-time provision of data needed in planning activities.

A good example of the use of new information technology for data dissemination is the World Wide Web (WWW) page developed by ABAG (Figure 1), which allows the user to pick any of some 140 places in the Bay Area and any of a set number of topical reports to pull up predeveloped profile reports. This rather straightforward WWW interface with choices such as "Pick Place," "Pick Topic," and "View Data" may likely be superseded in the years to come with more elaborate data-on-demand query-and-display setups that provide the data analyst with exactly those data needed for the analysis at hand.

The issue of access to computers and the Internet is in part addressed by the development of the Public Access Network (PAN), an example of which is PAN Islands, hosted by government agencies such as MTC and ABAG and sponsored by a consortium of private-sector companies in the Silicon Valley (e.g., Smart Valley, Inc., Pacific Bell, 3COM, Yahoo, Surf-Watch, and Arthur D. Little) (<http://www.svi.org/PROJECTS/PAN/ISLND>). The principal actors involved in public access to the Internet are local public libraries, many of which receive funds from the federal Library Services and Construction Act. Public access to the Internet via the public

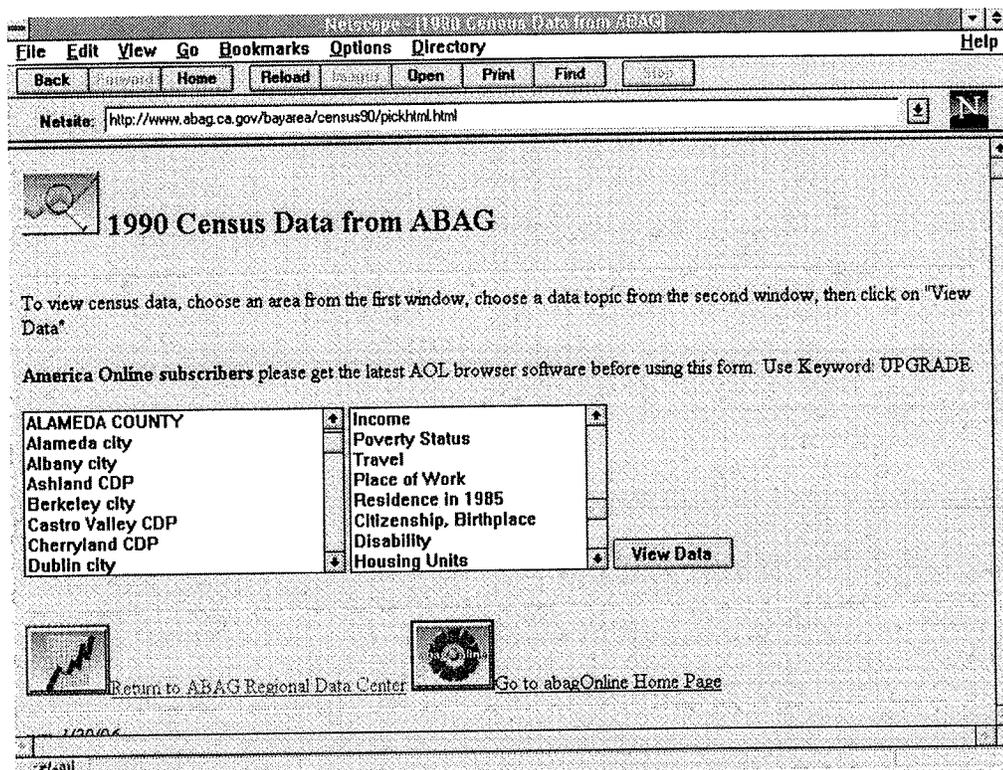


FIGURE 1 Association of Bay Area Governments World Wide Web page: 1990 census data.

library system is critical to ensure universal access to census information.

Many clients and patrons still prefer the paper-and-ink versions of census reports. In the Bay Area, this need is fulfilled by a comprehensive set of profile reports developed by the regional data center for the Bay Area, ABAG, and a set of transportation-related working papers authored by the staff at the MTC. A list of these MTC 1990 census working papers is provided in Table 1 and in the references (2-12).

As alternatives to the hard-copy working papers disseminated by MTC, electronic versions of these working papers and spreadsheets as well as special electronic publications (13-15) have been developed (Table 2). MTC Electronic Publications 1 and 2 provide comparisons of place-to-place commuters using data from the 1980 census Urban Transportation Planning Package (UTPP) and the 1990 CTPP. Electronic Publication 3 is MTC's version of area-level profile reports using place-level data from the CTPP/SE. These place-level profiles were only issued in electronic format, giving a 13-page profile report for 140 places in the Bay Area, for a grand total of 1,820 pages of information included in 7.9 megabytes of data files.

The need and value of these types of descriptive census reports, electronic or otherwise, should not be underestimated. They serve a vital role in informing the public, the media, policy makers, and planning professionals on many of the most relevant demographic and travel characteristics needed for public policy development. The census working papers have been some of the best-received products issued by MTC and have been of great assistance to librarians and the public information staff at MTC and throughout the Bay Area.

Looking toward the future, it is unlikely that MTC or others will completely abandon the practice of issuing major paper-and-ink reports on census data. It is highly probable, on the other hand, that the rapid changes in information technology will greatly enhance the ability of planners to electronically disseminate and exchange census and other planning data bases with clients and partners.

## MODEL ESTIMATION

The previous resource paper (1) provides a fairly detailed discussion on the use, or potential misuse, of census data for estimating demographic and travel models. New applications and insights for the period from 1994 to 1996 will be reported on here.

It bears repeating that the best sources of data for the estimation of travel demand models are household travel surveys. Survey data are essential, disaggregate data that should provide the transportation planner with the necessary input for the estimation and calibration of demographic and travel demand models. Decennial census data can, at best, be used in the estimation of household-level models to predict number of workers in the household or automobile ownership levels (16), or perhaps in the estimation of other types of aggregate travel models. For model validation, on the other hand, decennial census data form a critical and invaluable data base for the aggregate validation of various demographic and travel behavior models.

Two new examples of use of census data in model estimation are efforts at MTC in estimating aggregate trip-end mode share models and work in progress

TABLE 1 Metropolitan Transportation Commission 1990 Census Working Papers: 1992-1996

Working Paper No.	Data Source	Date	Title
1	STF1A	April 1992	Bay Area Population Characteristics
2	STF3A	August 1992	Bay Area Travel and Mobility Characteristics
3	STFS-5	December 1992	County-to-County Commute Patterns in the SF Bay Area
4	STFS-5	January 1993	SF Bay Area Interregional County-to-County Commute Patterns
5	CTPP/SE, Part C	April 1993	The Journey-to-Work in the SF Bay Area
6	STF3A	October 1993	Disability, Mobility Limitation and Self-Care Limitation Status
7	CTPP/UE, Part 3	March 1994	Detailed Commute Characteristics in the SF Bay Area
8	CTPP/UE, Part 3	May 1994	Detailed Interregional Commute Characteristics
9	CTPP/SE, Part A,B	September 1994	SF Bay Area: County & Regional Profiles
10	CTPP/UE, Part 4	April 1995	SF Bay Area Detailed Household Characteristics
11	STP-214	January 1996	SF Bay Area Commuters by Household Income Characteristics

TABLE 2 Metropolitan Transportation Commission 1990 Census Electronic Publications: 1992-1996

Electronic Pub. No.	Data Source	Date	Title
1	CTPP/SE; UTPP	April 1993	Bay Area Place to Place Journey-to-Work Characteristics
2	CTPP/SE; UTPP	March 1994	Bay Area Place to Place Journey-to-Work Spreadsheets
3	CTPP/SE	September 1994	SF Bay Area: Place-Level Profiles

at the Santa Clara County Center for Urban Analysis (SCCCUA) in estimating aggregate logit work-destination-choice models stratified by household income quartile.

### Trip-End Mode Share Models for Predicting Bicycle and Walk Commuters

One set of new trip-end mode share models developed at MTC are aggregate regression models estimated on zone-level shares of bicycle and walk commuters at the zone of residence and the zone of work (17). The models predict the percentage of workers who commute via bicycle or walk modes based on aggregate zonal characteristics such as employment density, share of multifamily dwelling units of total units, local workers-job balance within the traffic analysis zone, and dummy variables to reflect proximity to the university campuses in Stanford and Berkeley. Typical mode share models are estimated using zone-to-zone network levels of service and related demographic and land use characteristics. Typical mode share models are either logit in form or of the "diversion curve" style that was popular in the 1960s. The reason behind the development of these atypical, aggregate zone-level trip-end-based models is concern that there are too few sample walk and bicycle trips in the 1990 MTC household travel survey. Of the 18,300 sample total home-based-work trips in that survey, only 478 (2.6 percent) were by the walk mode and just 222 (1.2 percent) were by bicycle. Such a small and sparse data set on walk and bicycle commuters may prove a challenge in the model estimation process. The final decision on whether to use aggregate trip-end mode share models or a disaggregate trip interchange mode choice model depends

on current work in progress at the MTC to estimate best-practice nested work-trip mode choice models.

### Aggregate Work-Destination-Choice Models

Another example of travel model estimation using census data is the ongoing effort at SCCCUA to estimate aggregate logit work-destination-choice models. These logit destination-choice models are estimated separately by household income quartile using data from a special census file purchased from the Census Bureau by MTC and SCCCUA. This file, denoted STP-214 (Special Tabulation Product) by the Census Bureau, provides one cross-tabulation of block-group-to-block-group workers (within the nine-county Bay Area) stratified by 12 categories of means of transportation to work by four household income levels (annual household income less than \$25,000; \$25,000 to \$45,000; \$45,000 to \$75,000; and greater than \$75,000). MTC's analysis of this special tabulation product is included in Census Working Paper 11 (12). Work at SCCCUA on these aggregate work-destination-choice models will be completed in 1996.

Comparisons of regional average and median trip length (in miles) and average and median commute duration (in minutes) is shown in Table 3; these data show a notable increase in work commute duration and length with increasing household income levels, an indicator that supports the notion for an income-stratified work trip distribution (destination) choice model.

### TRAVEL MODEL MARKET SEGMENTATION

One of the challenges in travel demand forecasting is the use of disaggregate travel demand models in the aggre-

TABLE 3 Mean and Median Average Commute Length and Commute Duration by Household Income Quartile, 1990 Census, Special Tabulation Product 214: Regional Totals for San Francisco Bay Area

Income Quartile	Median Distance (mi)	Mean Distance (mi)	Median Time (min)	Mean Time (min)
< \$25,000	5.87	9.50	14.8	18.0
\$25,000-\$45,000	7.71	11.57	16.8	20.2
\$45,000-\$75,000	9.33	13.13	18.2	21.8
> \$75,000	9.94	13.46	18.9	22.5
TOTAL	8.58	12.37	17.6	21.1

gate prediction of travel behavior. Methods of aggregation fall into three principal categories: the "naive" method, market segmentation, and sample enumeration (18). In a nutshell, the naive method assumes that everyone in a traffic analysis zone has the same characteristics: for example, each household has the same number of workers, the same income, and the same number of persons. Zonal mean values are used exclusively in this method.

The market segmentation method assumes that there are distinct subgroups within each traffic analysis zone, for example, households by automobile ownership level, by workers in the household, or by household income level. In the market segmentation method, the analyst assumes that the average household size, the average workers per household, and so forth, is the same within each subgroup by each zone.

The third aggregation method, sample enumeration, does not use any group or subgroup mean of any input variable. Instead, the disaggregate model is applied at the disaggregate (i.e., household, person, or trip) level, and then the predictions are aggregated for reporting purposes. The sample enumeration technique is also known as microsimulation, where the forecasting of travel or other activity behavior is made at the discrete individual level rather than at the zone level.

At the MTC, use of market segmentation is a key feature of the aggregate forecasting system in place and under redevelopment (19). Also, sample enumeration is used at MTC for special analyses, such as evaluating the effectiveness of transportation control measures (20).

To apply disaggregate models in a market segmentation framework, analysts at MTC have used the 1980 and 1990 census Public Use Microdata Sample (PUMS) data bases as supplementary inputs to the model application process. Census PUMS data are critical because they provide information the analyst needs to adjust the input model parameters (e.g., household size, household income, percent multifamily) by the desired market segmentation. PUMS data are used because standard census products such as the STF3A or the CTPP do not provide

the necessary data at the traffic analysis zone level or any other geographic level.

MTC has a nested workers-in-household-automobile-ownership (WHHAO) choice model. This model splits the households residing in a traffic analysis zone into households by three levels of workers in the household (0, 1, 2+ workers/HH) and by three automobile ownership levels (0, 1, 2+ vehicles/HH). The input market segmentation to the WHHAO model is households by household income quartile. This means that the outputs of the WHHAO model application are the number of households in each traffic analysis zone stratified by household income (four), by workers in the household (three), by automobile ownership level (three), or 4 market segmentations into the model and 36 market segmentations coming out of the model application.

One of the input variables to the WHHAO model is average household size. Rather than zonal average household size, the census PUMS data are used to adjust zonal average household size to zonal average household size stratified by household income level because low-income households (less than \$25,000 per year) are smaller in size than higher-income households. PUMS data are used to develop county-level (or PUMA-level) adjustment factors, which are then multiplied by the zonal average household size to yield zonal average household size by household income quartile. County-level household size by income quartile and adjustment factors are summarized in Tables 4 and 5.

An example calculation follows: the North Beach traffic analysis zone in San Francisco has an average household size of 1.719 persons. Using the San Francisco County adjustment factors, it is estimated that the average low-income (Quartile 1) household in North Beach has an average household size of 1.361 persons ( $1.719 * 0.792$ ); the average medium low-income (Quartile 2) household has an average household size of 1.709 ( $1.719 * 0.994$ ); the average medium high-income household has an average household size of 2.020 ( $1.719 * 1.175$ ); and the average high-income household in North Beach has an average household size of 2.228

TABLE 4 Average Household Size by Household Income Quartile by Bay Area County, 1990 Census Public Use Microdata Sample, 5 Percent Sample

County	Income Q 1	Income Q 2	Income Q 3	Income Q 4	Total
San Francisco	1.808	2.269	2.682	2.958	2.283
San Mateo	1.905	2.452	2.965	3.216	2.644
Santa Clara	2.185	2.593	3.067	3.341	2.816
Alameda	2.034	2.487	3.008	3.239	2.582
Contra Costa	2.043	2.428	2.950	3.170	2.638
Solano	2.261	2.927	3.231	3.417	2.867
Napa	1.906	2.547	2.974	2.992	2.495
Sonoma	1.874	2.616	3.050	3.098	2.543
Marin	1.713	2.171	2.526	2.796	2.333
REGION	1.997	2.492	2.968	3.196	2.610

TABLE 5 Household Size Adjustment Factors by Household Income Quartile by Bay Area County, 1990 Census Public Use Microdata Sample, 5 Percent Sample

County	Income Q 1	Income Q 2	Income Q 3	Income Q 4	Total
San Francisco	0.792	0.994	1.175	1.296	1.000
San Mateo	0.721	0.927	1.121	1.216	1.000
Santa Clara	0.776	0.921	1.089	1.186	1.000
Alameda	0.787	0.963	1.165	1.254	1.000
Contra Costa	0.774	0.920	1.118	1.202	1.000
Solano	0.789	1.021	1.127	1.191	1.000
Napa	0.764	1.021	1.192	1.199	1.000
Sonoma	0.737	1.029	1.199	1.218	1.000
Marin	0.734	0.931	1.083	1.199	1.000
REGION	0.765	0.955	1.137	1.225	1.000

persons (1.719 \* 1.296). Thus, the subgroup mean household size in North Beach ranges from 1.361 to 2.228 persons. The naive method would just use the zonal mean household size of 1.719.

The adjustment factors used in the market segmentation process could also be developed using data from local household travel surveys. The problem will be the reliability of these factors based on typically too few sample observations in the small-scale household travel survey. For example, the 1990 Bay Area household travel survey provides sample data on 10,800 households. The 1990 census PUMS 5 percent sample includes disaggregate data on 108,500 Bay Area households. A valuable research project would be to calculate the standard errors of these adjustment factors comparing regional travel surveys, such as the 1990 Bay Area travel survey, with the 1990 census PUMS-based adjustment factors.

## DEMOGRAPHIC AND TRAVEL MODEL VALIDATION

One of the basic uses of census data is for the aggregate validation of demographic and certain travel demand models. *Validation* is the process of comparing predicted values with "observed" values and making the necessary adjustments (calibrations) to each of the component models to produce a valid model simulation. The decennial census data serve a most valuable purpose as an independent, observed estimate of various demographic and travel behavior characteristics. The following is a list of various uses of census data in demographic and travel model validation:

1. Workers in household models can be validated against CTPP/UE data at the regional, county, superdistrict, district, and traffic analysis zone levels.
2. Automobile ownership level models can be validated against CTPP/UE data at the regional, county, superdistrict, district, and traffic analysis zone levels.

3. Analysts can convert the zone-to-zone commuter matrixes, derived from Part 3 of the CTPP/UE, into observed home-based-work person trips using trips-per-worker conversion factors. Home-based-work trip generation (production) and trip attraction models can be validated against these CTPP-derived observed home-based-work trip tables at the regional, county, superdistrict, district, and traffic analysis zone levels.

4. Home-based-work trip distribution models can be validated against CTPP-derived observed home-based-work person trips. In the Bay Area, the census STP-214 file can be used to calibrate and validate work trip distribution models stratified by household income quartile. The validation process for work trip distribution models should include a careful evaluation of model versus observed average trip lengths (and average trip duration) at the regional, county, superdistrict, and perhaps zonal levels; evaluation of regional trip length and trip duration frequency distributions; and evaluation of county-to-county, superdistrict-to-superdistrict, and district-to-district predicted versus observed home-based-work person trips.

5. Home-based-work mode choice models can also be validated against CTPP-derived observed home-based-work person trip tables by means of transportation. Ideally, a multiday household travel survey or employer survey is used to adjust the "usual means of transportation" typology into an "average means of transportation."

The decennial census data cannot be used for the validation of nonwork trip frequency, nonwork trip destination, or nonwork mode choice travel demand models. Given that nonwork trips may typically encompass 75 percent of a large region's travel, it is imperative that a suitably sized household travel survey be on hand for the aggregate validation of nonwork travel demand models. Also, it is very useful to have two competing sets of "observed" home-based-work data. This gives the analyst flexibility in what he or she should be validating against. If the two observed data bases (census and survey) are in

agreement over a certain statistic, that gives the analyst a general indication of confidence, or lack of confidence, in a particular census-based or survey-based estimate of work travel behavior.

### MISCELLANEOUS TRANSPORTATION APPLICATIONS

Several new applications of census data for miscellaneous transportation planning and transportation research activities in the Bay Area are worth reporting on. The first application of interest is the use of 1990 census PUMS data as part of the Bay Bridge Congestion Pricing Demonstration Project. Funded by FHWA, this demonstration project included an analysis of the demographic characteristics of Bay Bridge commuters. MTC consultants were able to extract these commuters on the basis of Public Use Microdata Area of residence and county of work. The analysis enabled MTC to understand the income and modal usage characteristics of Bay Bridge commuters in 1990 (21), or, in other words, who would be affected by a toll increase during peak travel times.

Census PUMS data have also been used by MTC staff to produce a demographic profile of persons working at home in Marin County (22). Analysis focused on the industry, occupation, earnings, sex, age, years of schooling, and hours worked "last week." The typical work-at-home person in Marin County is female and highly educated, works part-time, is self-employed, is older, and earns less than workers who commute outside the home. Male work-at-home worker earnings are 140 percent higher than female work-at-home worker earnings (\$42,500 male versus \$17,500 female). The predominant industry for work at home in Marin County is real estate, management and public relations, and professional and business services. The predominant occupation of work at home in Marin are writers-artists-entertainers and managers-administrators. The work-at-home commute share in Marin ranges from a low of 1.4 percent for government workers to a high of 25.1 percent of self-employed Marinites.

The above examples show but two of the many applications that the creative transportation planner and analyst can produce using the census PUMS data sets, which constitute one of the best transportation research data bases offered by the Bureau of the Census.

An example of transit applications using census data is recent MTC work with the Central Contra Costa Transit Authority (CCCTA) on an analysis based on a geographic information system (GIS) of the transit-dependent population in the CCCTA service area. One of the layers in MTC's GIS is local bus stops and rail stations. The analyst then used the GIS to create a buffer

zone around each bus stop to represent areas within a certain walking distance of the bus stop. The GIS program then uses a "cookie cutter" technique to split out demographic data within and outside the buffer zone. Demographic variables such as zero automobile households, population aged 62 and over, and nonworking households were used as measures of transit dependency. This technique can provide the transit market analyst with the demographic characteristics of all persons residing within walking distance of each of the CCCTA routes as well as the characteristics of those not within walking distance of any of the system routes. Similar GIS efforts are under way at other Bay Area transit agencies, including the Bay Area Rapid Transit, Golden Gate Transit, and SamTrans.

Academic researchers at the University of California at Berkeley have made significant contributions to the research literature on urban structure, commuting, residential choice, and job location choice. The most recent research on the San Francisco Bay Area is included in a working paper by Cervero and Wu (23), who provide an analysis of the polycentric commuting patterns in the Bay Area using commuter flow data from the CTPP/UE and housing price data from the STF3A data files. They find an emerging hierarchy of employment centers ranging from the San Francisco CBD to outlying suburban business parks, as well as shorter commute times to suburban employment centers.

### SUMMARY

As a summary of the San Francisco Bay Area case study, an evaluation is given of the degree to which census data were crucial or essential to MTC planning and research applications and of the possibility that these applications could have been produced using other data bases. The paper concludes with a discussion of recommendations and expectations for Census 2000.

### Evaluation of Importance of Census Data and Possibility of Substitution

#### *Descriptive Analysis*

Descriptive analyses such as the census working papers and profile reports discussed earlier are best served by a national census including a sample with data from the long-form questionnaire as well as the 100 percent count short-form data. If higher unit costs and lower accuracy are acceptable, a national survey could be conducted that would replace the Census Bureau long-form sample and perhaps could be tailored to each metropolitan area's needs. The national survey would probably cost

more than the decennial census (which costs approximately \$25 per long-form questionnaire), the sampling rates would probably be substantially lower, and the statistical variance and standard errors would be substantially higher. Given that one component of descriptive analysis is trend analysis of demographic characteristics at the small-area level (e.g., census tract or block group), a smaller national survey could not be used for trend analysis for finer grains of geography, say, below place level. This would be a critical loss for city, county, and metropolitan area planners who depend on decennial census long-form data for neighborhood-level demographic characteristics.

### *Demographic Benchmarking*

Though not discussed in this paper, one of the primary uses of census data at the metropolitan and local levels is for benchmarking of most demographic variables, including housing units, households, population, household income, and automobile ownership. Much of the most important benchmarking data is included in the decennial census long form. The census long form could be replaced by national or local demographic surveys but, as stated earlier, probably at a higher unit cost, lower sampling rates, and higher statistical variance and standard errors. In addition, total overall costs of a national survey or sets of metropolitan-area surveys could conceivably exceed the cost of conducting the decennial census long-form survey.

### *Model Estimation*

MTC and others have demonstrated the use of decennial census data in estimating demographic and travel demand models, including data on workers in the household, automobile ownership, aggregate work trip mode choice models, and aggregate work trip destination-choice models. The best data sets for demographic and travel demand models, however, are still the locally conducted household travel surveys, often conducted concurrently with the decennial census (e.g., MTC's household travel surveys in 1981 and 1990).

The utility of future decennial censuses for model estimation could be enhanced by developing a "contextual PUMS" program in which the Census Bureau would hire researchers as "special sworn employees" in order to conduct research using raw, disaggregate census microdata records within the confines of a Census Bureau research station. An example of this sort of program is a research data center opened in January 1994 in Boston to examine topics relevant to current economic issues (24, pp. 9,12).

### *Market Segmentation in Travel Models*

The decennial census is the largest, most accurate data base available to transportation planners for use in de-

termining the demographic characteristics of subgroups of the population. Census PUMS data could be replaced by national or metropolitan-area survey data, but at higher unit costs, lower sampling rates, and higher variance and standard errors. Research should be conducted to determine just how much less accurate it is to use metropolitan-area survey data as opposed to census PUMS data for market segment adjustments.

### *Demographic and Travel Model Validation*

It may sound redundant, but the decennial census is the best data base that can be used for the aggregate validation of several demographic and travel behavior models, including those of workers in the household, residential and job location choice (land use allocation models), automobile ownership level, and work trip generation, distribution, and mode choice. The decennial census cannot be used for the aggregate validation of nonwork travel behavior models, the best sources for which are metropolitan household travel surveys.

The census is used to represent observed conditions. Household travel surveys can also be used to represent observed conditions, but problems with the lumpiness and sparseness of typical metropolitan travel surveys render them quite difficult to use as aggregate validation data bases at any fine level of geography, say, district or superdistrict. With the decennial census, aggregate validation can be performed at almost any geographical level, perhaps even down to the traffic analysis zone (neighborhood) level.

It is conceivable that metropolitan areas in the United States could return to the 5 percent sample surveys that were more typical in the 1950s and 1960s. A 5 percent sample survey of the 2.465 million households expected in the Bay Area in 2000 would be approximately 123,000 sampled households. At a current dollar cost of approximately \$125 per household, this expanded metropolitan household travel survey could cost on the order of \$15.4 million in current U.S. dollars. (This is substantially more than the \$1.0 million that the Bay Area spent on the 1990 household travel survey.) A national set of metropolitan travel surveys of this size could very well cost more than any conceivable decennial census.

### *Transportation Research Applications*

The transportation planning and research community has made considerable progress in using various census products in research efforts. PUMS data have been used in analyzing markets for congestion pricing and work-at-home commuters and in analyzing the demographics of transit users in the San Francisco Bay Area. The CTPP and other standard census products are used in studies on urban structure and economic development. Certainly the microdata records from household travel surveys provide

the researcher with the most flexibility in any intended analysis. However, the decennial census data, especially the microdata files, afford the researcher the opportunity to delve into the demographic, household, and commuter characteristics of rare or hard-to-reach populations.

## Recommendations and Expectations for Census 2000

### *Maintain Census Long Form*

The census long form is critical to provide the accurate and precise data needed to support demographic analysis and transportation planning and research activities. The likely substitute, in absence of a census long form, would be a set of metropolitan travel surveys that would be more costly and less accurate than a properly conducted national census.

### *Increase Involvement of Metropolitan and Local Planners To Improve Quality of Workplace Geocoding*

Accuracy of workplace geocoding is still an issue to be reckoned with. Improvements in GIS technology will certainly help, as will a cooperative program between the Census Bureau and local persons knowledgeable about local conditions. Legal barriers that limit the involvement of local planning staffs to assist in census data processing should be liberalized to allow greater involvement of local census partners and stakeholders.

### *Develop Contextual PUMS Program To Facilitate Improved Planning Research*

In order to increase the relevance of transportation planning research, it is desirable to create a census microdata research program. This program would allow bona fide researchers the opportunity to "add value" to census microdata and prepare more in-depth research than would otherwise be possible.

### *Embrace Changes in Information Technology To Provide Better, More Relevant Data*

Rapid changes in information systems and information technology should be dealt with in terms of Census Bureau plans to collect, analyze, and disseminate decennial census data. New information technology should lessen the need for paper-and-ink publications in favor of electronic data-on-demand systems. Public access to the Internet should be a high priority to facilitate collection and dissemination of decennial census data.

Given these changes in information technology, it may not make sense to talk about improvements to the CTPP

for 2000. Things may be changing to the degree that future analysts may get what they want when they need it and how they asked for it. This type of chaotic flexibility will likely be a challenge in terms of data consistency and comparability, so the Census Bureau may need to prepare "standard" census products in order to facilitate a transition from the highly structured products of the past to the chaotic data-on-demand products of the future.

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TRANSIT



# Transit Planning Applications: Chicago Region

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Eleven different applications are described in which 1990 census data are being used in ongoing Chicago-area transit planning. The relevance of census data for each application and whether the application could have been successfully carried out without such data are also discussed.

Use of 1990 census data for transit planning purposes in the Chicago region has been varied and wide-ranging. All four agencies involved in transit operations and planning have staff with appropriate training to access and analyze census data and have made specific applications. These agencies have also been involved in locally conducted travel surveys, which may also be matched up with census data. Together these agencies have employed census data at regional, corridor-subarea, and station-route levels of planning, with associated concerns for increasing level of detail. In general, it is the flexibility of census data for use at successively finer geographic levels of aggregation that permits this broad spectrum of planning applications, from analysis of regionwide travel flows between very large districts to grouping of census tract data around specific stations or transit routes.

Tables 1 and 2 summarize 11 different applications of 1990 census data in ongoing Chicago-area transit planning over the last few years. In general, these examples represent most of the applications revealed in a survey of the staff involved at each agency, though a few in-

complete or exploratory analyses of various kinds have been omitted. On other planning fronts, each of these agencies, as well as the Northeastern Illinois Planning Commission (NIPC), is also using census data in the exploration and development of geographic information system (GIS) applications, using several different software packages. In fact, the extensive knowledge and use of both census files and GIS systems in the NIPC regional planning program has allowed the commission to provide valuable assistance to other agencies in the region, including transit operators.

In Table 1 the objectives and planning issues addressed in each of the 11 examples are summarized. Objectives range from establishing a basic regional-level data base for understanding changes in multimodal travel demand between 1980 and 1990 to very localized analyses of work trip origin-destination patterns in the vicinity of specific commuter rail stations or bus and rail routes. In the localized examples, use of census data has also been an integral element in feasibility studies for station relocation or route-level service expansion, particularly in suburban portions of the region. Both the work trip file in the Census Transportation Planning Package (CTPP) and the demographic data in the Census Bureau Standard Tape Files have been employed in analyzing central business district (CBD) and non-CBD work travel patterns, including reverse commute patterns. The Chicago region is still focused mainly on its central area; significant radial corridor transit services are provided,

TABLE 1 Chicago Transit Planning Examples: Objectives and Planning Issues Addressed

<b>REGIONAL</b>			
<b>Example</b>	<b>Transit Agency</b>	<b>Objective</b>	<b>Planning Issues Addressed</b>
10-District Transit Origin-Destination Flow Analysis	Regional Transportation Authority (RTA)	Compare relative changes between 1980-90 in CTPP work trip flows between ten major districts.	Relative changes in travel demand, by mode, 1980-90: Implications for service/facility improvements.
Central Business District Modal Market Shares, By Work Trip Origin Zone	RTA	Analyze 1980-90 shifts in market share, by mode, for CBD work trips originating in outlying zones (city and suburbs).	Relative change in travel demand, by mode, for work trips specifically oriented towards the Central Business District: Implications for service/facility improvements.
Commuter Rail Station Area Market Shed Analysis	Metra (Commuter Rail Operator)	Analyze population, households, and employment in uniquely defined market sheds centered around each commuter rail station in region: 1980, 1990, 2010 forecast.	Relative change in demographic variables generating travel demand, 1980-90-2010: Implications for transit service/station change.
Suburban Bus Transit Marketing Plan	Pace	Analyze 1980, 1990, and projected 2000 work trip volumes, for Suburb-to-Suburb, City-to-City, Suburb-to-City, and City-to-Suburb markets.	Relative change in market size and Pace ridership potentials: Implications for marketing and service improvements.

<b>CORRIDOR/SUB-AREA</b>			
<b>Example</b>	<b>Transit Agency</b>	<b>Objective</b>	<b>Planning Issues Addressed</b>
Non-CBD Work Trip Origins: Selected Suburban Work Centers	RTA	Analyze distribution of home end of non-CBD work trips, as input to suburban transit feasibility analyses.	Ridership potential associated with proposed suburban bus routing/service improvements.
Near North Side Reverse Commuting: Distribution of Work Trip Destinations	RTA	Analyze distribution of trip destinations (non-CBD, outbound) for three major residential zones, near north side of Chicago.	Potential for improved feeder bus service to attract additional commuter rail riders in reverse commute direction.
Rapid Rail Transit Corridor Market Analyses: Orange and Blue Lines	Chicago Transit Authority (CTA)	Compare results of recent on-board passenger survey against related census travel and demographic variables, for geographically defined market sub-areas.	Defining future marketing and promotional strategies intended to increase ridership on CTA's O'Hare Line and Midway Line.
Bus Service Market Analysis: Northwest Corridor	CTA	Compare results of passenger on-board travel survey with related census travel and demographic variables, for one-mile and six-mile wide market sheds straddling key bus routes.	Define service adjustment and marketing strategies to better match ridership potentials with bus route service levels.

with morning-outbound and evening-inbound excess capacity that offers further ridership potential.

Table 2 summarizes the relevance of census data for each application and whether the application could have been successfully carried out without census data. In some cases, primary interest was focused on the CTPP data file, either for origin-destination flow patterns or for examination of the geographic distribution of work

trip origins or destinations. Market segmentation analyses tied to geographic subareas defined by agency-conducted rider surveys have been an important component of market research that utilizes census demographic data. In two instances, both associated with commuter rail service and station feasibility analyses, rider or license plate surveys were also conducted that supported the analysis to the extent that the census data applica-

TABLE 1 (continued)

<b>ROUTE/STATION</b>			
<b>Example</b>	<b>Transit Agency</b>	<b>Objective</b>	<b>Planning Issues Addressed</b>
Commuter Rail Station Feasibility Analysis, DuPage County	Metra	Analyze distribution of CBD-bound work trips in vicinity of proposed new commuter rail station in Wheaton, Illinois	Ridership potential associated with proposed new commuter rail station: station feasibility.
Commuter Rail Express Service Analysis: Distribution of Work Trip Origins Destined for CBD	Metra	Analyze distribution of 1990 and 2010 households along commuter rail line, in support of proposed addition of express service run.	Feasibility of proposed expanded parking capacity at selected stations along route.
Urban Core Bus Route Profiles: Atlas	CTA	Develop Atlas of key travel and census variables for census tracts within one-mile band straddling each of 125 bus routes in CTA service area.	Provide data base useful for examining feasibility of future proposed service adjustments, in relation to rider demographics and travel patterns.

tion was supplemental. In all of the other examples, however, comparable travel survey or other demographic data were not available from other sources, which reflects particularly the much larger geographic scale associated with these examples.

An important result of most of the applications was simply to establish a data base for ongoing planning efforts at the regional and corridor-subarea levels. Findings were also employed, however, in evaluating specific service change proposals, developing marketing programs, and making build or no-build decisions on rail transit stations. Figures 1 and 2 and Table 3 give examples of output from two of the regional applications.

Figures 3 and 4 and Table 4 similarly offer output illustrations for two of the corridor-subarea applications. Finally, Figures 5 and 6 represent similar examples for route and station planning applications.

## REGIONAL EXAMPLES

### Ten-District Analysis of Transit Origin-Destination Flow

Broad-brush shifts between 1980 and 1990 in major work trip flows between 10 "superdistricts" comprising

TABLE 2 Chicago Transit Planning Examples: Census Data Utilization, Results, and Findings

<b>REGIONAL</b>				
<b>Example</b>	<b>Transit Agency</b>	<b>Relevance of Census Data</b>	<b>Possible Without Census Data</b>	<b>Results, Findings</b>
10-District Transit Origin-Destination Flow Analysis	Regional Transportation Authority (RTA)	CTPP Work Trip Origin-Destination Flows.	No: Comparable Work Trip Origin-Destination Data not available from local travel surveys.	Data base for ongoing planning efforts.
Central Business District modal market shares, by work trip origin zone	RTA	CTPP Work Trip Origin-Destination Flows.	No: Comparable Work Trip Origin-Destination Data not available from local travel surveys.	Data base for ongoing planning efforts.
Commuter Rail Station Area Market Shed Analysis	Metra (Commuter Rail Operator)	Small-Area Demographic Data: Aggregate to market areas.	No: Comparable Small-Area Demographic Data not available from other sources.	Data base for ongoing planning efforts.
Suburban Bus Transit Marketing Plan	Pace	CTPP Work Trip Origin-Destination Flows.	No: Comparable Work Trip Origin-Destination Data not available from local travel surveys	Data base for ongoing planning efforts; 1996 Marketing Plan

(continued on next page)

TABLE 2 (continued)

<b>CORRIDOR/SUB-AREA</b>				
<b>Example</b>	<b>Transit Agency</b>	<b>Relevance of Census Data</b>	<b>Possible Without Census Data</b>	<b>Results, Findings</b>
Non-CBD Work Trip Origins: Selected Suburban Work Centers	RTA	CTPP Work Trip-Ends: Origins.	No: Comparable Work Trip Origin-Destination Data not available from local travel surveys.	Selected suburban bus service bus options evaluated.
Near North Side Reverse Commuting: Distribution of Work Trip Destinations	RTA	CTPP Work Trip-Ends: Destinations.	No: Comparable Work Trip Origin-Destination Data not available from local travel surveys.	Shuttle bus proposal under development.
Rapid Rail Transit Corridor Market Analyses: Orange and Blue Lines	Chicago Transit Authority (CTA)	Small-Area Demographic Data: Aggregate to Market Sub-areas. Small-Area CTPP Travel Data.	No: Comparable Small-Area Demographic Data not available from other sources.	Marketing program under development.
Bus Service Market Analysis: Northwest Corridor	CTA	Small-Area Demographic Data: Aggregate to Market Sub-areas. Small-Area CTPP Travel Data.	No: Comparable Small-Area Demographic Data not available from other sources.	Data base for ongoing planning efforts.

<b>ROUTE/STATION</b>				
<b>Example</b>	<b>Transit Agency</b>	<b>Relevance of Census Data</b>	<b>Possible Without Census Data</b>	<b>Results, Findings</b>
Commuter Rail Station Feasibility Analysis, DuPage County	Metra	CTPP Work Trip-Ends: Origins & Destinations.	Yes: License Plate Survey at existing park-ride lots also conducted to establish trip origins.	Proposed station not to be built.
Commuter Rail Express Service Analysis: Distribution of Work Trip Origins Destined for CBD	Metra	CTPP Work Trip-Ends: Origins. Small-Area Demographic Data: Route Corridor.	Yes: Rider Survey along route also conducted to establish trip origins.	Express service implemented and retained.
Urban Core Bus Route Profiles: Atlas	CTA	Small-Area Demographic Data: Aggregate to Market Sub-areas. Small-Area CTPP Travel Data.	No: Comparable Small-Area Demographic Data not available from other sources.	Data base for ongoing planning efforts.

the entire Chicago region were investigated (1). The purpose was to derive implications for future service and facility improvement changes by mode. No comparable work trip origin-destination data are available from local travel surveys to permit such an analysis; the CTPP work trip tables were essential.

### CBD Modal Market Shares by Work Trip Origin Zone

Because the central area of Chicago is still a major concentration of regional employment, area transportation

planners have a strong interest in changes over time in the geographic pattern of work trip flows to the Chicago CBD. Here 1980-1990 shifts in market share by mode for CBD work trips were mapped and compared to explore needs for potential transit service and facility improvement (Figure 1). Again, the CTPP work trip files provided the only available data base for such an analysis (2).

### Analysis of Commuter Rail Station Marketsheds

Chicago's commuter rail operator, Metra, has divided its market area into individual commuter rail station

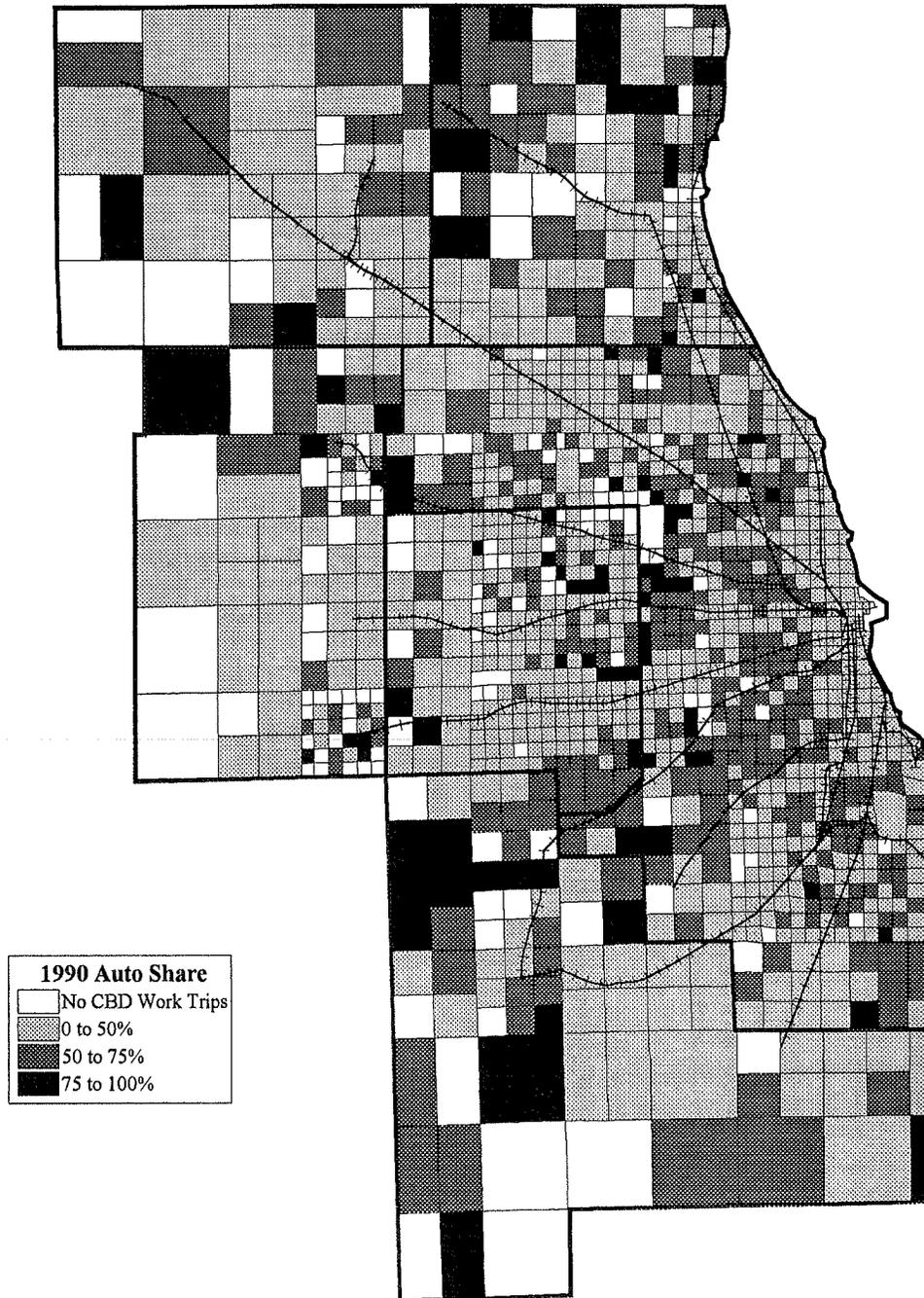


FIGURE 1 1990 CBD work trips: automobile shares by origin zones (source: 1990 census CTPP, RTA Planning Division, Oct. 1994).

marketsheds (Figure 2, Table 3). For 1980, 1990, and 2010, population, households, and employment were compared for each of these station-focused marketsheds in order to examine what types of transit service or station improvements might be most appropriate in the future. No comparable small-area demographic data sources were available to permit this analysis (3).

### Suburban Bus Transit Marketing Plan

The suburban bus operator, Pace, analyzed its extensive market area along four dimensions: suburb-to-suburb, city-to-city, suburb-to-city, and city-to-suburb (4). Work trip volumes for 1980, 1990, and projected year 2000 for these interchange types were analyzed to better understand market size changes and associated service improve-

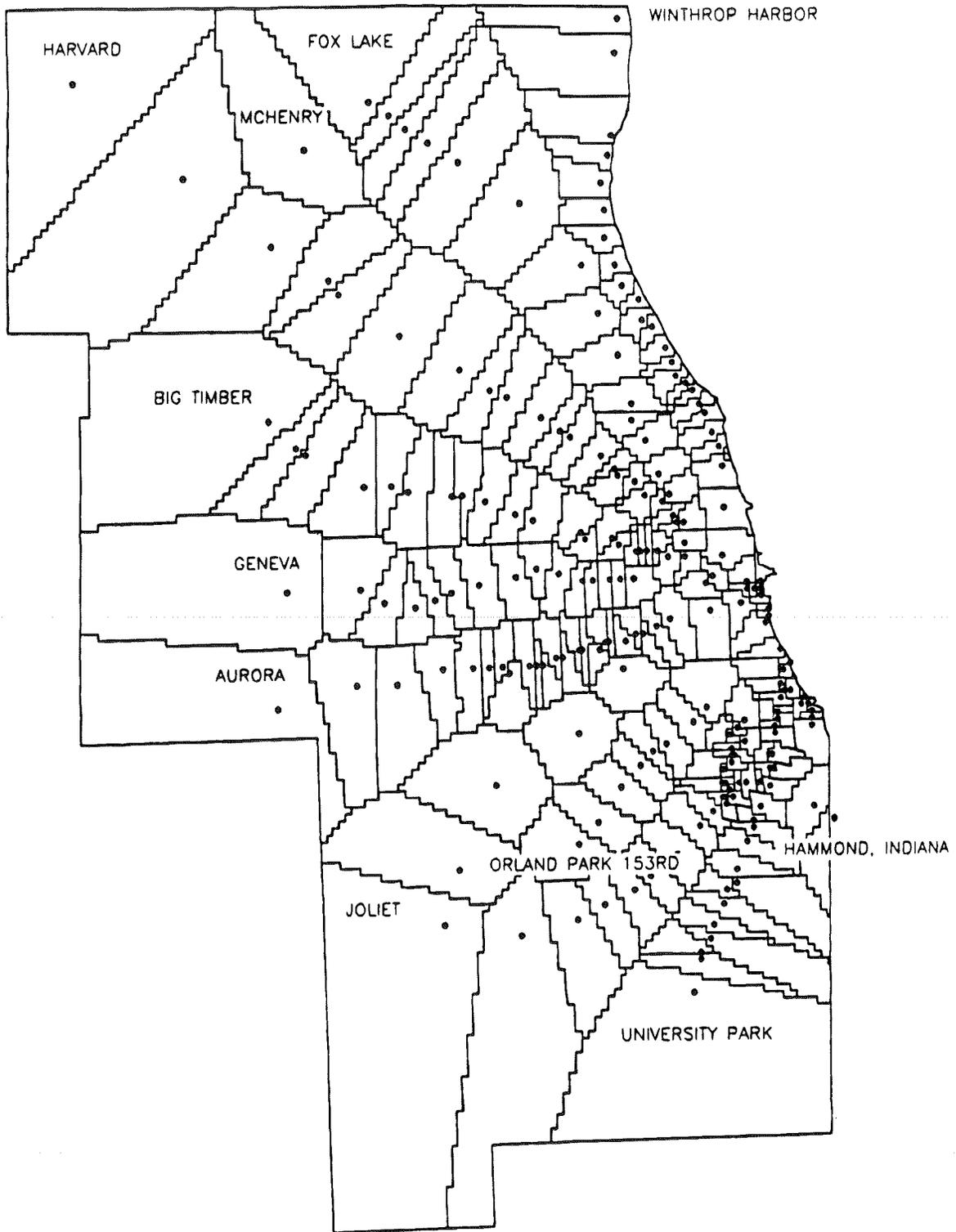


FIGURE 2 Marketshed boundaries (station locations approximate).

TABLE 3 Socioeconomic Data by Rail Station Marketshed: Households

HOUSEHOLDS BY LINE AND STATION C&NW NORTHWEST LINE	1980	1990	CHANGE 1980-1990		2010 FORECAST	CHANGE 1990-2010	
			ABSOLUTE	PERCENT		ABSOLUTE	PERCENT
CHICAGO CPT	21,199	21,615	416	2.0%	32,092	10,477	48.5%
CLYBOURN	80,596	79,120	-1,476	-1.8%	97,466	18,346	23.2%
IRVING PARK	29,093	28,007	-1,086	-3.7%	33,443	5,436	19.4%
JEFFERSON PARK	11,356	11,436	80	0.7%	10,325	-1,111	-9.7%
GLADSTONE PARK	17,065	17,282	217	1.3%	16,391	-891	-5.2%
NORWOOD PARK	8,524	8,892	368	4.3%	8,060	-832	-9.4%
EDISON PARK	13,366	13,527	161	1.2%	14,145	618	4.6%
PARK RIDGE	7,808	8,127	319	4.1%	7,995	-132	-1.6%
DEE RD	14,793	15,607	814	5.5%	15,756	149	1.0%
DES PLAINES	13,683	15,197	1,514	11.1%	15,648	451	3.0%
CUMBERLAND	10,163	10,269	106	1.0%	10,832	563	5.5%
MOUNT PROSPECT	26,897	30,290	3,393	12.6%	33,503	3,213	10.6%
ARLINGTON HEIGHTS	24,041	30,557	6,516	27.1%	33,313	2,756	9.0%
ARLINGTON PARK	19,471	23,681	4,210	21.6%	28,831	5,150	21.7%
PALATINE	26,157	37,933	11,776	45.0%	43,804	5,871	15.5%
BARRINGTON	11,031	16,488	5,457	49.5%	22,156	5,668	34.4%
FOX RIVER GROVE	10,640	13,531	2,891	27.2%	17,684	4,153	30.7%
CARY	7,951	11,243	3,292	41.4%	18,185	6,942	61.7%
CRYSTAL LAKE	11,562	15,347	3,785	32.7%	25,312	9,965	64.9%
MCHENRY (MCHENRY BRANCH)	11,259	14,020	2,761	24.5%	17,420	3,400	24.3%
WOODSTOCK	9,403	11,053	1,650	17.5%	15,029	3,976	36.0%
HARVARD	4,067	4,538	471	11.6%	4,826	288	6.3%
TOTAL	390,125	437,760	47,635	12.2%	522,216	84,456	19.3%

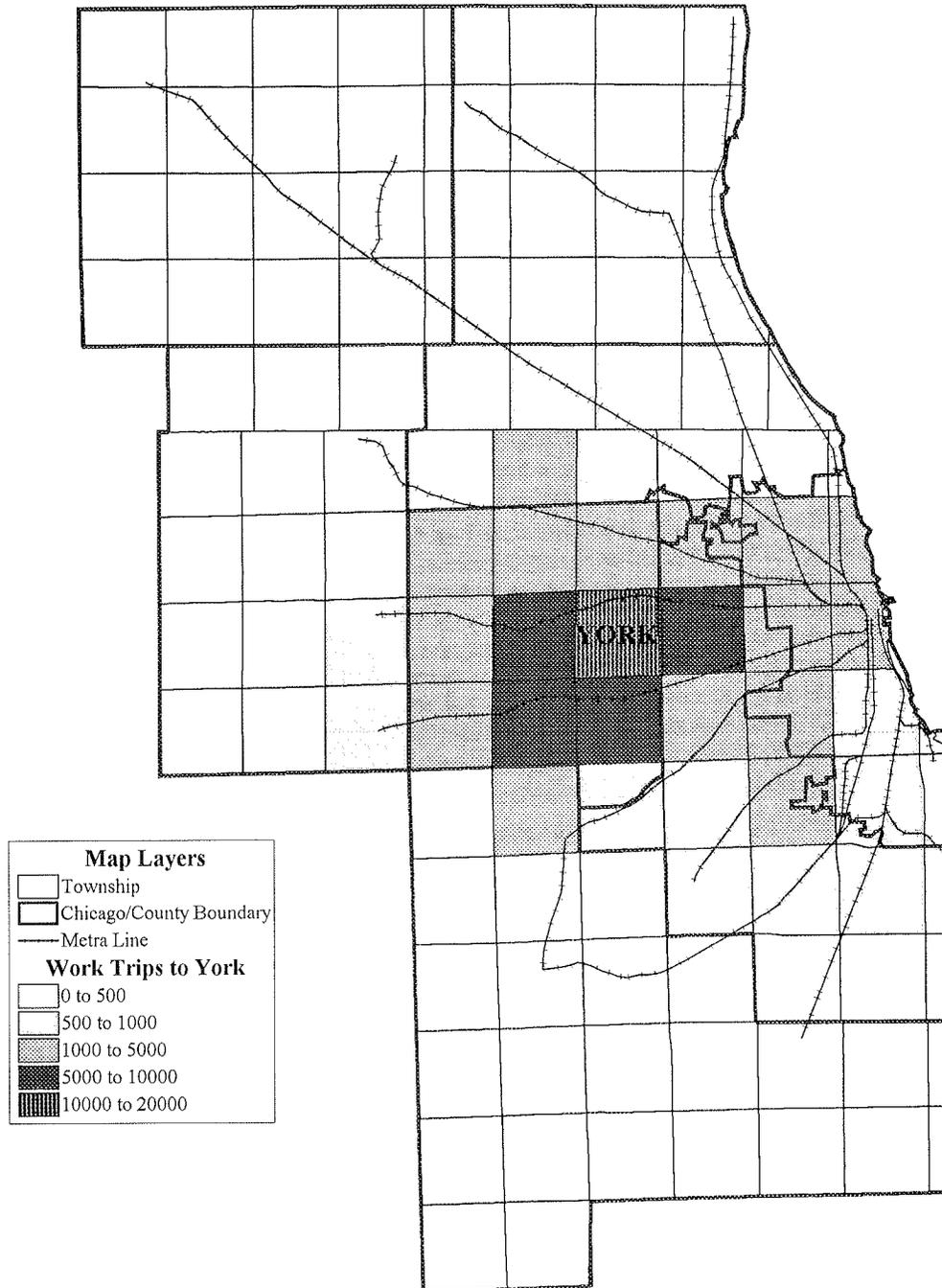


FIGURE 3 Origins of 1990 work trips to York township.

ment implications. CTPP work trip origin-destination flows were the only available data source for the analysis.

#### CORRIDOR-SUBAREA EXAMPLES

##### Non-CBD Work Trip Origins for Selected Suburban Work Centers

In order to facilitate suburban transit feasibility analyses for proposed bus route and service improvements, CTPP work-

trip-end data files for trip origins were analyzed (Figure 3) (2). The distribution of the home end of non-CBD work trips to outlying employment concentrations was mapped. Again, these data are not available from local travel surveys.

##### Work Trip Destinations for Near North Side Reverse Commuting

For three major residential zones of relatively high density on the near north side of Chicago, it was known that re-

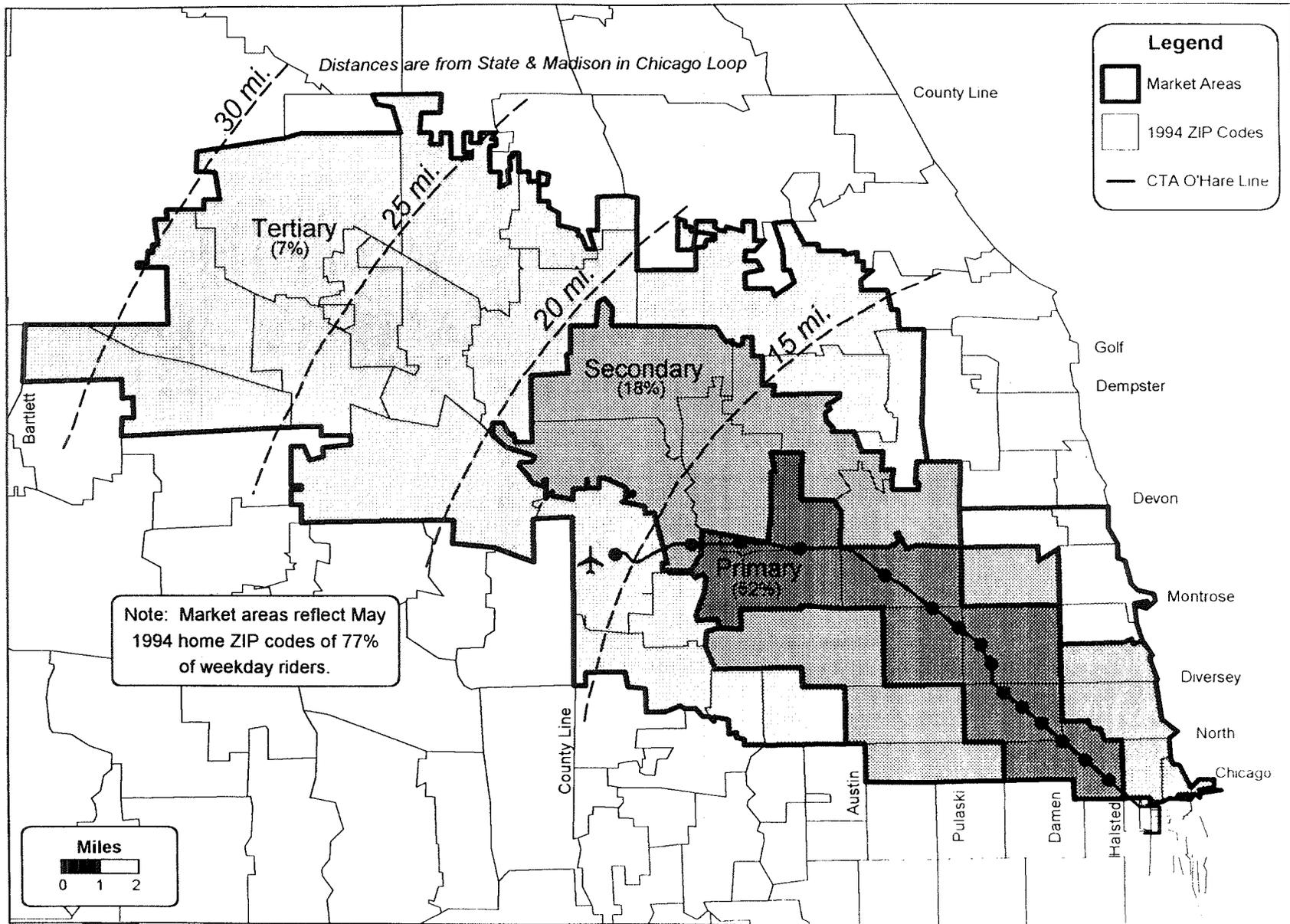


FIGURE 4 Market area geography: 1994 ridership survey.

TABLE 4 1990 Mode of Transportation to Work: O'Hare Corridor

Mode of Transportation	Core	% of Core	Secondary Sub-Area	% of Secondary	Tertiary Sub-Area	% of Tertiary	Market Area Totals	% of Market Totals
Drove Alone	103,647	51.95%	180,877	51.78%	267,824	68.80%	552,348	58.88%
Carpooled	32,370	16.23%	40,993	11.73%	40,031	10.28%	113,394	12.09%
Bus	28,028	14.05%	52,077	14.91%	24,904	6.40%	105,009	11.19%
Subway/'L'	17,636	8.84%	30,195	8.64%	18,126	4.66%	65,957	7.03%
Railroad	1,745	0.87%	4,928	1.41%	13,818	3.55%	20,491	2.18%
Taxicab	310	0.16%	5,318	1.52%	1,109	0.28%	6,737	0.72%
Walked	10,746	5.39%	24,986	7.15%	13,109	3.37%	48,841	5.21%
Work/Home	3,140	1.57%	8,038	2.30%	8,130	2.09%	19,308	2.06%
Other	1,877	0.94%	1,936	0.55%	2,206	0.57%	6,019	0.64%
<b>TOTAL WORK TRIPS</b>	<b>199,499</b>	<b>100.00%</b>	<b>349,348</b>	<b>100.00%</b>	<b>389,257</b>	<b>100.00%</b>	<b>938,104</b>	<b>100.00%</b>

NOTE: Percentage columns may not total exactly to 100.00% due to rounding.

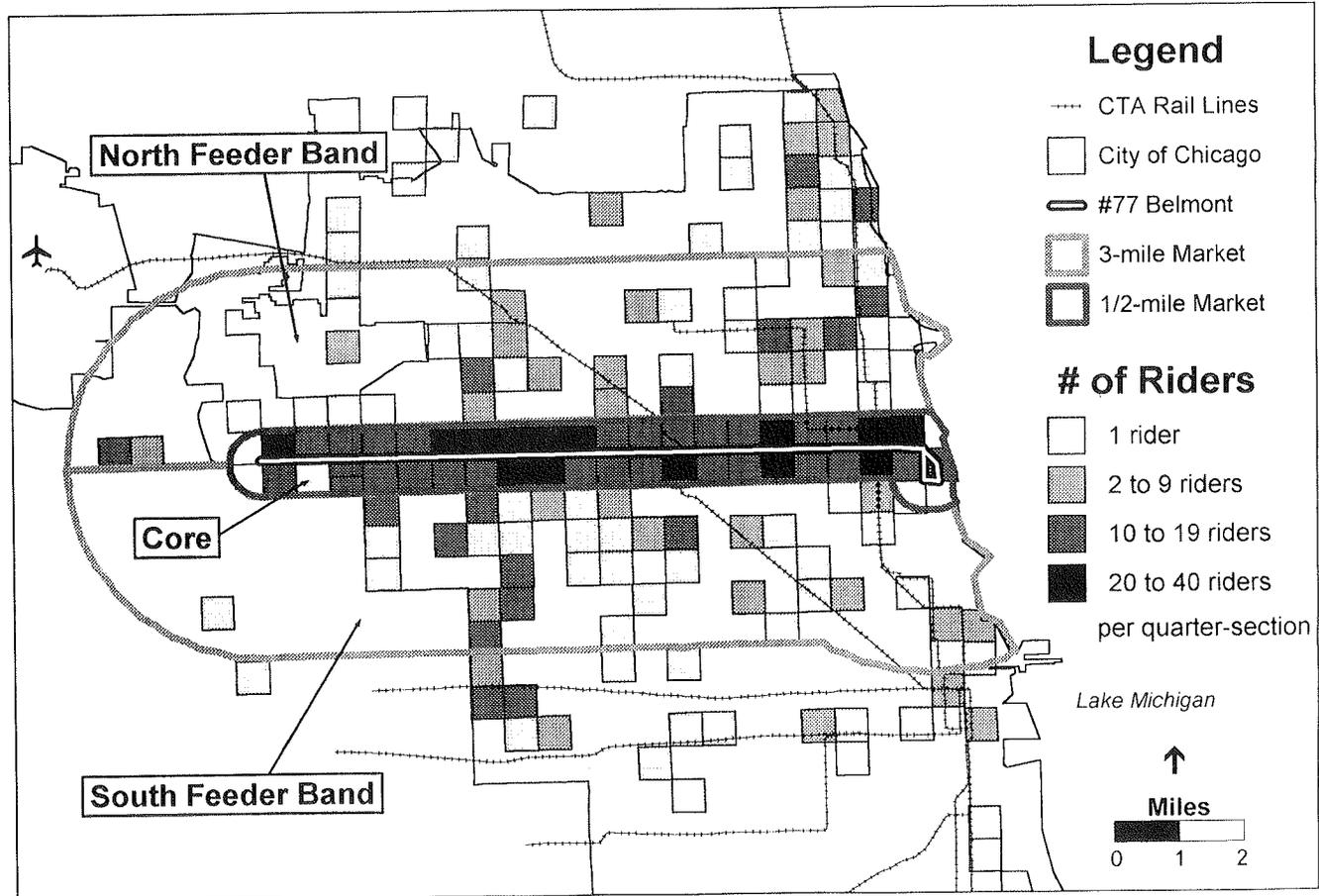


FIGURE 5 Market area for CTA Belmont bus route: rider origins.

verse commute travel linkages to the northwest sector were an important travel pattern. Analyzing CTPP work-trip-end (destination) files for these zones permitted the distribution of these reverse commute flows to be matched against potential feeder bus service improvements intended to allow these commuters to utilize commuter rail in the reverse direction. Shuttle bus proposals were under active development at the time of the analysis (5).

### Rapid Rail Transit Corridor Market Analyses

Results from recent on-board passenger surveys in two major travel corridors served by the Chicago Transit Authority (CTA) Orange and Blue lines were matched against small-area demographic and CTPP travel data for geographically defined market subareas (Figure 4, Table 4). The purpose was to gain a better understanding of these subareas in the design of future marketing and promotional strategies intended to increase ridership on the two rail lines. Both CTPP and demographic census data were essential in defining the overall community-based benchmark for interpreting the passenger surveys (6).

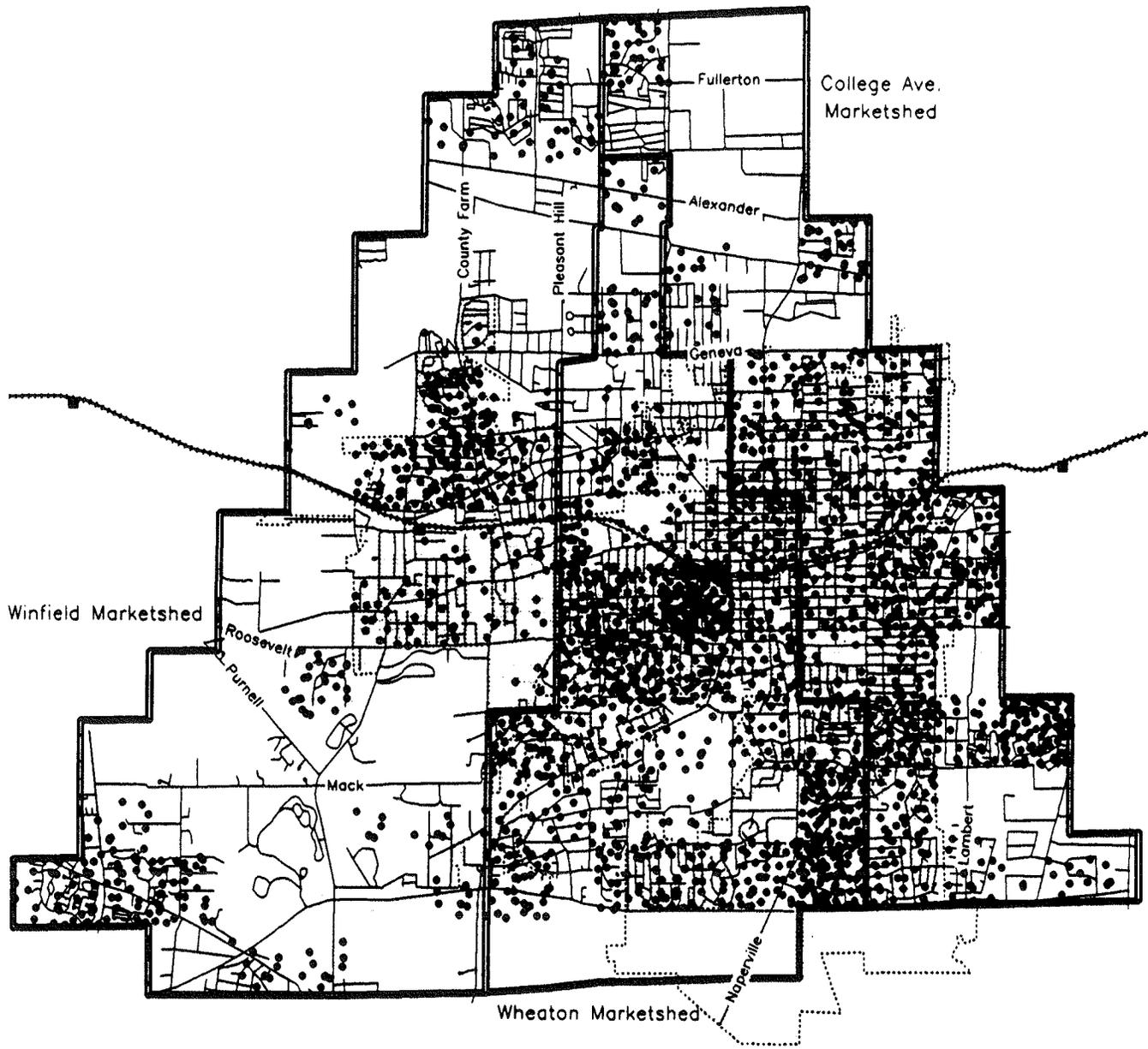
### Bus Service Market Analysis in Northwest Corridor

Again the results of a major passenger on-board travel survey were matched against related census travel and demographic variables (7) in order to better understand geographically defined marketsheds straddling five key bus routes (Figure 5). Assistance in the definition of service adjustment and marketing strategies to better match ridership potentials with bus route service levels was the objective. The small-area demographic data utilized were not available from other comparable local sources.

### ROUTE AND STATION EXAMPLES

#### Commuter Rail Station Feasibility Analysis for DuPage County

A new commuter rail station was proposed in Wheaton, Illinois, in association with a major county office center. A geographic-based analysis of ridership potentials associated with this new station was conducted through the analysis of CBD-bound work trips generated in



**Legend**

- Marketsheds
- Municipalities
- Metra Rail
- Lines
- Lines
- Lines
- Metra Stations

**Data Displayed**

- = One Worker using Metra

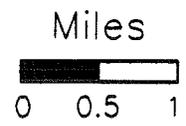


FIGURE 6 Residential quartersections of CBD workers who use Metra (source: 1990 CTPP).

the vicinity of the proposed station (Figure 6) as well as locally destined work trips (reverse commute potentials). CTPP work trip ends (origins and destinations) provided one data base, as did a license plate survey at existing park-ride lots serving the nearest commuter rail stations (on two lines); both were used to analyze the distribution of work trip ends. In part on the basis of this analysis (8), the proposed station will not be built.

### **Commuter Rail Express Service Analysis: Distribution of Work Trip Origins Destined for CBD**

A proposed service expansion along a commuter rail route led to associated proposals for expanded parking capacity at selected stations along the route. To project potential ridership growth, CTPP work-trip-end (origins) analyses were conducted in association with analysis of the distribution of 1990 and forecast 2010 households along the route. Both the CTPP file and a license plate survey at existing park-ride lots were used to establish the geographic pattern of present trip origins (9).

### **Atlas of Urban Core Bus Route Profiles**

Small-area demographic and CTPP data can be aggregated to route-specific market profiles for each of 125 bus routes serving the CTA market area. Using a GIS data base, an atlas of key travel and census variables has been assembled for census tracts within a one-mile band straddling each of these routes. The

atlas will be utilized in ongoing planning efforts and could not have been developed from other data sources (10).

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# Changes over Time in Transportation Mode for Journey to Work: Effects of Aging and Immigration

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The changing commuting behavior of immigrants in Southern California is studied. Using 1980 and 1990 census data, trends in transportation mode are analyzed for cohorts of immigrants defined by age and recency of arrival in the United States. Cohorts are further identified by sex and race-ethnicity. The study finds that recent immigrants are far more reliant on public transit, but after they gain an additional 10 years of residence in the United States, their transit use falls markedly. The change is especially sharp in the case of women, who increase their rate of solo car driving noticeably. The implication is that sustained high immigration bolsters the ridership base of public transit and reduces traffic congestion.

Transportation behavior varies markedly by demographic characteristics, as is well known. The present paper adds two elements to current knowledge. The main contribution is a focus on the role of immigration in shaping commuting behavior. Immigrants are characterized by sex, age, and race-ethnicity, as are native-born citizens, but their commuting behavior systematically differs from that of their native-born counterparts. Immigration researchers, who are largely sociologists or labor economists, have addressed many social and economic differences of immigrants, but to date none has addressed travel behavior.

Immigration is the subject of a comprehensive study under way at the University of Southern California. The

first report issued from the study, *The Changing Immigrants of Southern California* (1), addressed the characteristics of immigrants upon arrival in the United States, naturalization to U.S. citizenship, growth in English language proficiency, occupations, and poverty and income trajectories over time. The present paper is drawn from the second project report, *Transportation, Housing, and Urban Planning Implications of Immigration to Southern California*, principally Section 3 (2). Immigrants' differences and changes in travel behavior turn out to be among the most interesting of all the topics addressed in the overall study.

A second contribution of the present paper is its application of a new methodology for addressing change over time, one that is rooted in maximizing the information value of census data. Census data are essential because the study covered immigrants over time in Southern California, not in the nation, and thus national surveys of transportation, economic, or social behavior could not be used.

The present analysis illustrates the potential insights into longitudinal change that can be gained from cohort analysis with census data. Cohort analysis is a specialized use of census data that provides deeper insights into longitudinal change. An age group in one decade can be linked to the age group that is 10 years older in the next decade. Differences in behavior measured between these two observations reflect the aging of the cohort. This often gives insights that are very different from those

gained in a single survey year. Immigrants have an extra dimension of behavior, namely, the length of time they have resided in the United States and their degree of assimilation during that time. Research on immigrants is forced to consider their travel behavior within the temporal framework of an evolving career that is advancing over both a life cycle and an adjustment period following their arrival in the United States.

The new methodology, termed "double cohort" analysis, was presented by Myers and Lee (3). In this paper only the graphic expression of cohort trajectories is used, a tool invaluable for visualizing complex changes as well as a very useful method for communicating with policy makers and the public. The cohort trajectories also can be represented in a multivariate statistical framework that relies on multidimensional interaction terms. Logit models employed by Myers and Lee (3) permit the introduction of controls for income, education, or other traits likely to determine transportation behavior. Although only mode choice in the journey to work is addressed in this discussion, the outcome variables could be extended to a number of other transportation-related topics, including travel time, number of vehicles available, housing choices, and location.

Census data are indispensable for this analysis. As explained more fully elsewhere (4), census data are collected at regular intervals in a systematic coverage in which comparable questions are asked of a large sample, even the entire population. With these data, reliable investigations of change over decade intervals can be conducted for any local area in the United States. Such questions of change over time are central to most policy issues or other social inquiries. The transportation topic illustrates the value to be gained by exploiting the available census data. It is hoped that Census 2000 will collect data that are comparable in scope and quality to those in 1990 and 1980. Without those data, trends of the 1990s or a comparison of the 1990s trends with those of prior decades cannot be measured reliably.

To preview the findings of the paper, immigrants are far more likely than are those who are native born to use public transit and far less likely to drive alone to work [single-occupant vehicles (SOVs)]. In fact, recent immigrants account for over 40 percent of all transit users in Southern California. Immigrants show far more modest consumption of transportation services and far less per capita impact than do native-born residents. One would expect that the rapid increase in immigration would swell the number of public transit riders and thereby relatively decrease road congestion. Surprisingly, transit use has grown much more slowly than the number of workers in the region, and SOVs have surged ahead. The cohort analysis shows that transit usage, although higher for recent immigrants, plunges over time as they assimilate into Southern California life-style and econ-

omy. (Carpooling also decreases markedly.) Conversely, solo driving rises markedly, especially among women and in certain age ranges.

Transportation planners face a dilemma. They have been striving to attract new riders to transit systems, knowing that if ridership can be increased, service can be expanded and fares lowered. In this positive scenario, more people would find the bus a desirable alternative, which would take drivers off the road, lessen congestion, and improve air quality. As will be shown, immigrants play a major part in the effort to build a constituency for mass transit. Planners have also been trying to boost the number of carpoolers in hopes that higher occupancy levels will also reduce road congestion and air pollution.

However, as immigrants advance economically and adapt to the California life-style, they appear to abandon the buses and join the mainstream, who drive to work. More of them even drive solo, reducing their carpooling over time. The dilemma is that planners may wish to help immigrants assimilate into the middle class, but to do so, the data indicate, would undermine efforts to preserve transit ridership and reduce road congestion. Immigrant success in pursuing the American Dream has inevitable transportation consequences.

Only by closely analyzing census data across two decades can the dynamics of transportation behavior within the context of immigrants' evolving life cycles and careers be fully understood. In turn, the comparison of these immigrants with their native-born counterparts holds a mirror to the rest of society, promoting a better understanding of the transportation behavior of all segments of the diverse U.S. population.

## BACKGROUND

A very large body of literature exists about people's travel behavior. Unfortunately, none of this vast literature addresses the specific issue of immigrants. Instead, people are classified by their employment status, type of housing in which they live, sex, family status, age, and income. The literature is also generally cross-sectional; that is, people's travel behavior is studied at a moment in time, or comparisons of behavior at two different moments are sought. Apparently little effort has been made to connect people's behavior over time in a representation of travel careers. Thus, the application of an immigrant cohort model may shed new light on trends in travel behavior.

Pisarski (5) provides a comprehensive and systematic overview of travel behavior in the United States. Population trends, trips by men and women per capita, and average trip length combine to produce total person-miles of travel. In turn, that total travel demand is translated into vehicle-miles of travel (measuring road space

consumed) by factoring in decisions about alternative modes of travel such as mass transit, carpooling, or solo car driving.

In 1990, 20.1 percent of all personal travel in the United States was made up of trips to and from work (6). Travel to work is the centerpiece of travel behavior because many other trips are often chained together as part of the journey to and from work (such as stops at the dry cleaners or the grocery store). Also, travel to work often occurs at peak hours, contributing to congestion and drawing special attention from transportation planners.

During the course of the 1980s, transportation planners were frustrated by several nationwide trends. First, the number of vehicles on the road increased faster (+17.4 percent) than the population grew (+9.7 percent). At the same time, the number of persons driving to work alone (SOVs or solo drivers) grew by 35 percent. Meanwhile, the number of persons using public transit declined by 1.7 percent, and the number of carpoolers fell by some 19.3 percent. As a result of these divergent growth trends, public transit in 1990 accounted for only 5.3 percent of all work trips, whereas SOVs rose to nearly three-fourths of all trips (6, Table 2). Similar trends were found in the Los Angeles region between 1980 and 1990, with by far the largest increase in persons who drive alone, but Pisarski (6, p. 27) notes that the region resisted the decline in carpooling better than most other areas.

Behind the rise in solo driving to work and the decline in transit usage lies a story of increasing gender equality. Women's rising labor force participation has been the major factor in workforce growth, and these women have rapidly increased their rate of solo driving in a convergence with that of men. At the same time, women have reduced their dependence on public transit, which was historically greater than that of men. Here is another dilemma for the transportation planner: to encourage gender equality or to preserve the base of transit ridership?

As will be seen, immigration status—whether U.S. native born or length of residence in the United States—constitutes another important dimension for analysis of transportation behavior. To date, very little has been written on this topic. As part of the broader study of immigrants' progress in Southern California, immigrants' commuting patterns and their changes over time will be studied in depth.

## DATA FOR ANALYSIS

Persons who report being employed during the week before the census are asked the following questions: "How did this person usually get to work LAST WEEK? If this

person usually used more than one method of transportation during the trip, fill the circle of the one used for most of the distance." Also, those who traveled by car, truck, or van were asked, "How many people, including this person, usually rode to work in the car, truck or van LAST WEEK?" These questions were included on the long-form version of the census questionnaire, with responses collected from about one in eight persons who were employed the week before the census (4, Chap. 4).

Immigration effects are analyzed by classifying commuters according to their place of birth and year of arrival in the United States. Persons born abroad of U.S. parents or born in outlying territories of the United States (such as Puerto Rico) are treated as native born. The foreign-born commuters are further classified by their answers to the following question in the census: "When did this person come to the United States to stay?" Although a number of detailed categories are provided for answers, the responses have been grouped into decades of arrival: 1980-1990, 1970-1979, 1960-1969, and before 1960. Immigrants arriving in the decade before the census are termed "recent arrivals." Particular attention will be given the recent arrivals before 1980, identifying the 1970-1979 immigration cohort also in the 1990 census to learn how much their commuting behavior has changed after an added 10 years in the United States.

The data source used for the present analysis is the Public Use Microdata Sample (PUMS), File A, which amounts to a 5 percent sample of all persons. This file consists of approximately one-third of all the long-form questionnaires collected by the census. Comparable data were assembled for both 1980 and 1990 for the study region—the broad Southern California region consisting of the seven southern counties ranging from Ventura to San Diego.

Figure 1 presents the basic pattern of responses in both 1980 and 1990 by recent immigrants in Southern California; the responses of men are distinguished from those of women and the three main race-ethnicities are compared. In general, the patterns are broadly similar between the two census years. Concentrating on 1990, Latinos of both sexes are much less likely than whites or Asians to commute solo by car. Although their greater dependence on carpooling and walking or cycling to work is readily apparent, the greatest difference appears to be in their transit usage. Fully 13 percent of men and 26 percent of women rely on public transit, principally the bus (7). This transit usage rate is two to four times that of Asians or whites of the same sex.

Figure 2 presents comparable data for native-born men and women of the same race-ethnicities. Solo car driving is much more common among the native born, and transit use is far lower. This difference is true of both

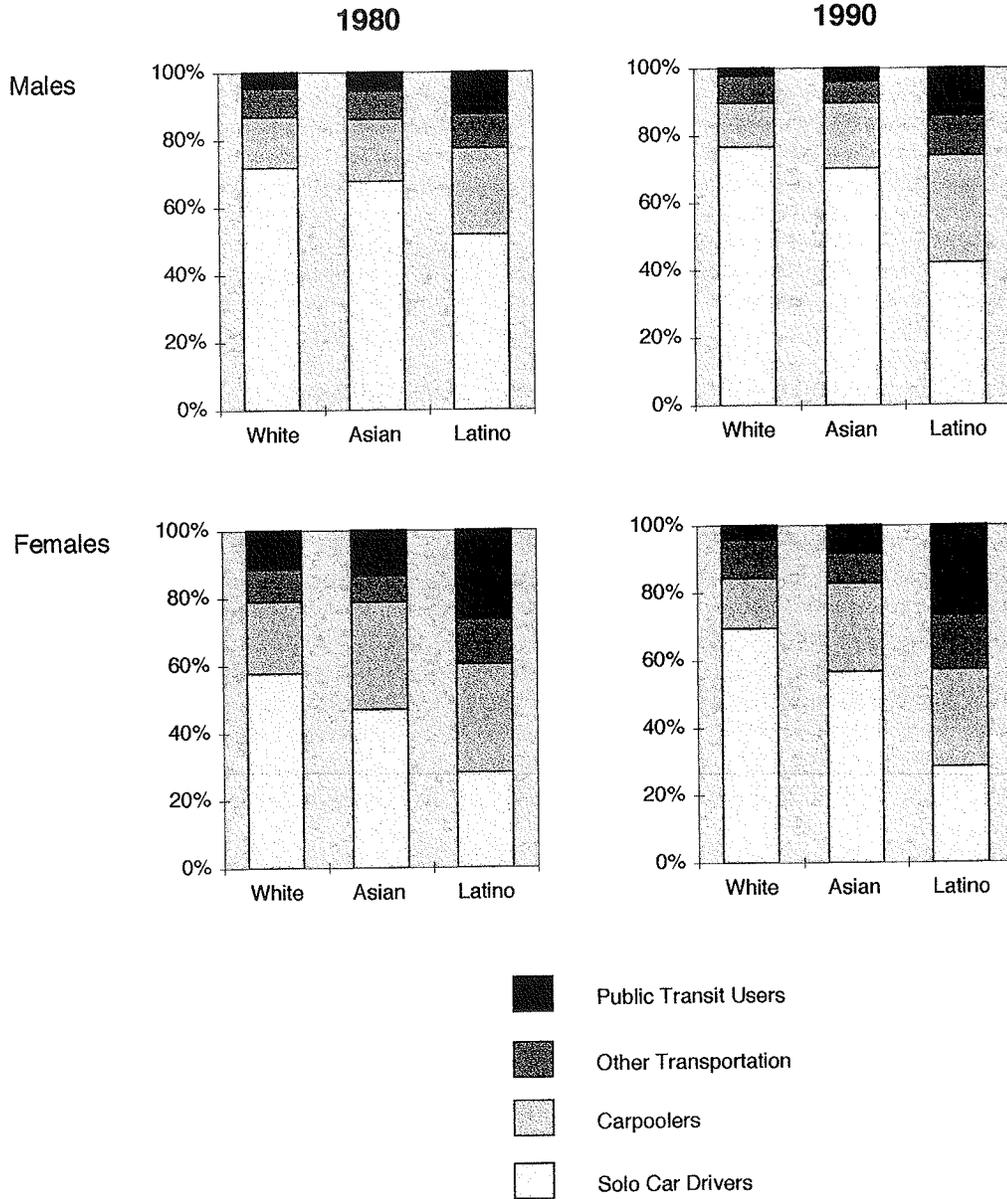


FIGURE 1 Transportation to work used by recent immigrants.

sexes and all race-ethnicities, but it appears greatest among male and female Latinos, especially the women. Given the much higher transit usage of immigrants than that of native-born residents, the implication is that the growing number of immigrants in Southern California should lead to a growing demand for public transit.

Three categories of transportation deserve more detailed analysis. Solo car driving, or SOVs, represents the most intensive use of the region's roadway system and deserves attention also for its popularity. Carpooling is a transportation alternative that increases vehicle occupancy and thus imposes a lower per passenger burden on the roadway system. Public transit is most efficient of all and has special importance to transportation planners,

especially in Southern California where there is heavy investment under way in construction of a new rail system.

### PATTERNS OF CHANGE FROM 1980 TO 1990

Between 1980 and 1990 the Southern California region experienced considerable growth: population increased by 26.6 percent, and the number of workers increased by 33.7 percent. During this time the foreign-born share of all workers grew from 18.2 percent to 29.5 percent, and nearly half of those foreign-born workers were immigrants who arrived in just those last 10 years. Thus, the growing presence of immigrants among commuters

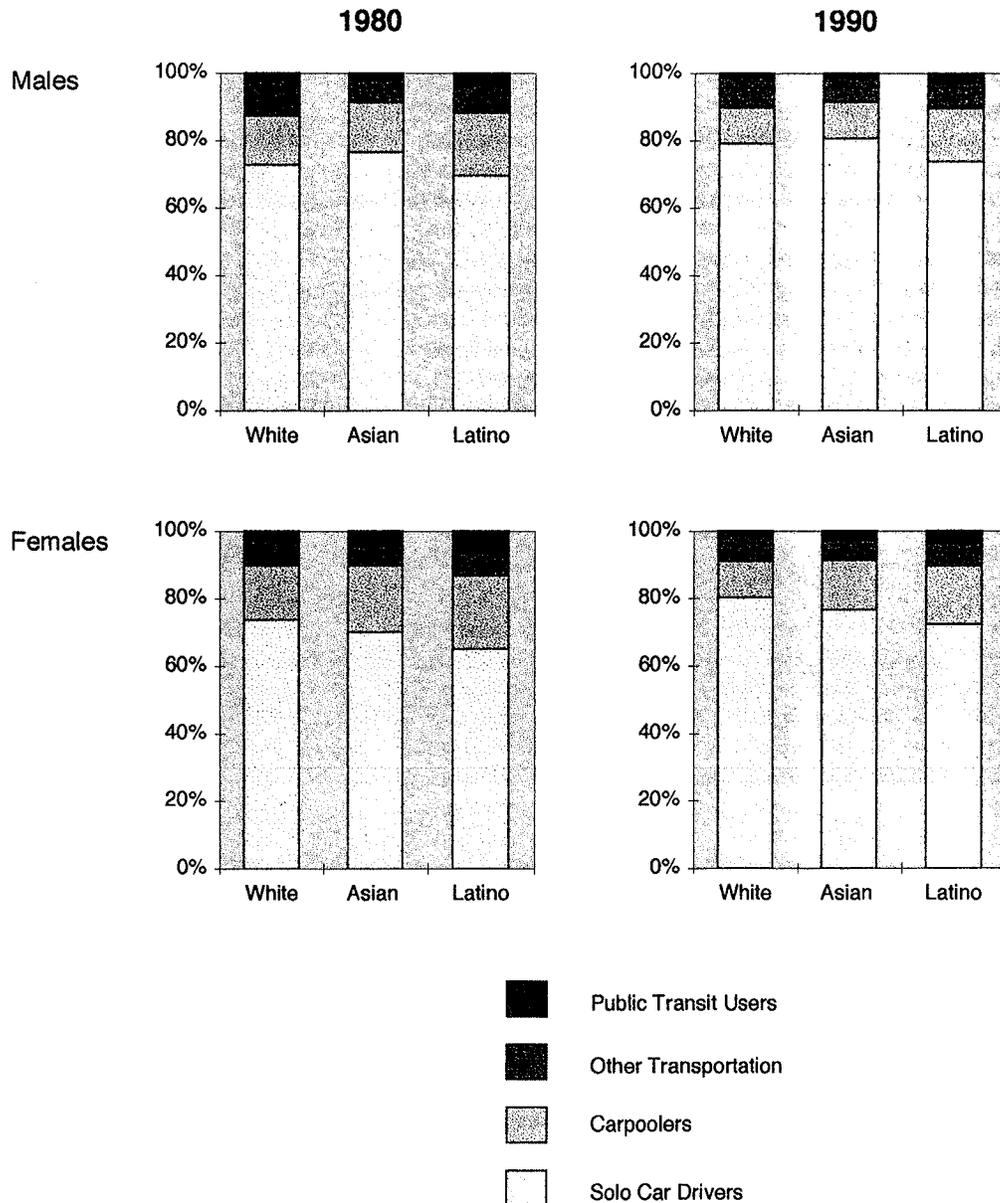


FIGURE 2 Transportation to work used by native-born residents.

should have led to disproportionate growth in transportation modes that are more relied upon by immigrants.

The evidence of transportation growth is puzzling. As shown in Table 1, the number of solo car commuters increased at a somewhat faster rate (38.5 percent) than the number of workers (32.8 percent). At the same time, the number of carpoolers grew more slowly (17.9 percent) than number of workers, and the number of transit commuters grew the slowest (16.7 percent). This pattern of growth seems at odds with the travel behavior of immigrants and their increasing presence in the population.

A better understanding of these dynamics of change can be gained by focusing in depth on changes in one particular mode of commuting. The use of public transit

is selected here because the difference between immigrants and native-born residents is so great (and yet, paradoxically, transit use has fallen relatively despite growing immigration).

Public transit usage rates in both 1980 and 1990 were disaggregated by ethnicity, sex, and age, as well as by immigration status. The aim was to discover the changes in subgroup-specific rates, weighting these rates by the changing number of workers in each subgroup and arriving ultimately at an understanding of how the changing population was contributing to the overall change in public transit usage. The required analysis is highly detailed and too voluminous to review in all its particulars. Instead, the main patterns are summarized, the age analysis is dis-

TABLE 1 Transit Use by All Workers, 1980–1990, Southern California

	1980	1990	Change	% Change
Solo Car Drivers	4,153,080	5,752,536	1,599,456	38.5
Carpoolers	1,017,480	1,199,475	181,995	17.9
Public Transit Users	282,800	330,065	47,265	16.7
Other Transit	524,420	659,388	134,968	25.7
Total Workers	5,977,780	7,941,464	1,963,684	32.8
Total Population	13,321,060	16,860,708	3,539,648	26.6

cussed, and the results of the overall calculation regarding immigrants' contribution to transit ridership are reported.

In Figure 3 the 1990 rates of transit use are displayed for each segment of the population defined by race-ethnicity and year of arrival in the United States (or native born). The top graph displays data for male workers and the bottom for female workers. As seen previously, women have higher transit ridership rates than do men, and Latinos' rates are higher than those of Asians or whites. Data are not shown for blacks because there are so few black immigrants in Southern California who arrived before the 1980s. However, the transit ridership of native-born blacks deserves note because it is higher than that of other native-born residents, 6.9 percent for men and 7.9 percent for women.

The main point to observe from Figure 3 is the apparent decline in transit use among immigrants who have lived in the United States for a longer time. The most recent arrivals have transit rates that are twice those who arrived in the 1970s, and earlier arrivals' rates are still lower, converging on the low rates of the native-born residents. It should be emphasized that this picture is only drawn from a single point in time, 1990, and thus may not reflect the true longitudinal behavior of immigrants. There is no age detail in this portrait either. As time passes, immigrants both increase the duration of their residence in the United States and advance through their life cycle. Thus it is possible that life-cycle effects may account for much of the apparent differences between immigrant generations. That question is addressed in the next section.

Turning now to the findings from the full matrix of transit behavior observed in 1980 and 1990 by sex, race-ethnicity, age, and immigration status within this full context, Figure 4 summarizes the importance of immigration status. Recent immigrants (who arrived within 10 years of each census) account for a very large and growing number of all transit commuters. The number

of transit commuters who immigrated more than 10 years before also increases, whereas the number of native-born riders shrinks substantially.

The top portion of Figure 4 shows that the recent immigrants' share of total transit commuters in all of Southern California grew from 27 percent to 42 percent between 1980 and 1990. The bottom portion of Figure 4 gives the absolute numbers, showing that the total number of transit commuters grew from 283,000 to 330,000, an increase of 47,000. Recent immigrants alone accounted for a growth of 62,000 riders and earlier immigrants added another 32,000 increase in ridership.

The clear conclusion is that without the growth in immigrants, absolute transit ridership would have plunged. Another way of assessing immigrants' effect on transit is to ask what would have happened if they commuted to work in the same fashion as their native-born counterparts of the same sex, age, and race-ethnicity. Although this "instant assimilation" is fanciful, it is still instructive. The last bar on the right in Figure 4 graphs this outcome: recent immigrants' share of all transit commuters would then collapse from 42 percent to only 15 percent, and their absolute number of riders would fall from 140,000 to only 28,000. The latter result reflects the fact that recent immigrants' per capita transit use rates are four times greater than those of their native-born counterparts. Thus recent immigrants provide a strong base of transit ridership, making possible a level of service that would otherwise not be available to other residents in the region. Without a growing number of new immigrants, transit services in Southern California likely would be sharply curtailed.

## PROGRESS IN TRANSPORTATION CAREERS

Figure 1 provided only a snapshot of transportation to work among the most recent arrivals before the 1990

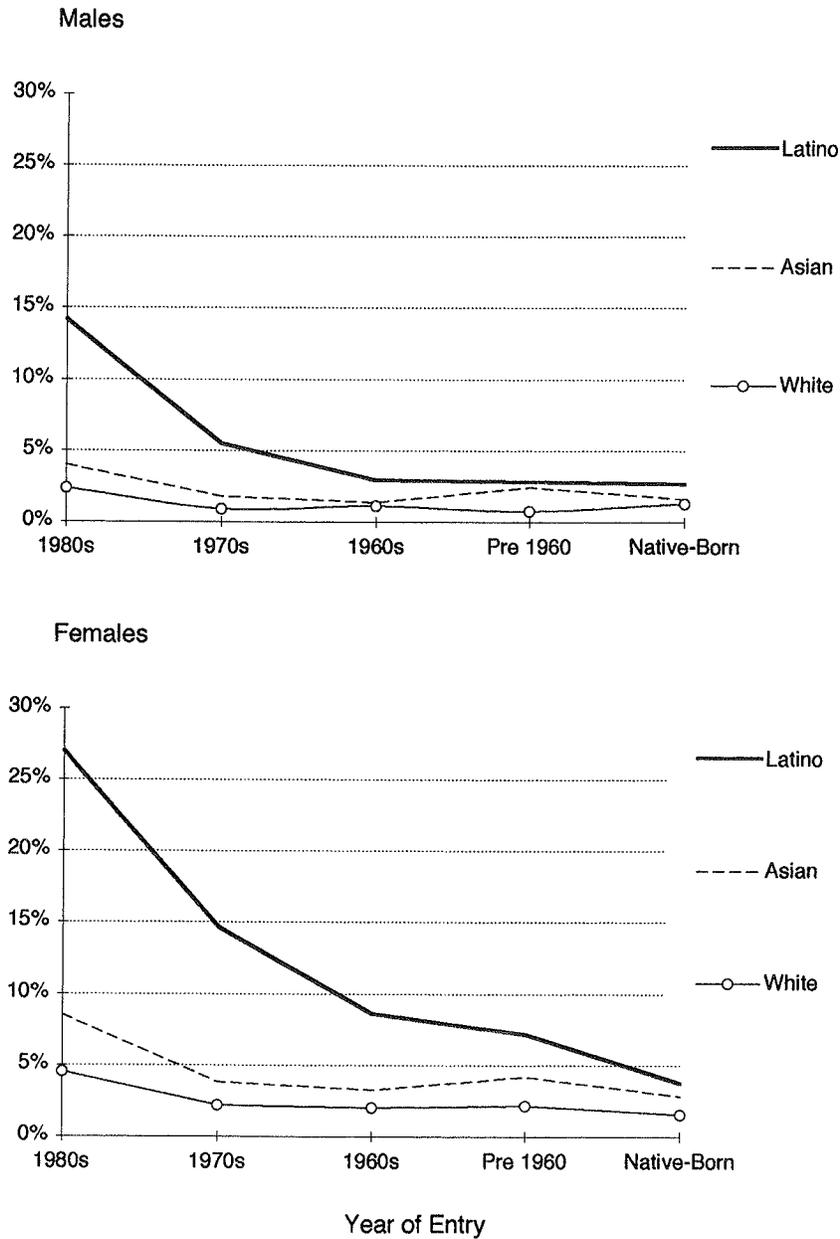


FIGURE 3 Percent using public transit in 1990 by race and immigration status.

census. Arriving over the entire decade of the 1980s, these immigrants have already resided in Southern California for an average of 5 years. How much they will change their commuting behavior after residing in the United States another 10 years remains in question.

**Insights from Linking Cohorts in Two Census Years**

The question of change over time is central to most social inquiries or policy studies. Census data are invaluable for this purpose. As explained more fully elsewhere (4), cen-

sus data are collected at regular intervals in a systematic coverage that asks comparable questions of a very large sample representing the entire population. With these data reliable investigations can be conducted of change over decade intervals for any local area in the United States.

Cohort analysis is a specialized use of census data that provides the deepest insights into longitudinal change. An age group in one decade can be linked to the age group that is 10 years older in the next decade. Differences in behavior measured between these two observations reflect the aging of the cohort. This often gives insights that are very different from those gained in a single survey year. Myers and Lee (3) recently extended this methodology in

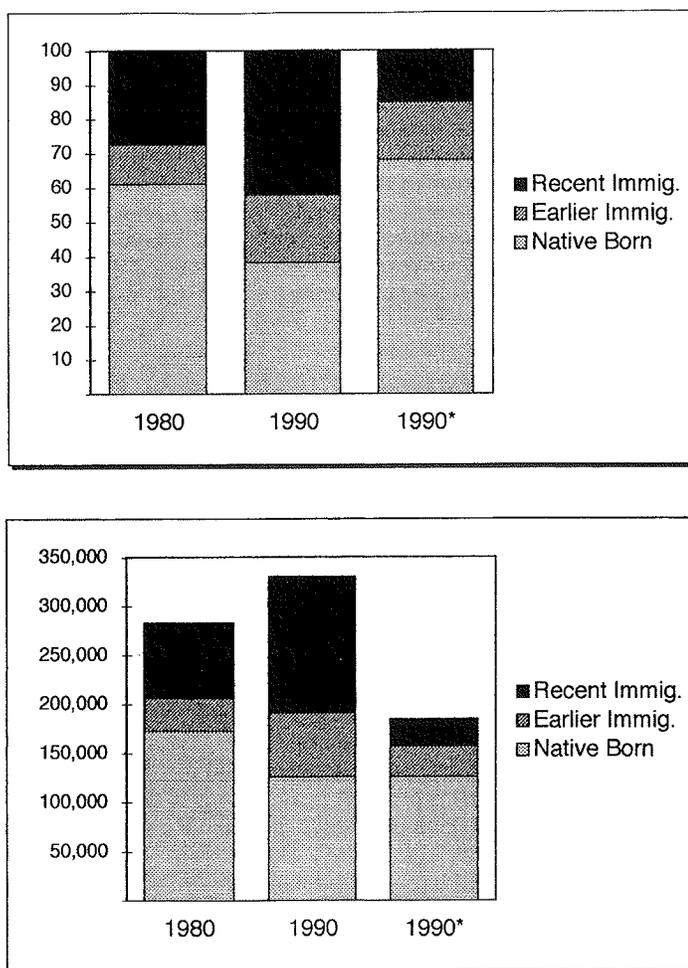


FIGURE 4 *Top*: Share of total transit commuters; *bottom*: total number of transit commuters.

a “double cohort” framework that not only traces changes along the age dimension but also follows immigrants as they remain in the United States an additional 10 years. Thus, age cohorts can be traced within immigration cohorts as they pass through a life cycle and as they assimilate into U.S. society. That methodology is applied in the following discussion in a graphic representation of cohorts’ trajectories of change. [See also the fuller explanation provided in the first report from the Southern California immigration study (1).]

The best answer to the question of how much recent immigrants will change their transportation behavior over time can be gained by studying the progress of previous new arrivals. A cohort of new arrivals was identified at the time of the 1980 census as those who arrived in the 1970s. When the 1990 census was taken, individuals from that same arrival group were again identified as those who had arrived in the 1970s. By comparing the answers given in 1990 with those given by persons from the same cohort in 1980, the rate of change in commuting behavior over a 10-year segment of their transporta-

tion careers can be judged. Similarly, within this immigration cohort specific age cohorts can be traced by linking, for example, women aged 25 to 34 in 1980 with women aged 35 to 44 in 1990.

With this methodology some significant questions can be addressed. For example, Latino women are especially prominent in their transit usage, but how loyal is their patronage over time? Among other groups, is there any evidence of increased transit usage? Conversely, female immigrants have lower rates of solo driving than do their male counterparts. Over time, do they close the gap by increasing their reliance on personal vehicles for commuting? Or do men increase their solo driving at least as fast as do women? The increase in solo driving is examined next, followed by trends in carpooling and transit usage.

### Solo Driving to Work

From initially low levels, immigrants rapidly increased their reliance on personal vehicles for commuting to work. Figure 5 compares the upward trajectories of male

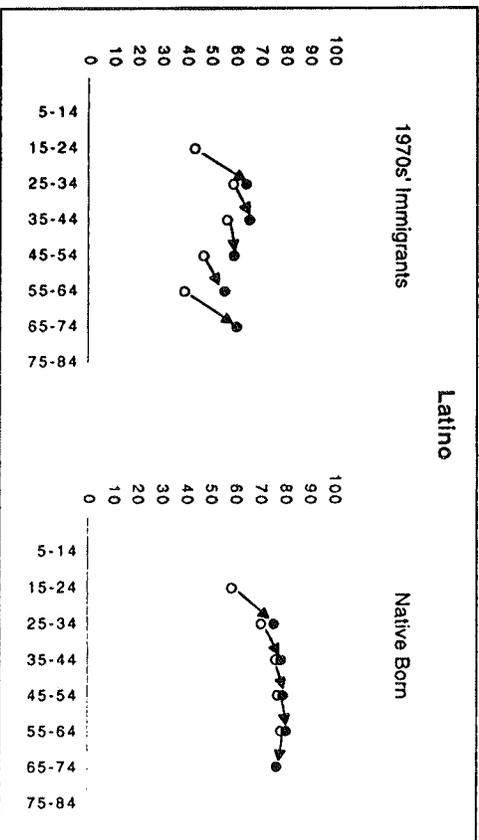
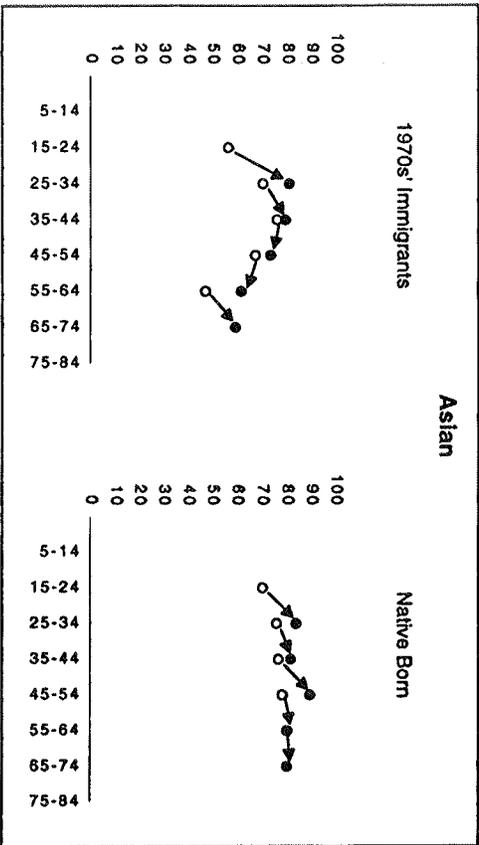
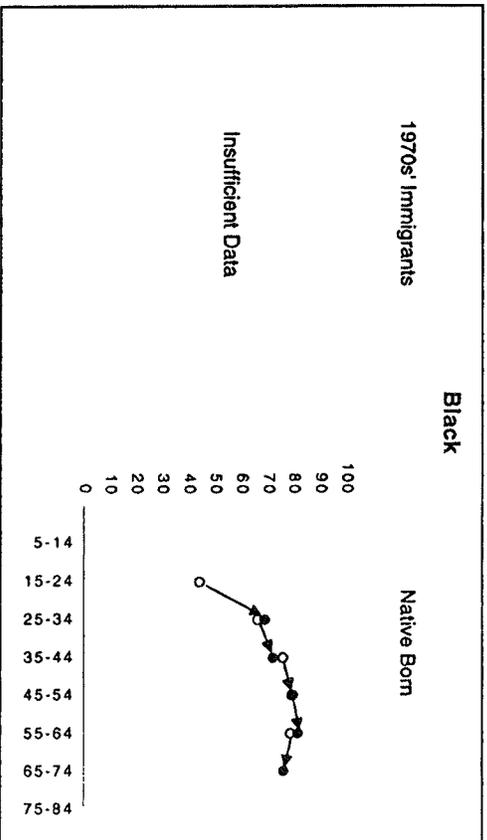
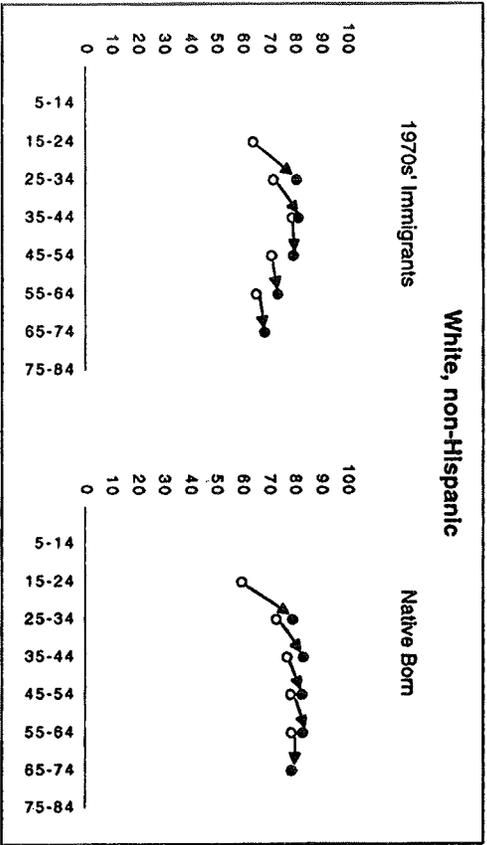


FIGURE 5 Percentage of men driving alone to work, 1980 to 1990.

workers between 1980 and 1990 among native-born residents and recent immigrants for each of the major race-ethnicities. In general, as cohorts grew older they increased their rate of solo driving, with the greatest increases occurring in the younger half of the life cycle. Immigrant men have somewhat lower reliance on solo driving than do their native-born counterparts of the same race-ethnicity. Aside from some sharp upward turns among the very oldest immigrant workers (a small and unusually self-selected group), there are no large differences in the pattern between immigrants and native-born residents.

In contrast, the pattern of change for female workers is more dramatic. Figure 6 shows that immigrant women in 1980 had much lower rates of solo commuting than did their native-born counterparts. However, by 1990 the cohort trajectories have thrust sharply upward with increases from 10 to 30 percentage points in their solo commuting rate. Immigrant women are moving rapidly toward parity with immigrant men, and both sexes are converging on the commuting pattern of native-born workers.

In general, these upward trajectories of solo car commuting are consistent with nationwide trends. However, the increases among immigrants are stronger than those observed for native-born workers, reflecting the gains of assimilation made by these immigrants.

As a methodological note, observe that if the data used were restricted to only 1980 or to only 1990, the cross-sectional pattern by age might lead to the conclusion that people would be less likely to drive solo as they became older. This is a reflection of the well-recognized age-cohort fallacy: comparisons between age groups at one point in time often do not reflect the effects of aging; only analysis of cohorts over time can yield valid conclusions about increasing age (8).

### Carpooling to Work

Workers who drive alone to work are not sharing their vehicles with other passengers. With so many solo drivers, it is unlikely that many others can be carpooling. However, it is possible that carpooling is a significant and growing option for certain selected groups.

Figure 7 compares the trajectories of carpooling participation among male workers who are native born or recent immigrants among each of the major race-ethnicities. In 1980, among the native born, younger workers tended to carpool more than older ones, and as cohorts grew older over the decade they decreased their rate of carpooling. The rate of change is about the same at all points in the life cycle. Among the recent immigrants, however, the pattern is different: older whites and Asians tend to carpool more than younger workers,

and only among the two youngest white cohorts is there any evidence of decline with passing time.

Among female workers (Figure 8), the pattern of change is once again more dramatic. Native-born female workers reveal greater decreases in carpooling than men as they grow older. Among immigrants the decreases are even sharper. This likely reflects the rapid growth in solo car driving by immigrant women, many of whom probably once carpooled.

### Commuting by Public Transit to Work

Turning to the question of how much immigrants sustain or increase their reliance on public transit over time, given the harsh inconveniences of public transit in Southern California, one would expect immigrants to switch to other modes of transportation as they are able (7).

Figure 9 presents the findings for male workers. Use of public transit among native-born whites, Asians, and Latinos in Southern California is nearly zero. Transit commuting is substantially greater for blacks, especially among the younger workers. This may be because the black population is more centrally concentrated and their homes are better served by bus lines. Among the immigrants, the transit commuting rates of most cohorts drop substantially. Among whites and Asians under age 55, transit use falls to a level comparable with that of native-born workers. However, among Latinos, transit use remains at 5 percent or higher even after the decade's declines.

Among female workers (Figure 10), the sharp declines in transit commuting by immigrants are dramatic. For example, among female workers aged 25 to 34 in 1980 and 10 years older in 1990, transit use fell from 10.0 to 2.5 percent for whites, from 9.3 to 1.7 percent for Asians, and from 25.1 to 15.2 percent for Latinas. Native-born Latinas had much lower rates of transit use than immigrants, but their ridership also dropped somewhat over the decade. Blacks again evidenced the highest ridership of the native-born female workers, but their ridership also fell over the decade.

Overall, this pattern of declining transit patronage is consistent with the rising rate of solo car driving, and it also reflects nationwide trends toward declining transit use. From the perspective of the transit agencies, what might be especially alarming is the fact that the young age groups containing the majority of immigrant workers experienced the sharpest reductions in transit use. One misleading interpretation would be to focus only on the 1990 rates of transit use by age—much higher for older than younger Asians and Latinas—and conclude mistakenly that the older people grow, the more likely they are to ride public transit. The cohort trajectories tell a much different story.

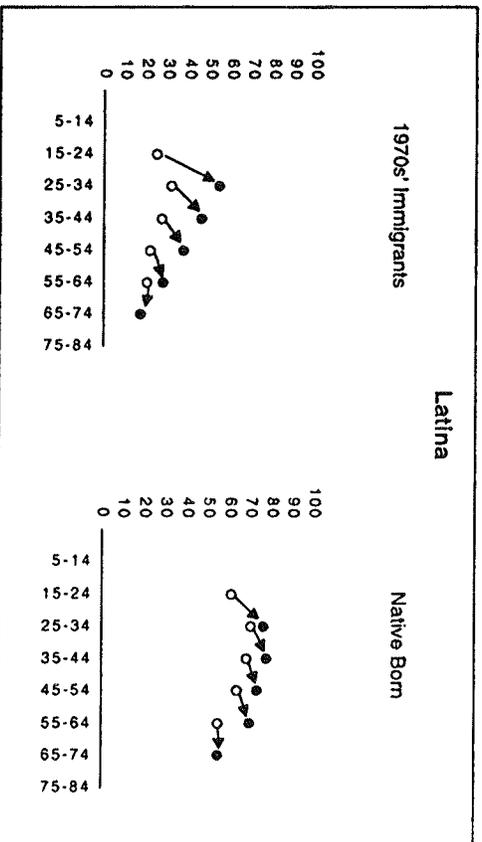
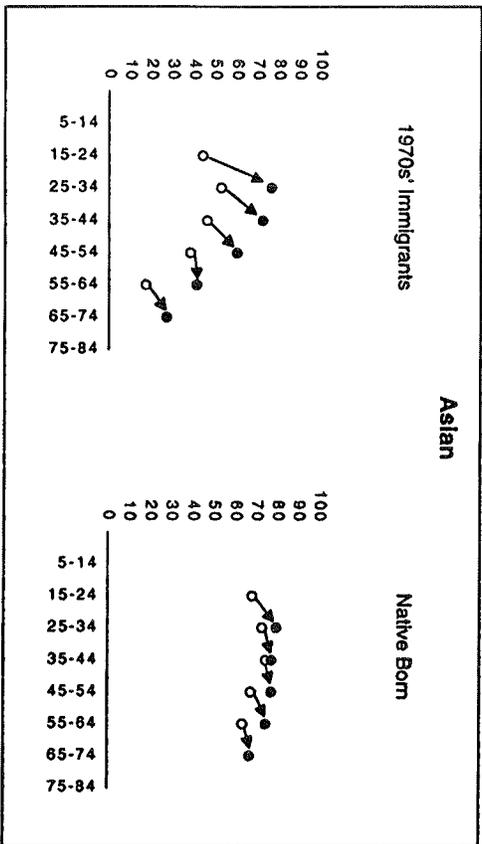
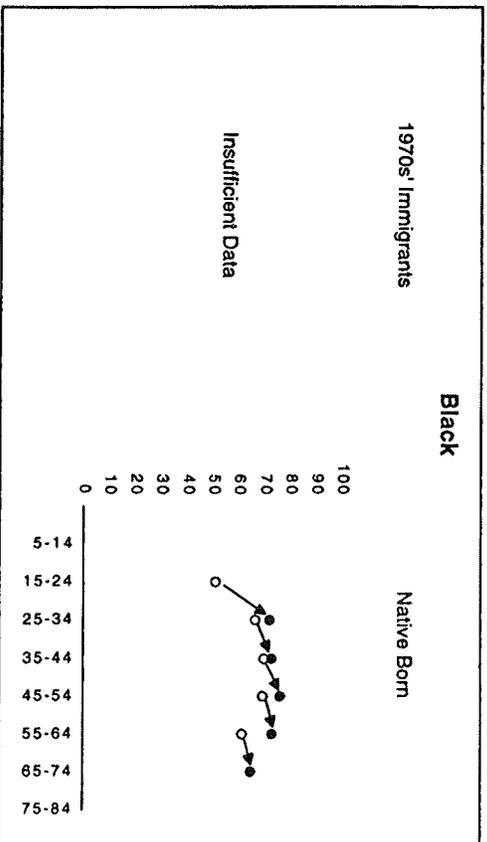
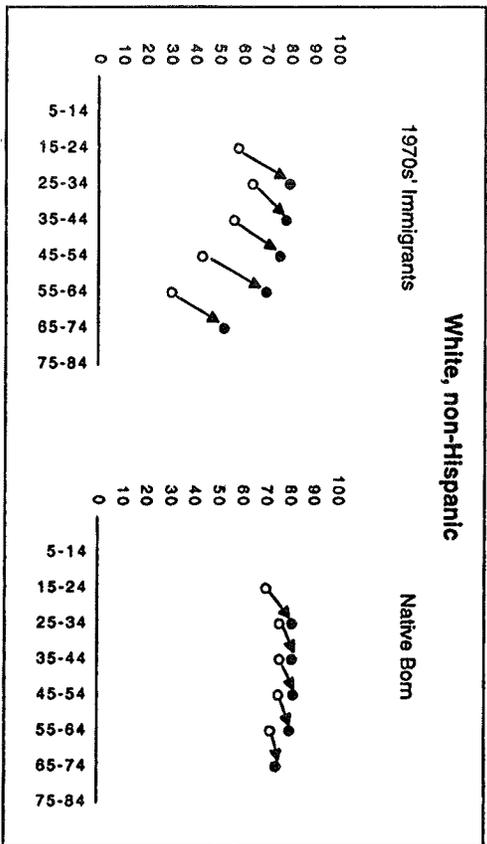


FIGURE 6 Percentage of women driving alone to work, 1980 to 1990.

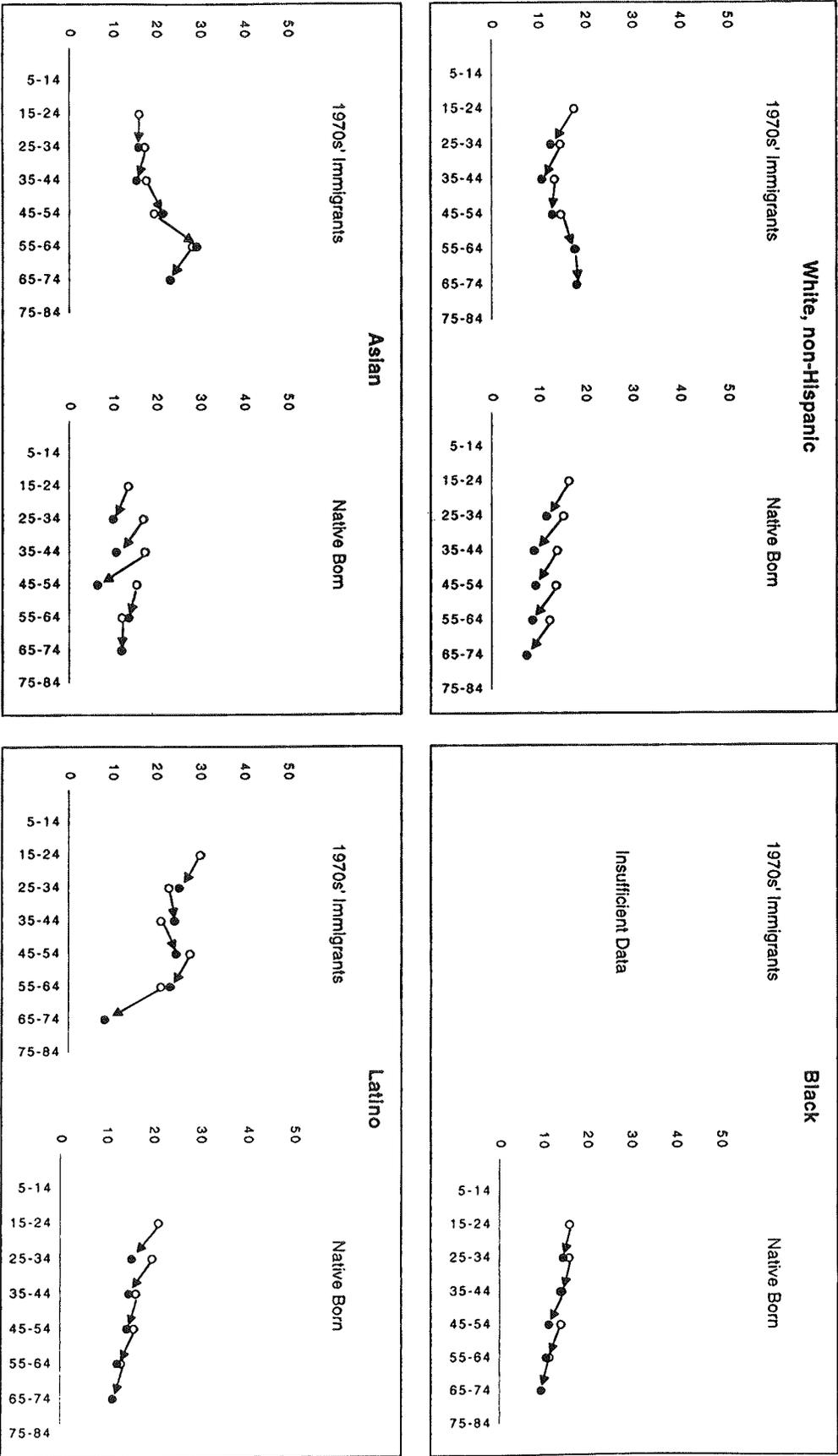


FIGURE 7 Percentage of men carpooling to work, 1980 to 1990.

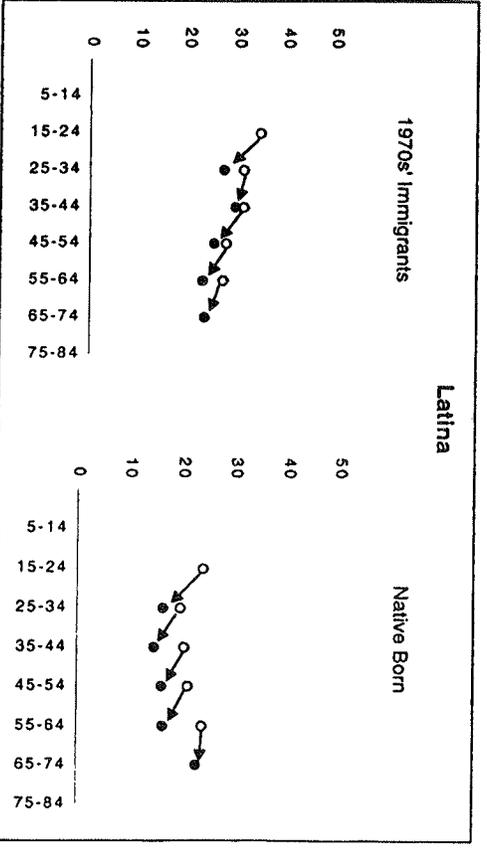
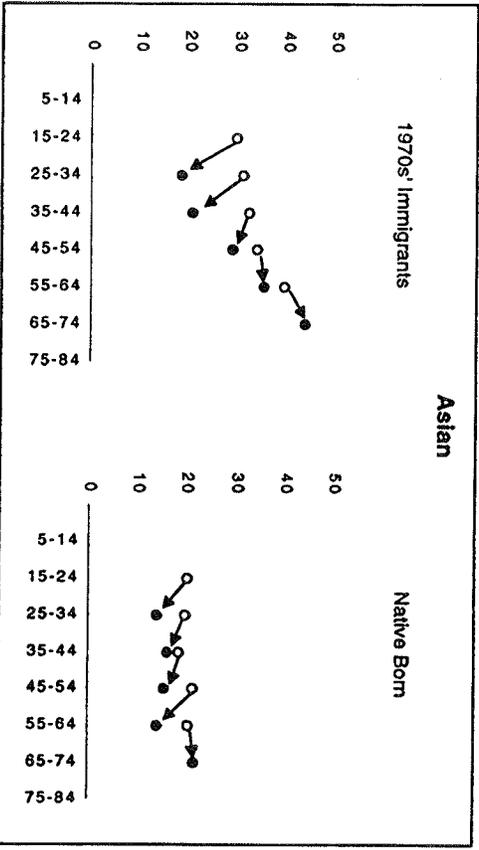
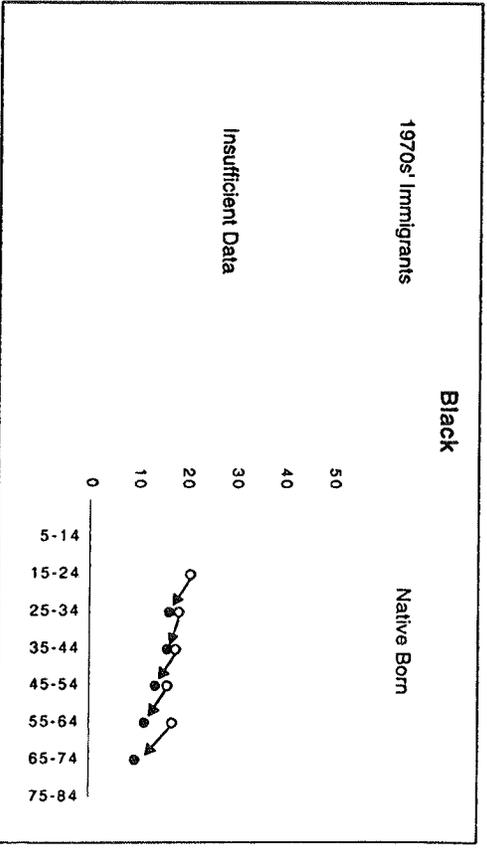
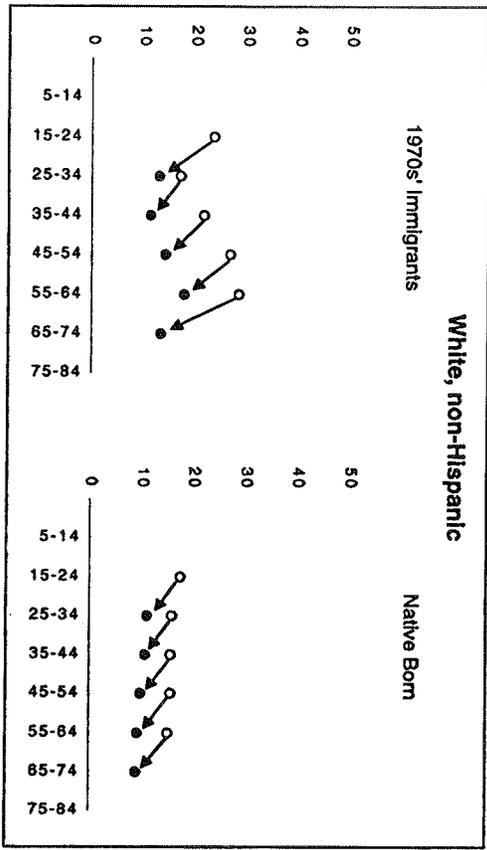


FIGURE 8 Percentage of women carpooling to work, 1980 to 1990.

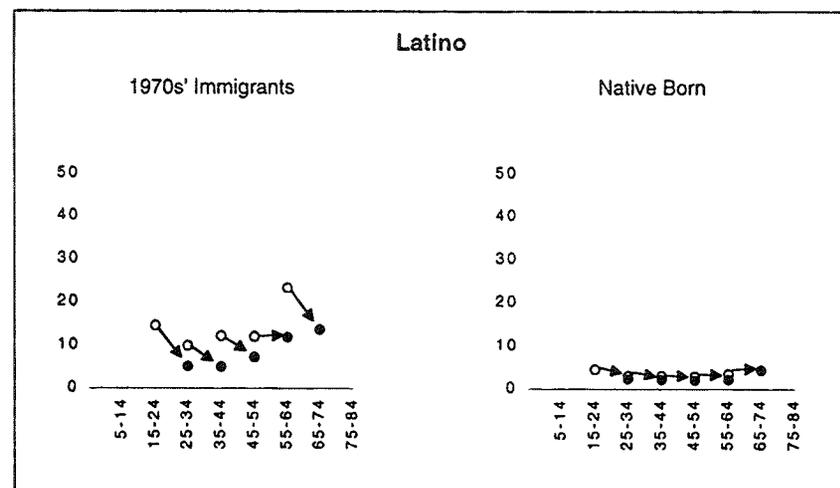
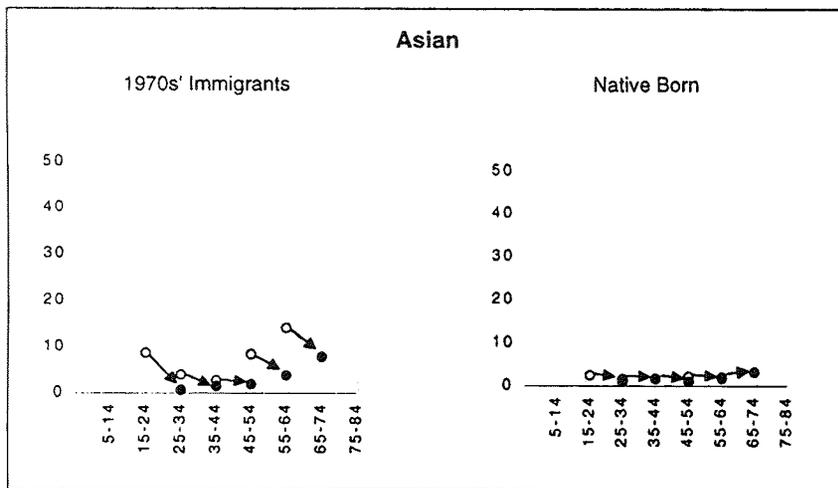
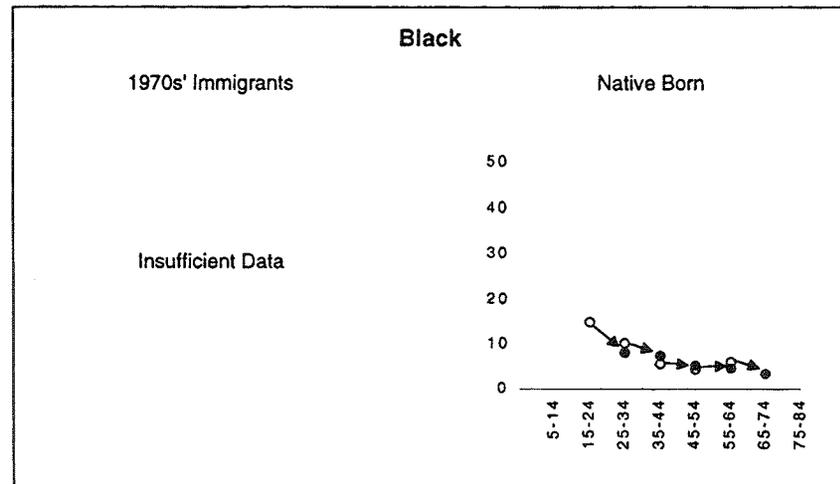
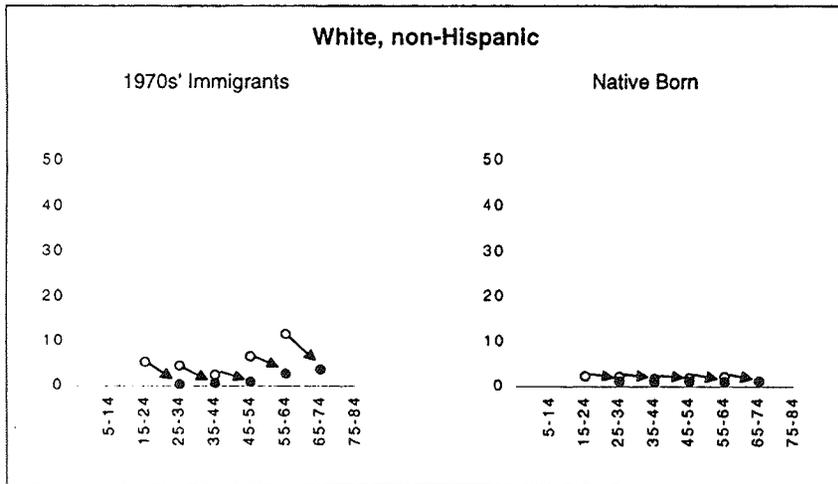


FIGURE 9 Percentage of men taking public transit to work, 1980 to 1990.

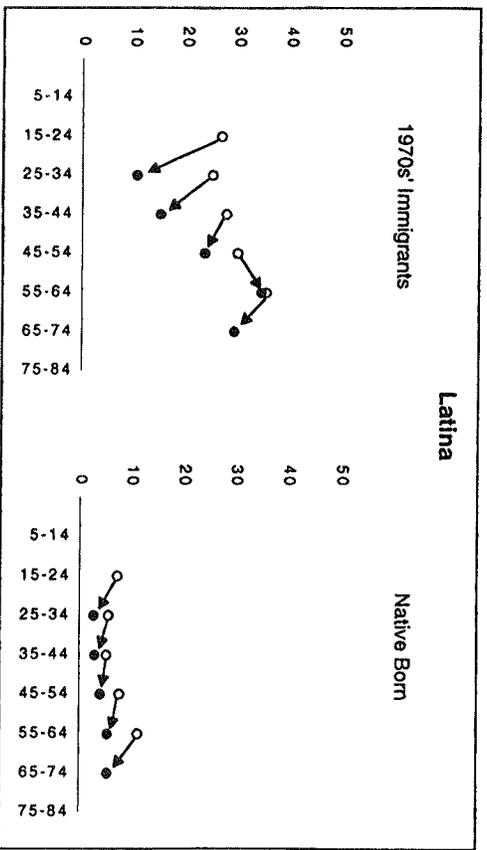
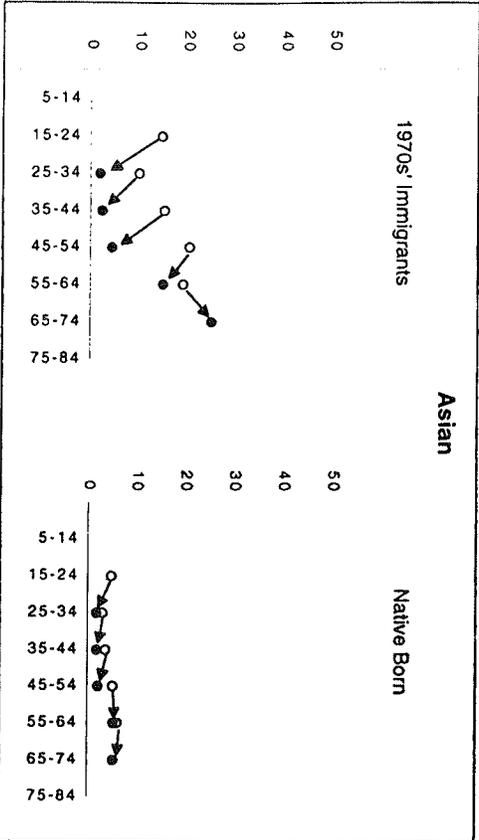
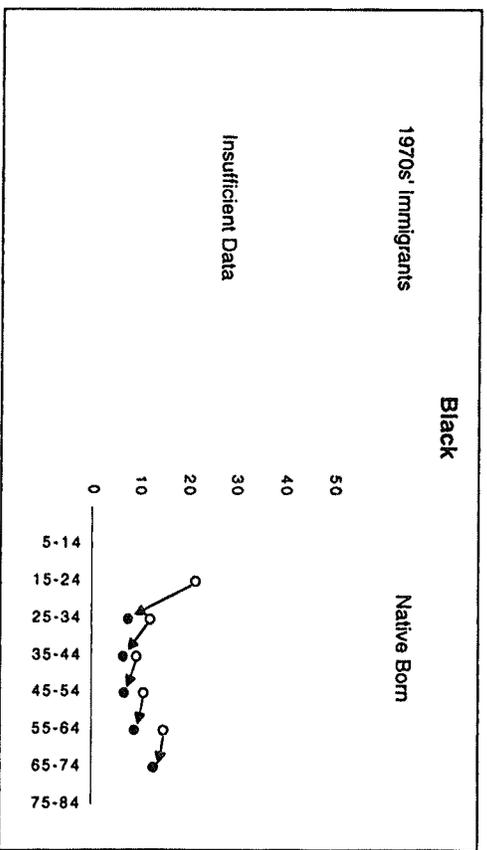
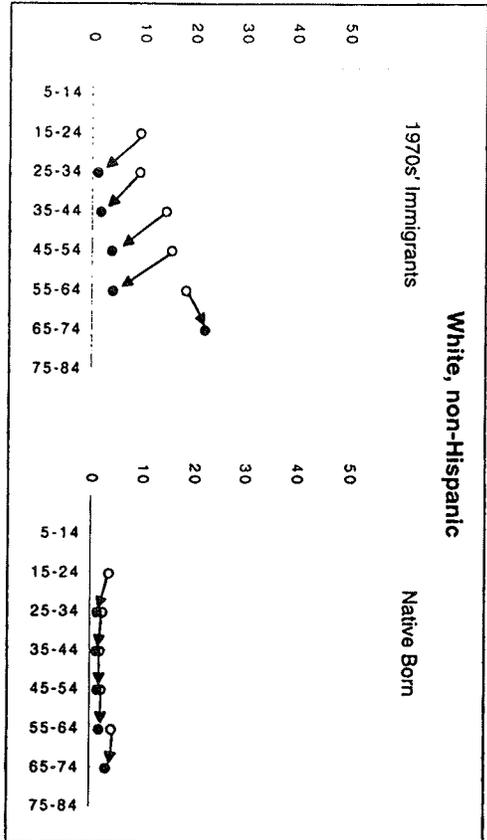


FIGURE 10 Percentage of women taking public transit to work, 1980 to 1990.

## SUMMARY

Immigrants are found to have very different commuting behavior than that of native-born workers. Recent immigrants are much more likely to ride public transit than other workers, and they make up 45 percent of the total transit commuters. At the same time, they are also much less likely to drive alone to work; thus, they have much less impact on the roads than do native-born commuters.

Unfortunately, or not, this modest transportation behavior is not a permanent characteristic of individual immigrants. Over time, recent arrivals adapt themselves to California society and improve their economic status. Their convergence on the commuting behavior of native-born residents is one demonstration of the immigrants' assimilation into the mainstream of California life. This is a desirable outcome from the perspective of immigrants' personal well-being, but it poses a challenge to transportation planners and a threat to transit agencies.

Transit planners have been the unintended beneficiaries of a liberalized immigration policy and the post-1965 surge in immigration. These new arrivals have provided a solid base upon which to base transit ridership, extend service, and preserve low fares. In one planning scenario, the new immigrants would learn to appreciate public transit and develop a sustained attachment to its use. At the same time, more of the native-born residents would be attracted to public transit by its efficient service and low fares, thus building an ever-broadening base of ridership.

However, there is a counterscenario to consider, one more consistent with the evidence in this paper. The speed of immigrants' adaptation is remarkable, with their propensity to commute by public transit plunging by as much as half in just 10 years. Meanwhile, native-born residents continue to move away from public transit. The pattern portrayed here suggests that the only way to sustain present levels of transit ridership would be to continue importing fresh waves of new immigrants who can replace their upwardly mobile neighbors. Should immigration policy seal the border, or at least slow the rate of new arrivals, this would lead quickly to an accelerated decline in transit ridership. Thus, transit ridership in Southern California is built on a precarious base.

More generally, the present analysis has illustrated the potential insights into longitudinal change that can be gained from cohort analysis with census data. This paper has only sketched the broad contours of possibilities. Cohort trajectories can be represented not only graphically as has been shown here but also in a multivariate statistical framework. As shown by Myers and Lee (3),

this permits the introduction of controls for income, education, or other traits likely to determine transportation behavior. The outcome variables can also be extended beyond mode choice to a number of other topics, including travel time, housing choices, and location.

It is hoped that the Census 2000 will collect data that are comparable in scope and quality to those in 1990 and 1980. Without those data, the trends of the 1980s cannot be measured reliably or compared with those of prior decades.

## ACKNOWLEDGMENT

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# PRIVATE SECTOR

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# Application of Census Commuting Data in Specification of Life-Style Clusters by Place of Work

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Life-style cluster segmentation systems are among the more popular products provided by commercial data suppliers. However, because these systems are based on the demographic composition of an area's residential population, they often suggest little about the population employed in the area. This paper describes how a special tabulation of 1990 census journey-to-work data was used to adapt a residence-based cluster segmentation product for use with the workplace population.

Using small-area census data and multivariate clustering techniques, life-style cluster segmentation systems establish sets of neighborhood types, known as clusters, and assign small geographic areas to these clusters on the basis of their demographic composition. The PRIZM cluster system, developed by Claritas in the 1970s, was the first product of its type; in its present form, it assigns each of the nation's 226,399 block groups to one of 62 life-style clusters. PRIZM clusters are defined within a framework of 15 broad cluster groups defined by socioeconomic status and an urban-rural typology developed by Claritas (1,2). For ease of use, the clusters are given descriptive names such as Kids & Cul-de-Sacs, Big City Blend, or Rural Industria. The broad cluster groups are identified in Table 1, and the 62 PRIZM clusters are given in Table 2.

In a typical application, a business might geocode its customer list in order to append the relevant block group cluster code and then analyze its product's performance

for persons living in different neighborhood types, or clusters. By describing a cluster "profile" of their present customers, businesses can fine-tune their marketing efforts and identify areas with untapped sales potential.

Promotional materials often reference the saying "Birds of a feather flock together" to convey the premise that small areas are sufficiently homogeneous to comprise a neighborhood typology strongly related to life-style and consumer behavior. Such assumptions are better met in some areas than others, but experience confirms that life-style clusters provide impressive consumer segmentation and predictive capability, while sparing the time and expense of a multivariate analysis for each application.

## WORKPLACE CLUSTERS

The demand for daytime or workplace demographic data has grown as businesses realize the opportunities to market to consumers at or near their place of work. For example, in evaluating potential bank branch locations, the size and composition of the population employed in an area during business hours can be more relevant than that of the area's residential population.

As the demand for workplace demographics has grown, users of life-style cluster systems have asked for workplace versions of these products. Workplace demographic data are a challenge, since so little census data

TABLE 1 PRIZM Cluster Groups

	Rural		Urban	
High SES	T1	C1	S1	U1
	R1	T2	S2	
	R2		S3	U2
Low SES	R3	T3	C3	U3

SES = Socioeconomic Status

#### Cluster Groups

<b>S1:</b> Elite Suburbs	<b>S3:</b> Inner Suburbs	<b>U3:</b> Urban Cores
<b>U1:</b> Urban Uptown	<b>U2:</b> Urban Midscale	<b>C3:</b> 2nd City Blues
<b>C1:</b> 2nd City Society	<b>C2:</b> 2nd City Centers	<b>T3:</b> Working Towns
<b>T1:</b> Landed Gentry	<b>T2:</b> Exurban Blues	<b>R2:</b> Heartlanders
<b>S2:</b> The Affluentials	<b>R1:</b> Country Families	<b>R3:</b> Rustic Living

#### Urban-Rural Types

<b>R = Rural</b>
<b>T = Town</b>
<b>C = 2nd City</b>
<b>S = Suburban</b>
<b>U = Urban</b>

NOTE: The 62 PRIZM life-style clusters are grouped into 15 broad "cluster groups," as illustrated in the grid above. The vertical dimension reflects socioeconomic status (as measured by income, education, occupation, and housing value), and the horizontal dimension reflects position on the urban-rural typology defined by Claritas.

are tabulated by place of work. However, workplace clusters present a special challenge because the homogeneity assumption is often unrealistic for place of work. Birds of a feather may reside together, but the workplace is characterized by life-style diversity—with everyone from upper management to clerical and custodial staff and persons at various life-cycle stages working in the same location.

Even if one could specify the demographic composition of an area's workplace population, this composition would not translate into life-style clusters comparable with those of the residential system. The workplace is populated with individuals, not families, and one would not expect to find workplace versions of clusters such as Pools and Patios or New Empty Nest. Furthermore, the diversity of life-styles in the workplace would likely dilute the predictive power of workplace cluster assignments.

Given such realities, the Workplace PRIZM product was developed using a different approach. Rather than defying workplace diversity by assigning single workplace cluster codes based on the characteristics of workers, the objective was to reflect this diversity in terms of the residential cluster system. Specifically, the objective was

to identify the mix of residential life-styles (clusters) brought to the workplace by commuters. Grounding the workplace product in the standard PRIZM scheme facilitates residential-workplace comparisons and preserves relevance to the household—the unit most relevant to consumer segmentation.

#### 1990 CENSUS COMMUTING FLOWS

The Workplace PRIZM product was made possible by a special tabulation of the 1990 census journey-to-work data designated Special Tabulation Product (STP) 154. Originally produced for the U.S. Department of Agriculture, this tabulation was possible because the 1990 census long-form questionnaire collected information on the journey to work, including the respondent's workplace address. By geocoding respondents' residential and workplace addresses to census tract, the tabulation defines the journey to work in terms of a tract of origin and a tract of destination.

Thus, STP 154 can be viewed as a large origin-destination matrix, including over 5 million tract-to-tract

TABLE 2 PRIZM Life-Style Clusters

Cluster Group	Cluster	Cluster Nickname	Brief Description	Race, Ethnicity
S1	01	Blue Blood Estates	Elite Super-Rich Families	Dominant White, High Asian
S1	02	Winner's Circle	Executive Suburban Families	Dominant White, High Asian
S1	03	Executive Suites	Upscale White-Collar Couples	Dominant White, High Asian
S1	04	Pools & Patios	Established Empty Nesters	Dominant White, High Asian
S1	05	Kids & Cul-de-Sacs	Upscale Suburban Families	Dominant White, High Asian
U1	06	Urban Gold Coast	Elite Urban Singles & Couples	Dominant White, High Asian
U1	07	Money & Brains	Sophisticated Townhouse Couples	Dominant White, High Asian
U1	08	Young Literati	Upscale Urban Singles & Couples	Dominant White, High Asian
U1	09	American Dreams	Established Urban Immigrant Families	Mixed Ethnic Diversity
U1	10	Bohemian Mix	Bohemian Singes & Couples	Mixed Ethnic Diversity
C1	11	Second City Elite	Upscale Executive Families	Dominant White
C1	12	Upward Bound	Young Upscale White-Collar Families	Dominant White, High Asian
C1	13	Gray Power	Affluent Retirees in Sunbelt Cities	Dominant White
T1	14	Country Squires	Elite Exurban Families	Dominant White
T1	15	God's Country	Executive Exurban Families	Dominant White
T1	16	Big Fish Small Pond	Small Town Executive Families	Dominant White
T1	17	Greenbelt Families	Young Middle-Class Town Families	Dominant White
S2	18	Young Influentials	Upwardly Mobile Singles & Couples	Dominant White, High Asian
S2	19	New Empty Nests	Upscale Suburban Fringe Couples	Dominant White
S2	20	Boomers & Babies	Young White-Collar Suburban Families	Dominant White, High Asian
S2	21	Suburban Sprawl	Young Suburban Townhouse Couples	Mixed Ethnic Diversity
S2	22	Blue-Chip Blues	Upscale Blue-Collar Families	Dominant White
S3	23	Upstarts & Seniors	Middle Income Empty Nesters	Dominant White
S3	24	New Beginnings	Young Mobile City Singles	Mixed Ethnic Diversity
S3	25	Mobility Blues	Young Blue-Collar/Service Families	Dominant Hispanic
S3	26	Gray Collars	Aging Couples in Inner Suburbs	Mixed Ethnic Diversity
U2	27	Urban Achievers	Mid-Level White-Collar Urban Couples	Dom. White, High Asian & Hispanic
U2	28	Big City Blend	Middle-Income Immigrant Families	Dominant Hispanic, High Asian
U2	29	Old Yankee Rows	Empty-Nest, Middle-Class Families	Dominant White, High Asian
U2	30	Mid-City Mix	African-American Singles & Families	Dominant Black
U2	31	Latino America	Hispanic Middle-Class Families	Dominant Hispanic
C2	32	Middleburg Managers	Mid-Level White-Collar Couples	Dominant White
C2	33	Boomtown Singles	Middle Income Young Singles	Dominant White
C2	34	Starter Families	Young Middle-Class Families	Mixed Ethnicity, High Hispanic
C2	35	Sunset City Blues	Empty Nests in Aging Industrial Cities	Dominant White
C2	36	Towns & Gowns	College Town Singles	Dominant White, High Asian
T2	37	New Homesteaders	Young Middle-Class Families	Dominant White
T2	38	Middle America	Midscale Families in Midsize Towns	Dominant White
T2	39	Red, White & Blues	Small Town Blue-Collar Families	Dominant White
T2	40	Military Quarters	GIs & Surrounding Off-Base Families	Mixed Ethnic Diversity
R1	41	Big Sky Families	Midscale Couples, Kids & Farmland	Dominant White
R1	42	New Eco-topia	Rural White/Blue-Collar/Farm Families	Dominant White
R1	43	River City, USA	Middle-Class Rural Families	Dominant White
R1	44	Shotguns & Pickups	Rural Blue-Collar Workers & Families	Dominant White
U3	45	Single City Blues	Ethnically-Mixed Urban Singles	Mixed, High Asian
U3	46	Hispanic Mix	Urban Hispanic Singles & Families	Dominant Hispanic
U3	47	Inner Cities	Inner City, Solo-Parent Families	Dominant Black
C3	48	Smalltown Downtown	Older Renters & Young Families	Dominant White, Some Hispanic
C3	49	Hometown Retired	Low-Income, Older Singles & Couples	Dominant White
C3	50	Family Scramble	Low-Income Hispanic Families	Dominant Hispanic
C3	51	Southside City	African-American Service Workers	Dominant Black
T3	52	Golden Ponds	Retirement Town Seniors	Dominant White
T3	53	Rural Industria	Low-Income, Blue Collar Families	Dominant White, High Hispanic
T3	54	Norma Rae-ville	Young Families, Bi-Racial Mill Towns	Dominant Black
T3	55	Mines & Mills	Older Families, Mine & Mill Towns	Dominant White
R2	56	Agri-Business	Rural Farm-Town & Ranch Families	Dominant White
R2	57	Grain Belt	Farm Owners & Tenants	Dominant White, Some Hispanic
R3	58	Blue Highways	Moderate Blue-Collar/Farm Families	Dominant White
R3	59	Rustic Elders	Low-Income, Older, Rural Couples	Dominant White
R3	60	Back Country Folks	Remote Rural/Town Families	Dominant White
R3	61	Scrub Pine Flats	Older African-American Farm Families	Dominant Black
R3	62	Hard Scrabble	Older Families in Poor Isolated Areas	Dominant White

commuting flows. The file presents each census tract as a place of work and identifies the number of workers commuting to that tract from various tracts of residence. The characteristics of commuters are not identified—just the total numbers—and these numbers are sample data weighted to 100 percent.

Employment destinations often draw commuters from many origin tracts. For example, Tract 2018.02 in the Old Town section of Alexandria, Virginia, shows a total inbound flow of 3,425 workers from 256 tracts of residence, and Tract 102.00 in the midtown Manhattan section of New York City indicates 53,361 commuters

from 2,585 tracts. Table 3 illustrates the inbound commuting totals for a mostly residential tract in Fairfax County, Virginia, which draws from a smaller number of origin tracts.

An examination of the commuting flows reveals several limitations. Since the data are based on place of work during the census reference week, they do not always reflect a worker's regular commute, and place of work is sometimes a vast distance from place of residence. A resident of Memphis might have spent the reference week working at the company's Minneapolis facility. However, such occurrences are relatively rare,

TABLE 3 Commuting Flows into Fairfax County, Virginia, Tract 4207.00

Origin of Commute							
State	County	Tract	Total Flow	Tract Allocated	Place Allocated	County Allocated	Flow Used
24	003	7070.00	11	0	0	0	11
24	017	8507.03	7	0	0	0	7
24	027	6067.01	7	0	0	0	7
51	013	1010.00	5	0	0	0	5
51	013	1011.98	14	0	0	0	14
51	013	1012.00	5	5	5	0	0
51	013	1023.00	7	0	0	0	7
51	013	1030.00	6	0	0	0	6
51	050	4159.00	4	0	0	0	4
51	059	4201.00	5	0	0	0	5
51	059	4202.00	4	0	0	0	4
51	059	4203.00	33	0	0	0	33
51	059	4207.00	112	0	0	0	112
51	059	4208.00	6	0	0	0	6
51	059	4211.00	8	0	0	0	8
51	059	4214.00	7	0	0	0	7
51	059	4217.00	6	0	0	0	6
51	059	4223.00	8	0	0	0	8
51	059	4304.00	8	0	0	0	8
51	059	4306.00	6	0	0	0	6
51	059	4314.00	6	0	0	0	6
51	059	4321.00	5	0	0	0	5
51	059	4324.00	22	11	11	11	11
51	059	4325.00	6	0	0	0	6
51	059	4326.00	9	0	0	0	9
51	059	4408.00	8	0	0	0	8
51	059	4515.00	10	0	0	0	10
51	059	4523.00	39	14	14	7	25
51	059	4524.00	9	0	0	0	9
51	059	4525.00	8	0	0	0	8
51	059	4607.00	8	0	0	0	8
51	059	4615.00	6	6	6	0	0
51	059	4811.00	10	10	10	0	0
51	059	4911.00	8	0	0	0	8
51	059	4924.00	8	0	0	0	8
51	069	0504.00	6	0	0	0	6
51	113	9901.00	4	4	4	4	0
51	153	9012.08	3	0	0	0	3
51	153	9012.15	7	0	0	0	7
51	153	9015.98	6	0	0	0	6
51	510	2003.02	6	0	0	0	6
51	510	2008.02	5	0	0	0	5
51	510	2018.01	12	0	0	0	12
<b>Total</b>			480	50	50	22	430

and their impact on overall commuting patterns is negligible.

STP 154 also makes it clear that there is much room for improvement in the geocoding of workplace addresses. For each workplace-residence tract pair, the file indicates the "total" commuting flow, the flow allocated to tract, the flow allocated to place, and the flow allocated to county (or Minor Civil Division in New England). Allocation indicates uncertainty in address coding and is most common at the tract level. For a specific tract pair, the file might identify a total of 40 persons in the commuting flow, with 15 allocated to tract, 5 allocated to place, and none allocated to county. Nationwide, tract of work was allocated for about 52 percent of all commuters, but allocation rates varied widely from area to area. Allocation counts are illustrated in the Table 3 example.

Although the Census Transportation Planning Package (CTPP) indicates 1990 census commuting flows, it was not a viable option for this project. Even if nationwide files of small-area CTPP data had been available, their presentation for tracts in some areas and traffic analysis zones in others would have made their application cumbersome. By comparison, STP 154 was ready to use.

## DEVELOPMENT OF WORKPLACE PRIZM

The strategy for Workplace PRIZM was to use STP 154 to transport residence-based cluster codes with commuters to their tract of work and thereby construct a residential cluster composition at the workplace. The more commuters originating from areas with a common cluster code, the more that cluster would be represented in the tract of work. Although conceptually straightforward, the process was complicated by the limitations of the commuting data. First, the issue of allocation had to be confronted, and second, a decision had to be made on how to use tract-level commuting flows to transport cluster codes specified at the block-group level.

### Allocation

The first inclination was to not allow allocation at any geographic level. This stringent definition of commuting flows often works well in major employment areas where workplace addresses tend to be more codable, but flows become sparse to nonexistent in outlying areas. Because much of the flow allocated to tract is not allocated to place, there was concern that eliminating this portion of the flow would sacrifice valuable information. Therefore, the definition was relaxed to include that portion of the flow requiring allocation to tract but

not to place. In other words, only that portion was removed from the "total" flow that was so uncertain as to require allocation to county, place, or both. The example in Table 3 indicates the "flow used" based on this definition. (Although the "relaxed definition" was used for the standard Workplace PRIZM product, results also were produced with the "stringent definition" for use where it might be judged preferable.)

Tract allocation can result in the misspecification of tracts sending commuters to a tract of work and a distortion of the workplace cluster composition. The impact is impossible to measure, but it can be mitigated by accurate geocoding to place. Because the relaxed definition requires geocoding to place, the residential tracts paired with a workplace tract should be valid for the place in which the workplace tract is located. In outlying areas, where tract coding is most problematic, places tend to be small, and geocoding to place can approach the precision of geocoding to tract. Defaulting to place of employment would be most problematic in large cities with many tracts. However, large cities tend to be major employment centers, where geocoding is relatively strong, and there tends to be less difference between the stringent and relaxed definition of commuting flows. An exception would be the unincorporated portions of large counties, which can have many tracts and high rates of tract allocation.

The consequences of tract allocation can be negated in applications involving tract aggregations, and where such aggregations include whole places, the stringent definition would sacrifice valuable information. Even for individual tracts, the impact of tract allocation can be modest if the cluster mix brought to a workplace through erroneous tract allocation is similar to that brought in through accurate geocoding. In short, allocation probably affects the extent of a cluster's contribution to the workplace mix more than its presence or absence.

Thus, tract allocation is a source of imprecision in the current Workplace PRIZM product, but the impact does not offset the value of the unique capabilities made possible by the census commuting flow data.

### Block Group Clusters into Tract-Level Flows

The Workplace PRIZM strategy was to transport residential cluster codes through a network of commuting flows, and with PRIZM clusters defined for block groups, one would want commuting flows specified at this level. However, tract allocation rates suggest that tract-to-tract flows are sufficiently daring. Tract-level PRIZM codes are available, but their precision and use levels are so much lower that their use in Workplace PRIZM was not seriously considered.

The alternative was to feed block group cluster codes into the tract-level commuting flows. Census tracts contain from one to nine block groups, so up to nine cluster codes had to be transported through each tract-to-tract flow. Rather than weighting all block groups in a tract equally, they were weighted according to the number of workers in the block group—based on the 1990 census journey-to-work tables. If an origin block group had 60 percent of a census tract's outbound workers, that block group's PRIZM code was assigned a 60 percent weight in the relevant tract flow. Note that these within-tract weights are independent of the tract's weight relative to others sending commuters to a specific tract of work.

### WORKPLACE PRIZM PRODUCT

Workplace PRIZM provides a distribution of PRIZM clusters brought to the workplace by inbound commuters. The distribution relates to workers (including those working at home or commuting within the tract) and does not include nonworkers remaining in the area or nonresidents arriving for nonwork purposes. The workplace cluster mix does not necessarily reflect the life-styles of individual workers, but rather the composite life-style and consumer preferences of the neighborhoods from which they commute.

Workplace PRIZM distributions can be viewed in percentage terms, but for many applications, counts of workers by cluster type are desired. Basing such counts on total inbound commuters from STP 154 would place additional pressure on the allocation-laden tract flows and preclude estimates for the current year. For this reason, Workplace PRIZM percentages were applied to independent estimates of tract-level employment produced by Claritas. [Using input from a business list compiled by a commercial supplier and geocoded by Claritas, the Claritas employment estimates also are subject to the limitations of workplace address coding but are based on more recent input and are adjusted for conformity with employment estimates from the Bureau of Labor Statistics and the Census Bureau's County Business Patterns series (3).]

As expected, Workplace PRIZM draws contrasts between residential and workplace compositions, with the workplace reflecting greater diversity. The differences are striking, even for areas as large as Manhattan, whose 886 block groups are assigned to only 13 life-style clusters. In part, this is because clusters in the "suburban," "town," or "rural" cluster groups are not assigned in areas as urban as Manhattan. In contrast, all 62 clusters are represented (albeit sparsely) in Manhattan's workplace composition. As illustrated in Table 4, "native" clusters, such as Urban Gold Coast, Hispanic Mix, Bohemian Mix, and Inner Cities, are well represented in the workplace mix. However, affluent suburban clusters, such as Winner's Circle,

Blue Blood Estates, and Pools & Patios, also have a significant presence, as does Old Yankee Rows, an urban cluster more typical of Brooklyn and Queens. Clusters least represented among commuters to Manhattan include Rural Industria, Grain Belt, and Back Country Folks.

Table 5 illustrates a similar contrast for a census tract in midtown Manhattan. The tract had a 1990 census population of only 320 people living in block groups assigned to the Single City Blues and Young Literati clusters. The inbound commuting flow is much larger at 53,361, and only 7.6 percent come from areas assigned to the two "native" clusters. The largest numbers come from neighborhoods classified as Urban Gold Coast (17.5 percent), Old Yankee Rows (10.3 percent), and Bohemian Mix (8.8 percent). (Of the 53,361 inbound commuters, 20,257 were allocated to tract 102.00. Estimated employment from the Claritas Workplace Population product is 38,139. Workplace PRIZM counts are based on this smaller number.)

The pattern of greater workplace diversity is in part a reflection of reality and in part an artifact of the product's design. By definition, tracts have no more than nine block groups and therefore a maximum of nine block group clusters. A typical tract might have four block groups assigned to just two clusters—clusters that reduce demographic composition to a single code. By drawing from commuters' tracts of residence, Workplace PRIZM casts a wide net and can associate up to 62 PRIZM codes for a single tract of employment. Thus by design alone, Workplace PRIZM will show greater diversity. Nevertheless, there is reason to expect that PRIZM and Workplace PRIZM reflect real and important differences in residential and workplace compositions.

### APPLICATIONS

Workplace PRIZM is not a replacement for standard PRIZM but a supplement that measures life-style and consumer preference patterns that are not detected by the residence-based product. A product might appear to have unimpressive sales potential based on an area's residential cluster composition but look promising on the basis of the workplace composition. In PRIZM terms, the product would be said to have a low market potential index (MPI) but a high workplace potential index (WPI). (MPI and WPI are index scores relative to national penetration rates measured by consumer surveys. If 20 percent of consumers nationwide own a product but a site's PRIZM profiles suggest only a 15 percent penetration, the MPI for that area would be 75. In contrast, the area's Workplace PRIZM composition might suggest a 25 percent penetration, or a WPI score of 125.)

Table 6 presents MPI and WPI scores for a small sample of product categories in the Manhattan tract (102.00)

TABLE 4 Percent Cluster Compositions: Manhattan, New York City

Cluster Group	Cluster	Cluster Nickname	Residential PRIZM	Workplace PRIZM
S1	01	Blue Blood Estates	0.00	2.73
S1	02	Winner's Circle	0.00	3.76
S1	03	Executive Suites	0.00	1.22
S1	04	Pools & Patios	0.00	2.75
S1	05	Kids & Cul-de-Sacs	0.00	2.27
U1	06	Urban Gold Coast	30.73	15.32
U1	07	Money & Brains	0.01	3.90
U1	08	Young Literati	4.50	5.64
U1	09	American Dreams	0.00	5.54
U1	10	Bohemian Mix	17.89	9.17
C1	11	Second City Elite	0.00	1.35
C1	12	Upward Bound	0.00	0.52
C1	13	Gray Power	1.87	1.69
T1	14	Country Squires	0.00	1.06
T1	15	God's Country	0.00	0.70
T1	16	Big Fish Small Pond	0.00	0.19
T1	17	Greenbelt Families	0.00	0.06
S2	18	Young Influentials	0.00	0.31
S2	19	New Empty Nests	0.00	0.86
S2	20	Boomers & Babies	0.00	0.08
S2	21	Suburban Sprawl	0.00	0.47
S2	22	Blue-Chip Blues	0.00	0.41
S3	23	Upstarts & Seniors	0.00	0.22
S3	24	New Beginnings	0.00	0.05
S3	25	Mobility Blues	0.00	0.09
S3	26	Gray Collars	0.00	0.20
U2	27	Urban Achievers	2.69	4.64
U2	28	Big City Blend	0.12	1.49
U2	29	Old Yankee Rows	5.73	11.26
U2	30	Mid-City Mix	0.00	2.60
U2	31	Latino America	0.08	3.81
C2	32	Middleburg Managers	0.00	0.09
C2	33	Boomtown Singles	0.00	0.04
C2	34	Starter Families	0.00	0.09
C2	35	Sunset City Blues	0.00	0.05
C2	36	Towns & Gowns	0.51	0.16
T2	37	New Homesteaders	0.00	0.08
T2	38	Middle America	0.00	0.02
T2	39	Red, White & Blues	0.00	0.03
T2	40	Military Quarters	0.21	0.14
R1	41	Big Sky Families	0.00	0.10
R1	42	New Eco-topia	0.00	0.08
R1	43	River City, USA	0.00	0.03
R1	44	Shotguns & Pickups	0.00	0.01
U3	45	Single City Blues	4.94	2.64
U3	46	Hispanic Mix	19.49	7.13
U3	47	Inner Cities	11.26	4.61
C3	48	Smalltown Downtown	0.00	0.02
C3	49	Hometown Retired	0.00	0.07
C3	50	Family Scramble	0.00	0.04
C3	51	Southside City	0.00	0.08
T3	52	Golden Ponds	0.00	0.02
T3	53	Rural Industria	0.00	0.00
T3	54	Norma Rae-ville	0.00	0.01
T3	55	Mines & Mills	0.00	0.01
R2	56	Agri-Business	0.00	0.01
R2	57	Grain Belt	0.00	0.00
R3	58	Blue Highways	0.00	0.02
R3	59	Rustic Elders	0.00	0.03
R3	60	Back Country Folks	0.00	0.00
R3	61	Scrub Pine Flats	0.00	0.00
R3	62	Hard Scrabble	0.00	0.00

TABLE 5 Percent Cluster Compositions: Manhattan, Tract 102.00

Cluster Group	Cluster	Cluster Nickname	Residential PRIZM	Workplace PRIZM
S1	01	Blue Blood Estates	0.00	4.14
S1	02	Winner's Circle	0.00	4.85
S1	03	Executive Suites	0.00	1.67
S1	04	Pools & Patios	0.00	2.97
S1	05	Kids & Cul-de-Sacs	0.00	2.10
U1	06	Urban Gold Coast	0.00	17.49
U1	07	Money & Brains	0.00	4.17
U1	08	Young Literati	3.08	5.57
U1	09	American Dreams	0.00	5.04
U1	10	Bohemian Mix	0.00	8.79
C1	11	Second City Elite	0.00	1.52
C1	12	Upward Bound	0.00	0.56
C1	13	Gray Power	0.00	1.75
T1	14	Country Squires	0.00	1.64
T1	15	God's Country	0.00	0.74
T1	16	Big Fish Small Pond	0.00	0.18
T1	17	Greenbelt Families	0.00	0.05
S2	18	Young Influentials	0.00	0.46
S2	19	New Empty Nests	0.00	0.81
S2	20	Boomers & Babies	0.00	0.07
S2	21	Suburban Sprawl	0.00	0.55
S2	22	Blue-Chip Blues	0.00	0.36
S3	23	Upstarts & Seniors	0.00	0.21
S3	24	New Beginnings	0.00	0.05
S3	25	Mobility Blues	0.00	0.08
S3	26	Gray Collars	0.00	0.17
U2	27	Urban Achievers	0.00	4.46
U2	28	Big City Blend	0.00	1.58
U2	29	Old Yankee Rows	0.00	10.26
U2	30	Mid-City Mix	0.00	2.20
U2	31	Latino America	0.00	4.11
C2	32	Middleburg Managers	0.00	0.05
C2	33	Boomtown Singles	0.00	0.07
C2	34	Starter Families	0.00	0.05
C2	35	Sunset City Blues	0.00	0.03
C2	36	Towns & Gowns	0.00	0.13
T2	37	New Homesteaders	0.00	0.11
T2	38	Middle America	0.00	0.01
T2	39	Red, White & Blues	0.00	0.05
T2	40	Military Quarters	0.00	0.03
R1	41	Big Sky Families	0.00	0.11
R1	42	New Eco-topia	0.00	0.06
R1	43	River City, USA	0.00	0.05
R1	44	Shotguns & Pickups	0.00	0.00
U3	45	Single City Blues	96.92	2.05
U3	46	Hispanic Mix	0.00	5.09
U3	47	Inner Cities	0.00	3.22
C3	48	Smalltown Downtown	0.00	0.03
C3	49	Hometown Retired	0.00	0.04
C3	50	Family Scramble	0.00	0.02
C3	51	Southside City	0.00	0.09
T3	52	Golden Ponds	0.00	0.02
T3	53	Rural Industria	0.00	0.00
T3	54	Norma Rae-ville	0.00	0.00
T3	55	Mines & Mills	0.00	0.01
R2	56	Agri-Business	0.00	0.02
R2	57	Grain Belt	0.00	0.02
R3	58	Blue Highways	0.00	0.02
R3	59	Rustic Elders	0.00	0.02
R3	60	Back Country Folks	0.00	0.00
R3	61	Scrub Pine Flats	0.00	0.00
R3	62	Hard Scrabble	0.00	0.00

**TABLE 6 Residential and Workplace Product Potential:  
Manhattan, Tract 102.00**

<b>Consumer Profile</b>	<b>Nat'l Pct</b>	<b>MPI</b>	<b>WPI</b>
<b>Fine Jewelry \$400+ Last Yr.</b>	<b>6.2</b>	<b>113</b>	<b>109</b>
<b>Have a Passport</b>	<b>16.4</b>	<b>109</b>	<b>193</b>
<b>Own Pagers/Beepers</b>	<b>4.0</b>	<b>106</b>	<b>132</b>
<b>Own \$1,000+ Computer System</b>	<b>13.4</b>	<b>96</b>	<b>117</b>
<b>Gourmet Coffee Beans Last 6 Mos.</b>	<b>3.5</b>	<b>80</b>	<b>169</b>
<b>3+ Business Trips by Plane</b>	<b>2.3</b>	<b>71</b>	<b>164</b>
<b>Own Luxury Size Car</b>	<b>14.3</b>	<b>63</b>	<b>92</b>
<b>Own Cellular Phone</b>	<b>6.0</b>	<b>57</b>	<b>104</b>
<b>Own Gas Grill</b>	<b>22.1</b>	<b>53</b>	<b>71</b>
<b>Own a Mercedes</b>	<b>0.8</b>	<b>6</b>	<b>130</b>

**MPI = Market Potential Index (Residence)**

**WPI = Workplace Potential Index**

described above. The scores are similar in some categories, such as the purchase of fine jewelry, but quite different in others. For example, on the basis of the residential and workplace cluster compositions, one would expect a greater demand for gourmet coffee beans among the workplace population (WPI = 169) than the residential population (MPI = 80). Similarly, one would expect the tract's workers to be more likely than its residents to be in the market for pagers, cellular phones, and products associated with international and domestic air travel.

Marketers must use judgment, because a high WPI score does not guarantee demand for purchase within the tract. For example, the impressive WPI for Mercedes ownership does not mean that this midtown tract would be a good location for a dealership. However, evidence that Mercedes owners are well represented in the area's large workplace population could be valuable in a variety of marketing applications.

## CONCLUSION

If life-style clusters assume that "you are where you live," workplace clusters assume that "you are where you live even when you are at work." Obviously, the world is not that simple. PRIZM clusters do not reflect the life-style and consumer preferences of every person in an area, and Workplace PRIZM is not a definitive characterization of

the workplace population. Transporting neighborhood clusters with individual commuters leaves ample room for uncertainty, and improvements in the geocoding of workplace addresses are needed to refine even these neighborhood-based specifications.

However, Workplace PRIZM accurately reflects that the workplace is populated with commuters from varied neighborhoods, with characteristics different from those of its residential population. The combination of PRIZM segmentation, small-area employment estimates, and 1990 census commuting flows enables one to specify life-style and consumer preference patterns from the unique perspective of the workplace. Thus, even in its present form, Workplace PRIZM provides valuable information that was previously unavailable and that is already being used in a variety of business applications.

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# Uses of Census Transportation Data by COMSIS Corporation

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William R. Loudon, *COMSIS Corporation*

Over the years COMSIS has developed a number of products related to the census as well as other census-related applications. Working with information from 1970, 1980, and 1990, COMSIS has developed many products that are of direct use to both transportation practitioners and policy makers, including technical reports, training materials, trend and factoring information, and topological geographic information. Through technical committee representation and conference presentations, COMSIS has provided extensive insight into the use of the census data. More specifically, COMSIS has provided guidance in the use of census data as related to transportation planning and travel forecasting. This information is integral to the development of travel models and the understanding of work trip making in a specific region.

Census journey-to-work information continues to be a valuable tool for transportation planning. The use of census data provides information that can be used directly and very cost-effectively to generate travel demand models for home-based-work trip making, which is at the core of peak-hour demand. Information related to trips by mode, trip origin-destination patterns, and trip length can be extracted from census data in support of travel demand model calibration and validation.

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related applications. Working with information from 1970, 1980, and 1990, COMSIS has developed many products that are of direct use to both transportation practitioners and policy makers, including technical reports, training materials, trend and factoring information, and topological geographic information data. Through technical committee representation and conference presentations, COMSIS has provided extensive insight into the use of the census data. More specifically, COMSIS has provided guidance in the use of census data as related to transportation planning and travel forecasting. This information is integral to the development of travel models and the understanding of work trip making in a specific region.

## CENSUS CONVERSION FACTORS HANDBOOK

In order for the 1990 census data to be useful for transportation planners, it must reflect information collected in transportation surveys such as home interviews and on-board studies. COMSIS developed the handbook *Transportation Planning Conversion Factors for Using the 1990 Census*. Inherent to the 1990 census are problems related to biases created by the way in which the journey-to-work questions are asked. Issues related to questions that ask for "typical" or "usual" activity in the previous work week tend to overestimate certain trip making while underestimating others. For example, an

individual might generally use an automobile to go to work but might occasionally use transit. The census data would not reflect any transit use for this case. An analysis compared the 1990 census and the 1990 Nationwide Personal Transportation Survey (NPTS) and developed factors by urban area size. Factors developed include

- **Absenteeism:** related to sick time, vacation, personal business, part-time employment, and business-related travel.
- **Day of the week:** to adjust to any given weekday since certain days represent atypical travel.
- **Mode of travel:** shifts between highway and transit modes.
- **Multiple jobs:** for individuals who hold multiple jobs or make multiple trips to the same place of work from home.
- **Trip chaining:** to distinguish between direct home-to-work trips, as defined in travel model home-based work, from trips that make intermediate stops.

A final analysis included the review of one urban area case study and the use of locally collected survey data as a comparison with the factors developed using the 1990 census and NPTS. This comparison proved to be an important factor in the use of census data for a specific area. Definitions related to trip making and geographic coverage can make the direct comparison of census data with local data difficult. COMSIS was able to provide FHWA with guidance that will foster further investigation of these types of problems.

## CENSUS MAPBOOK

The *Census Mapbook for Transportation Planning* was designed to provide many examples of how U.S. census-related data can be utilized to assist with transportation planning and policy decisions. The mapbook includes 49 examples of how census data can be used in travel demand model development and model validation, population forecasting, corridor analysis, and transit route planning.

## TOPOLOGICAL GEOGRAPHIC INFORMATION

The Census Bureau issues the Topologically Integrated Geographic Encoding and Referencing (TIGER) File periodically as well as specifically for each decennial census. These files provide the geographic units at which census data are collected. The units or "zones" are integral to the development of transportation planning travel models. Through the use of commercially available geographic information system (GIS) software,

COMSIS has used the TIGER File for numerous planning applications. The development of these zone systems is integral to COMSIS project work and the interpretation of census and locally derived data and forecasts. COMSIS also uses the TIGER File and the National Transportation Planning Atlas Data Bases to develop the computerized highway and transit networks needed for planning studies. These data sets can provide the initial step in the definition of a spatially accurate set of transportation networks and can save a local planning agency months of work in setting up a new transportation model or in expanding an existing planning model.

Through project work related to the conduct of major investment studies (MIS) and the predecessor alternatives analyses (DEIS/AA and FEIS/PE), COMSIS has used the TIGER File for

- Geocoding of addresses using TIGER street networks;
- Worker, employment, population, and other data at the block group or block level that can be analyzed for trip generation;
- Common identifier numbers that can reference any collected demographic information and display it graphically;
- Point data for transportation terminals, churches, schools, cemeteries, parks, and other landmarks;
- Reference coverages for use with other topological information such as wetlands, hazardous waste sites, and floodplains;
- Census feature class codes to extract line segments from the TIGER File and build line coverages for numerous classes of roads, railways, and water features;
- Polygon Geographic Entity Codes to create polygon coverages ranging from county to traffic analysis zone level and the accompanying equivalency tables; and
- Definition of transit walk and drive accessibility markets and densities for transit modes that penetrate specific zones.

The ability of planners to tap the wealth of information in the census is somewhat limited by the lack of computer programs that can access the data. Both the Statewide Element and the Urban Element of the Census Transportation Planning Package (CTPP) have limited the ability of transportation professionals to gain quick and direct access to the data. COMSIS has developed generic, platform-independent Statistical Analysis Software (SAS) programs to access and produce tabular summaries of all tables including both the CTPP Statewide Element, Parts A, B, and C, and the CTPP Urban Element, Parts 1, 2, and 3. The programs are designed to allow the user to specify any geographic summary level included in the CTPP. Summary tables are produced by integrating the CTPP and Geographic Reference

Files (GRFs) to provide accurate naming of each geographic summary level available in the CTPP.

The SAS programs can be easily executed either interactively or in a batch mode. They are available for application on any hardware platform (personal computer, work station, mainframe) by adding the appropriate program control commands and are to be available on the Census Bureau computer Bulletin Board System (BBS) by spring 1996. Each program will produce a formatted set of tabular results.

COMSIS has also provided these and other utilities for using census data that are also available on the Census Bureau BBS. These utilities included routines that make access to the Statewide and Urban elements of the CTPP easier with formatted reports that clarify the expansive detail in the CTPP.

### MORE ADVANCED GIS APPLICATIONS

In another more advanced project, COMSIS, working with GIS/Trans Ltd., assisted FHWA in integrating GIS with informational data bases and designing a spatial data base. The product of the study improved the accessibility of the Highway Performance Monitoring System (HPMS) and the National Highway Planning Network (NHPN) to state departments of transportation, FHWA field offices, and other public agencies. It provides organizations that wish to use this information the opportunity to enhance their own planning programs. COMSIS also assisted in improving the National Transportation Planning System through the addition of supplementary data bases and analytical tools in support of the transportation management goals outlined by the Intermodal Surface Transportation Efficiency Act (ISTEA). COMSIS developed import utilities for transferring information between the GIS and the National Transportation Planning System.

A final product of the work was the delivery of transportation-related applications in GIS with the use of video imagery (GIS/video imagery) for use in an FHWA demonstration project (No. 85).

### COMMUTER RAIL STUDIES

As an example of direct integration of off-the-shelf census products, COMSIS has developed a set of simplified models for estimation of commuter rail ridership that are independent of the availability of a traditional set of highway and transit networks. Working on projects for the Georgia and Delaware departments of transportation, COMSIS combined the use of the TIGER File and census journey-to-work files to develop a model that estimates ridership based on employment densities at the

destination end of the trip, the in-vehicle trip distance, and automobile access distance, all estimated with readily available census files. This approach has been used directly to estimate ridership (Delaware Department of Transportation) and as a means to provide distance-sensitive validation of a more traditional mode choice logit model (Georgia Department of Transportation). Such applications are good examples of the cost and time savings that are available to state and local governments through the creative application of readily available census materials.

### TECHNICAL REPORTS

Under contract to FHWA and FTA to develop Urban Transportation Planning Software (UTPS) planners' aids, COMSIS developed the *Transportation Planner's Guide to the 1980 Census*, which describes available data from the 1980 decennial census of value to transportation planners. The material includes

1. Using census data for analytical and model purposes, information available and reporting mechanisms that the Census Bureau uses in their normal decennial data distribution;
2. A special Urban Transportation Planning Package that brings together in one release for each metropolitan area those data items most useful to transportation planners—the most important features of this package are the data available on a tract or zone basis and the trip information available for the journey to work;
3. Data collection methods to supplement census data; and
4. Uses of census data for analysis and model-related purposes—including current situation assessment, trend evaluation, transit planning, accessibility analysis, park-and-ride lot location, land use and arterial spacing consideration, input to planning models, and model calibration and development.

For FHWA, COMSIS has produced technical reports for the 1969, 1977, 1983, and 1990 NPTS and is part of the technical assistance team for the 1995 NPTS (quarterly sample). This survey gathers a national sample of transportation data, which is then used to develop national trends and figures used by transportation planners. This information complements census journey-to-work data, which are derived from the percentage of the census population requested to provide additional detailed information related to traveling to work. NPTS is a true "survey" sample of individuals, with questions related to a specific survey day.

Before the 1990 NPTS, COMSIS was placed under contract to reassess the survey, which had been conducted

three times (1969, 1977, and 1983). This assessment was a result of a serious threat to eliminate the 1990 NPTS. Major incompatibility was suggested between the growing cost of home interview survey methods (as applied by the Census Bureau) and the available resources to conduct the survey. A thorough reassessment of what the survey was intended to be and what alternative methods might exist to carry out and fund the survey was conducted. COMSIS led a study effort in which the firm

1. Contacted and interviewed past and potential users regarding their needs and problems with the existing data,
2. Performed analysis and assisted discussions to establish priorities for data,
3. Developed alternative survey designs and cost estimates, and
4. Developed recommendations to FHWA regarding survey options and follow-up procedures.

As a result of the reassessment, a major new direction was taken for the survey. It is now telephone based and is being conducted by a private market research firm, providing significant cost advantage and time efficiency. The reassessment allowed the survey to continue on schedule,

enjoy a much larger sample size than the previous survey, and offer the users much greater flexibility in its use.

COMSIS developed the 1980 *Census Training Course Student's Notebook*, which includes comprehensive problems and other materials related to a workshop course on using 1980 census data. The beginner's manual was developed to help the first-time census user on the options related to transportation. The course covered the material in the general census releases as well as in the Urban Transportation Planning Package, uses of the data, and lectures and workshops on data use in trip generation, trip distribution, transit use estimation, vehicle occupancy estimation, and pivot point procedure for estimating travel.

COMSIS summarized information from the 1970 and 1980 census data sets and from the 1960 census publications to a geographic base compatible for the three decennial years to develop the report *Journey-to-Work Trends Based on 1960, 1970 and 1980 Decennial Censuses*, in which the changes that have occurred in population, journey-to-work patterns, mode of travel to work, and vehicle availability at the household level were identified. The report focused on those metropolitan areas of the United States with 1980 populations of 1 million or more. Evaluations were made of the differences in the data over the three time periods.

# Services for Use of Census Transportation Planning Package

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Chris Sinclair, *JHK & Associates, Inc.*

Working extensively with the Census Transportation Planning Package (CTPP), JHK & Associates, under contract to the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA), developed and taught the Census Applications Workshops in 1991. The goals of the workshops were to inform transportation professionals about the availability and applications of the CTPP data and to provide hands-on experience with the data. The workshops were conducted in over 30 cities throughout the country with an average of 30 participants in each (about 900 transportation professionals attended). The workshops are no longer being conducted; however, a CTPP Handbook is available from FHWA that documents the topics covered and includes the Lotus 1-2-3 spreadsheet templates that participants used. A brochure and a video oriented toward managers and nontechnical staff that provide an overview of the CTPP and its uses are also available from FHWA. Because interest in the workshops continues to be strong, FHWA and the Bureau of Transportation Statistics have contracted with JHK to offer CTPP Urban Element technical assistance. Also detailed are other uses by the firm of census data, including the Topologically Integrated Geographic Encoding and Referencing (TIGER) File.

**W**ork by JHK & Associates with the Census Transportation Planning Package (CTPP) includes training, use of census data with geographic information system (GIS) software, and model validation.

## TRAINING

### Census Applications Workshops

JHK developed and taught a three-day CTPP training course for FHWA and FTA. The purpose of the workshops was threefold: to inform transportation professionals about the CTPP, to demonstrate how the data could be used in a variety of transportation planning applications, and to enable course participants to work with the data in a series of applications-oriented case studies. The course was designed for a wide variety of interests, including a half-day overview session for non-technical audiences and a series of sessions and case studies that provided hands-on experience to technically oriented participants. FHWA and JHK staff taught the course in over 30 cities throughout the country, with an average of approximately 30 participants per course (over 900 transportation professionals attended the workshop).

JHK prepared a course notebook that was distributed to all participants. The notebook included a diskette with the computer files used in the workshops, so participants had the opportunity to review course materials after completing the workshops. JHK also prepared a CTPP Handbook that was designed for those unable to attend the workshops. A brochure and a 20-minute video were also developed by JHK. The handbook, brochure, and video are still available from FHWA [contact Monica Francois (202-366-6072)].

The course was divided into three modules. The first module, a half-day session, was intended to inform the transportation profession about the usefulness of CTPP data by providing a comprehensive overview of the CTPP and its potential applications.

The second module provided instructions about how to download and present the CTPP data. Downloading the data to a format that could be read by personal computers proved to be one of the biggest challenges for the Census Bureau and FHWA. The CTPP is a huge data base that cannot be effectively stored on floppy disks for distribution. Furthermore, because of the size of the data base, the Census Bureau had organized it in mainframe formats, with record lengths that could not be read by personal computer software.

Recognizing this problem, the Bureau of Transportation Statistics (BTS) contracted with the Caliper Corporation to develop the TransVU software, which operates in a Windows environment. It uses pull-down menus and icons that simplify downloading CTPP data from CD-ROMs into data base or spreadsheet files.

Work on TransVU started after the CTPP workshops began, so earlier courses could only present what the software would potentially do. In the final few courses, an overview of the software was provided. Therefore, Urban Element Technical Assistance (discussed in the next section) will focus on how to use TransVU to download data.

The third workshop module included several case studies that provided hands-on experience with using the CTPP data in a variety of practical situations. The case studies used menu-driven Lotus 1-2-3 spreadsheet templates that uploaded simulated CTPP data (actual data were not available at the time the course was developed) and helped participants through the analysis procedures. The case studies included in the third module were as follows:

- Case Study 1: Downloading CTPP tables. This case study initially used simulated CTPP data files and spreadsheet templates to demonstrate how data were stored and could be downloaded into PCs. Case Study 1 was updated with a TransVU demonstration once the software became available for distribution.

- Case Study 2: Producing outputs. Course participants used the downloaded files from Case Study 1 to prepare tables and graphs in a Lotus 1-2-3 spreadsheet file. Templates were provided to assist participants. This case study was updated once the TransVU software was available.

- Case Study 3: Converting CTPP journey-to-work (JTW) data into home-based-work data for use in travel demand models. Two options were presented; the first was developed by William Mann and the second by Chris Fleet. The procedures were incorporated into a

spreadsheet template that students received with the course materials.

- Case Study 4: Using the CTPP JTW tables directly for transportation analysis. This case study included four situations, each of which had a corresponding spreadsheet template for students to use. The four situations were

- Assessing tax incentives for commuters,

- Evaluating the effectiveness of commuter bus service, and

- Assessing the impact of a plant relocation and identifying carpool potential.

- Case Study 5: Using the CTPP for model validation. This case study demonstrated how the CTPP could be used to develop or check key travel demand model parameters. As with the other case studies, a spreadsheet template was provided.

Detailed case study instructions and spreadsheet templates are available in the CTPP Handbook available from FHWA.

### CTPP Urban Element Technical Assistance

The Census Applications Workshops are no longer offered by FHWA; however, FHWA and BTS are offering CTPP Urban Element Technical Assistance free of charge to the host site. JHK has been retained by FHWA and BTS to coordinate with the host communities. The assistance was scheduled to begin in March 1996 to coincide with the release of specially indexed CTPP Urban Element data on CD-ROM. A brochure describing the assistance was sent to over 1,000 transportation professionals throughout the country and JHK has received a number of workshop requests. Interested communities should contact Whit Blanton at JHK (407-422-8813).

The technical assistance program will focus on the Urban Element of the CTPP, which summarizes the data by traffic analysis zone (TAZ) as defined by metropolitan planning organizations (MPOs). The Census Bureau is in the process of releasing the Urban Element on CD-ROM, along with the TransVU software, to all MPOs in the country. The technical assistance workshops are designed to allow participants to learn what is in the data set and how to apply actual data (which were not available in the Census Applications Workshops). Before providing technical assistance, JHK will contact each host community to learn what its issues and needs are. The workshop will then be tailored to address the specific needs of the host community.

The program will also cover the use of TransVU, which is designed specifically to access the CTPP Urban

Element data base. Participants will use TransVU to work through several case study applications.

## GIS/CTPP APPLICATIONS

JHK assisted several MPOs in Florida with their Transportation Plan updates, as required by the Intermodal Surface Transportation Efficiency Act (ISTEA). The Topologically Integrated Geographic Encoding and Referencing (TIGER) File and CTPP data were extensively used in these plan updates, with the help of PC ArcInfo geographic information system (GIS) software. The following sections describe the firm's use of TIGER and CTPP data.

### TIGER File and Networks

The TIGER File was used to update TRANPLAN travel demand model networks. JHK developed a routine that automatically converts TRANPLAN networks into a GIS layer. A modified rubber sheeting process was used to match TIGER and TRANPLAN network layers. Detailed network checks were made with the overlay.

Several routines were developed by JHK to upload TRANPLAN network assignment results. Network links were grouped into longer segments and a routine was developed that calculates a weighted average segment volume from individual link volumes (link lengths were used as the weights). A second routine estimated the segment's level of service (LOS) using the Florida Department of Transportation's Generalized LOS Tables (based on 1985 *Highway Capacity Manual* procedures). A third routine (still under development) will determine a segment's LOS threshold using a lookup table and segment information entered by the user. This segmentation simplified the network evaluations using LOS thresholds (as adopted by the localities in the MPO study area) rather than model-estimated capacities.

The TIGER-based TRANPLAN GIS network became the base for a number of network data bases. For many MPOs, this layer will be used by the Congestion Management System (CMS) for existing and future year deficiency analyses. Other pertinent information attached to this layer included items such as functional classification (i.e., National Highway System, Florida Intrastate Highway System, local road), hurricane evacuation route, freight and goods movement route, and so forth.

### TAZ Data

The TIGER File was used by JHK to create a TAZ polygon layer in GIS. The TAZ layer enabled a number of

checks to locally developed data. JHK developed a routine that downloads CTPP data from CD-ROM (outside the TransVU software) and compares these data with locally developed data. As expected, the residential data (Part 1 in the Urban Element) closely matched local data; however, employment data (Part 2 in the Urban Element) did not match well. GIS was used to highlight TAZs on a series of maps where there were large differences between local and CTPP data. Corrections were made with aerial photographs, phone calls to large employers, and land use maps.

In Orlando, the TAZ layer was used to aggregate socioeconomic information from the CTPP and local sources and land use information from a Water Management District GIS layer into sector data needed by the DRAM/EMPAL land use allocation models. The models were used by the MPO to help determine future year development patterns based on transportation alternatives.

### Model Validation Checks

JHK used the CTPP to check TAZ data and to review the accuracy of trip distribution and mode choice models. Home-based-work (HBW) trip tables estimated by the models were compared with factored JTW information in Gainesville, Florida, to determine the reasonableness of district-to-district trip interchanges (each district was an aggregation of TAZs). Results indicated that the models reasonably estimated interchanges; however, adjustments were needed between districts. In addition, the CTPP was used to check the reasonableness of peak-period (HBW) transit trip tables from the modal choice model. Again, adjustments were made to more closely match the CTPP.

The University of Florida is located in Gainesville, and bicycle trips represent a significant portion of the overall travel demand. The CTPP was used to develop a bicycle trip table (the MPO's model does not include bicycle or pedestrian trips) that was expanded to include all trips and factored on the basis of growth trends in individual TAZs and parking limitations on the University of Florida campus to estimate future year bicycle travel.

## SUMMARY

JHK prepared and conducted over 30 Census Applications Workshops for FHWA. As part of the contract with FHWA, JHK prepared a CTPP Handbook, which covers the same material as the workshops, and an informational brochure and video designed for managers and nontechnical staff. The workshops are no longer

available, but the handbook, brochure, and video are. Because of the demand for CTPP training, FHWA and BTS have contracted with JHK to provide Urban Element Technical Assistance to transportation professionals. The assistance will demonstrate how to use TransVU, a CTPP extraction software, and how to use TAZ-level data to address local issues. A number of re-

quests have been received for the training, which will begin in March 1996.

JHK has also used the CTPP in several transportation planning applications. The firm used the TIGER File and the CTPP in GIS software to update Transportation Plans for MPOs in Florida. JHK also used the CTPP for model validation checks.



# SMALL METROPOLITAN AREAS

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# Census Data in Transportation Planning, Rutland County, Vermont

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Dean L. Pierce, *Rutland Regional Planning Commission*

Recent experiences are described of a predominantly rural regional planning organization that is using data from the U.S. census for transportation planning purposes. These experiences include analyzing the statewide Census Transportation Planning Package to reveal journey-to-work trip patterns and to improve the calibration of the region's newly developed traffic forecasting model. In light of the planning organization's limited budget and staff, census transportation data proved essential to the timely completion of these tasks. The data also significantly increased policy makers' understanding of transportation issues and, when used in a "fratar" technique, vastly improved the usefulness of the traffic model. In general, any limitations of the census transportation data were easily overcome or were small relative to their advantages. Experience suggests that the Census Bureau should consider release of Urban Element data for very small metropolitan areas in the future.

Since late 1992, the Rutland Regional Planning Commission (RRPC) has provided a range of transportation planning services to 27 predominantly rural municipalities in west central and southwestern Vermont. The RRPC has participated in a statewide Transportation Planning Initiative (TPI), working in close cooperation with the Vermont Agency of Transportation (VAOT) and Vermont's 11 other regional planning organizations.

As a partner in the TPI, the RRPC has been responsible for the completion of numerous tasks, including the development of a comprehensive regional transportation plan, a regional traffic forecasting model, and lists of transportation problems and improvement priorities. In carrying out these tasks, the RRPC has made extensive use of data from the U.S. census, particularly the Census Transportation Planning Package (CTPP) (1).

The purpose of this case study is to document some of the applications related to transportation planning that were performed using census data in the Rutland region. Indicated in connection with each application will be how crucial the data were to the completion of the application, including whether or not the data were essential and, if not, what information might have been substituted. Also touched on are issues such as the context and objectives of the applications, relevance to transportation planning at other administrative levels and in other geographic locations, and problem solving. However, in light of space and time limitations, extensive details are not provided.

## BACKGROUND

The RRPC was created in 1968 and provides leadership and technical expertise to encourage cooperative planning among the Rutland region's communities and areawide interests. The RRPC's policies are advisory, although some do have legal standing in certain regulatory

proceedings (2). The Rutland Region Transportation Council (RRTC) serves as the Transportation Advisory Committee (TAC) to the RRPC and provides members for several working groups and subcommittees.

The Rutland region, which comprises 27 predominantly rural municipalities in west central and southwestern Vermont, has a total population of 61,753 (1990). The heart of the Rutland region, which includes the state's second largest city (Rutland), is located approximately 100 mi northeast of Albany, New York, and 165 mi northwest of Boston, Massachusetts (Figure 1).

Approximately 945 mi<sup>2</sup> in size, the region boasts a wide range of natural resources, which serve as the foundation for several sectors of the economy, ranging from agriculture and mining to recreation and tourism. The Rutland region is the home of the nationally recognized Killington and Pico ski areas.

The transportation system in the Rutland region, as in most other rural areas, is primarily highway-oriented. The region is located at the intersection of two National Highway System (NHS) routes—US-7 and US-4; however, it does not have a direct connection to the federal Interstate highway system, and only limited sections of the NHS routes are access controlled. The transportation system also includes a small commercial aviation airport and significant mileage in railroad track. Public transit is available in and around the urban core and between the urban core and the Killington ski area (Figure 2).

The primary transportation issues facing the region include the need to address traffic congestion and safety problems in the urban core and in village areas along the

major highway corridors. Also included is the need or desire to improve the transportation connections between the region and surrounding regions and states through highway, air, and rail improvements (3).

Through the Vermont TPI, the staff of the RRPC/RRTC and similar organizations have attempted to use planning as a tool to depoliticize the identification and programming of projects needed to solve important transportation problems in the state. Census data have been used extensively in analyses and evaluations intended to serve as the foundation for informed and rational decision making. In the next section of this paper some of the applications related to transportation planning that have been performed in the Rutland region using census data will be briefly documented.

### APPLICATIONS AND EXPERIENCE

Census data have been used in comprehensive transportation planning activities in the Rutland region since 1992. Some possibly noteworthy applications of census data for transportation purposes include the following:

1. Using CTPP data to reveal journey-to-work (JTW) trip patterns by major (and minor) mode regionwide,
2. Using CTPP data to reveal JTW town-to-town trip patterns (across all modes) regionwide, and
3. Using the CTPP-based JTW town-to-town trip table to improve the calibration of the region's newly developed traffic forecasting model (by "fratarating" the initial distribution of trips using the CTPP JTW trip table).

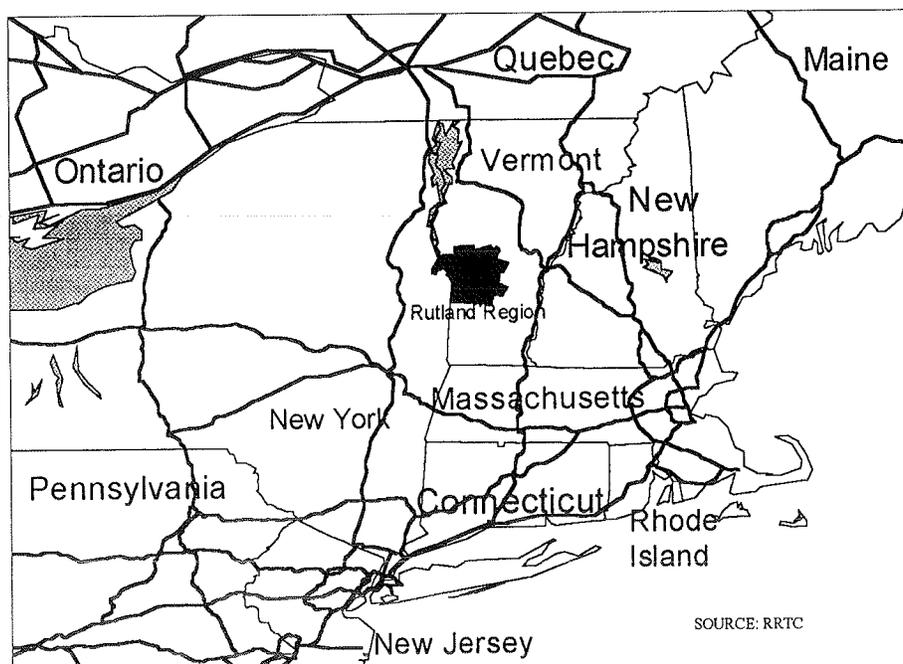


FIGURE 1 Location of Rutland region within northeast United States.

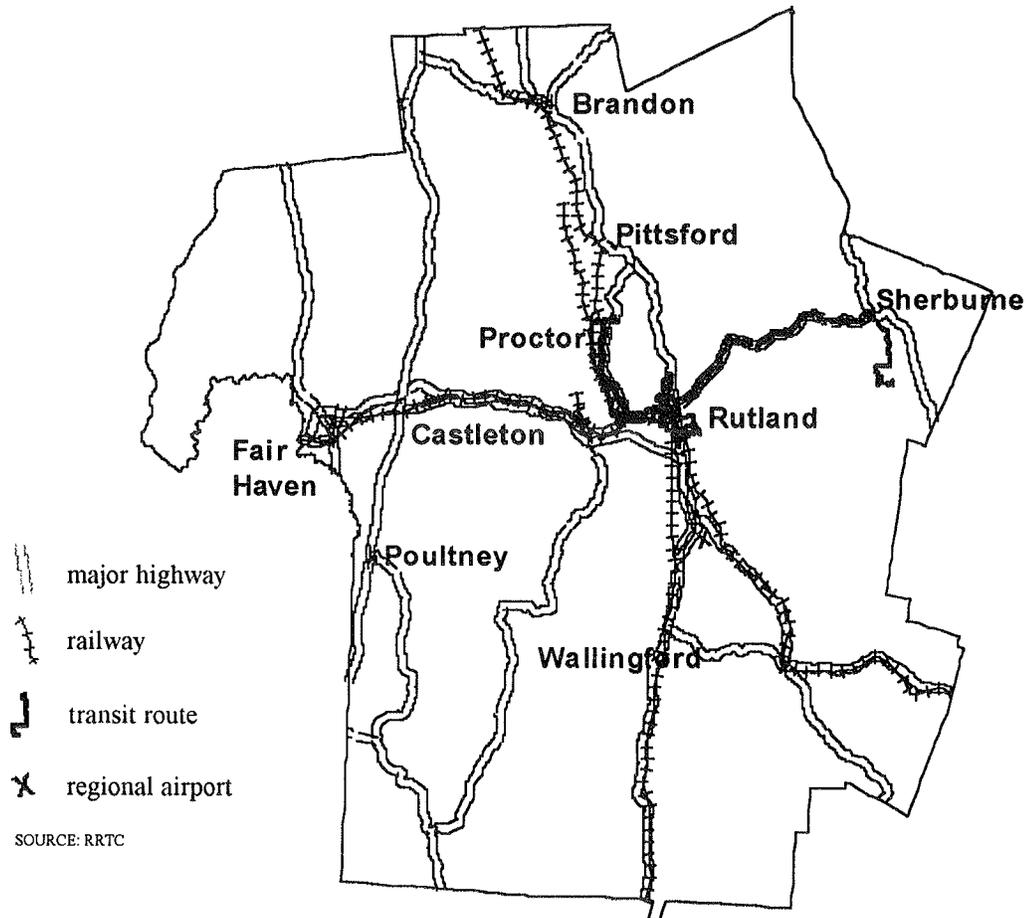


FIGURE 2 Rutland region transportation system.

Applications 1 and 2 were carried out in the course of developing the "Existing and Future Conditions" section of the Rutland Region Transportation Plan. As noted earlier, Application 3 was carried out during the development of the Rutland region's regional traffic forecasting model based on Quick Response System II for Windows (4); the model was used in a limited capacity in the transportation plan.

#### Application 1: Using CTPP Data To Reveal JTW Trip Patterns by Major (and Minor) Mode Regionwide

The approach used to carry out Application 1 was straightforward and involved little more than the extraction of the data from the CTPP dataset, entry into commercial presentation software (Harvard Graphics for Windows, Version 2.0, and Microsoft Publisher for Windows, Version 2.0), and preparation of suitable tables and pie charts. For comparative purposes, similar data for 1980 were obtained by referencing Census Bureau publications and handled in the same manner (Table 1

and Figure 3). To disseminate this information, the tables and charts were published in regional transportation newsletters and the regional transportation plan.

Presentation of this information confirmed for policy makers the overwhelming reliance of residents on the personal automobile for work trip travel. Perhaps more important, it also hinted at the potentially significant impact that relatively small changes in JTW mode choice could have on vehicle miles traveled by alternative transportation modes.

#### Application 2: Using CTPP Data To Reveal JTW Town-to-Town Trip Patterns (Across All Modes) Regionwide

Application 2 was also carried out by extracting data from the CTPP dataset, entry into commercial presentation software, and preparation of suitable tables and graphics. It also involved the preparation of data-base files (.dbf) compatible with Arc/Info geographic information system (GIS) software and the use of Arc/Info to prepare maps portraying regional place-of-work patterns (Figure 4).

TABLE 1 Means of Transportation to Work, Rutland County, 1980 and 1990

Mode	1980	1990
Single Occupancy Vehicle	14,551	21,612
Car Pool	6,487	4,384
Public Transportation	185	87
Other	2,897	2,228
Worked at Home	1,117	1,732
Total	25,237	30,043

Source: U.S. Census

The first step in the process was the preparation of a master matrix showing where workers live and where they work on a town-by-town basis across the entire region. The next step in the process was the preparation of "simplified" tables based on the master matrix. Examples of these include tables showing where workers live on a town-by-town basis and where they work on the basis of various categories, for example, at home, in their home municipality, in another municipality within the county, in the Rutland urban core, and outside the county (Table 2).

Numbers included in the simplified tables were then exported in data-base format (.dbf) for use with Arc/Info software. Finally, the GIS software was used to prepare shaded thematic maps based on the tables, and the matrix, tables, and maps were published in community data profiles, newsletters, and the regional transportation plan (Figure 5).

Presentation of the information produced in the second application confirmed policy makers' intuitive understanding of the macro (regional) pattern of JTW trips within the region. The information also shed light on

micro (town-level) patterns that had heretofore been undocumented and therefore were not very well understood.

### Application 3: Using CTPP-Based JTW Town-to-Town Trip Table To Improve Calibration of Region's Newly Developed Traffic Forecasting Model

The third application of census data took place within the considerably more complex process used to develop the region's new traffic forecasting model. In the most basic terms, however, Application 3 was simply an extension of one of the products created in Application 2, the master matrix depicting where workers live on a town-by-town basis and where they work on a town-by-town basis across the entire region.

With the assistance of consultants, the Rutland region initiated the development of a microcomputer-based regional traffic forecasting model using QRS II software. Model development was initiated with an eye toward

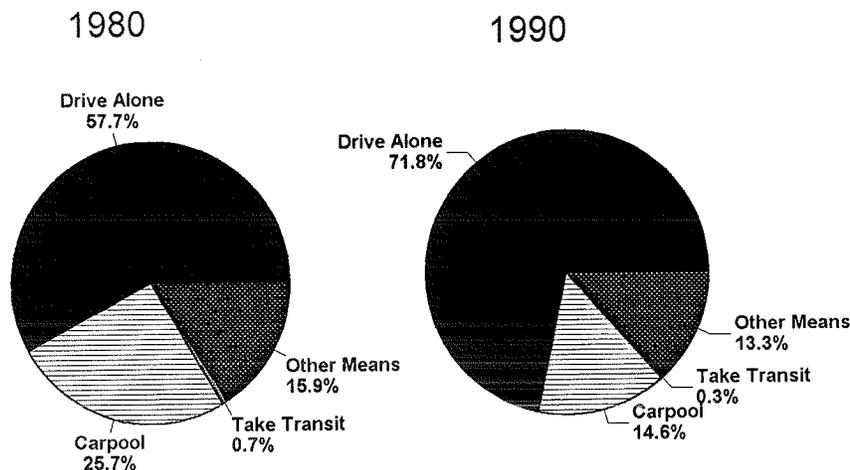


FIGURE 3 Generalized means of transportation to work, Rutland region, 1980 and 1990.



TABLE 2 General Location of Work by Place of Residence, Rutland Region, 1990

Place of Residence	Work Location:			
	At Home	In Place (town), Outside Home	In Region, Outside Place	Outside Region
Benson	407	107	300	47
Brandon	1880	926	954	278
Castleton	2097	768	1329	192
Chittenden	541*	115*	426*	34*
Clarendon	1541	291	1250	88
Danby	567	164	403	258
Fair Haven	1183	444	739	157
Hubbardton	262	41	221	26
Ira	221	30	191	14
Mendon	584	137	447	37
MiddletownSprings	350	85	265	43
Mount Holly	458	128	330	162
Mount Tabor	114	7	107	54
Pawlet	679	258	421	387
Pittsford	1527	413	1114	61
Poultney	1622	777	845	208
Proctor	933	225	708	38
Rutland City	8587	6088	2499	342
Rutland Town	1974	250	1724	151
Sherburne	441	315	126	67
Shrewsbury	545	133	412	50
Sudbury	256	59	197	67
Tinmouth	191	61	130	19
Wallingford	1107	311	796	85
Wells	415	65	350	215
West Haven	166	37	129	13
West Rutland	1222	212	1010	42
Total				

Source: U.S. Census, Census Transportation Planning Package

\*NOTE: Town of Chittenden data as reported prior to correction

in the region (as documented by the CTPP and described in Application 1), the decision was made to assign all trips generated in Step 2 to the highway-nontransit mode and assume the NCHRP Report 187 defaults for automobile occupancy (Step 3 of the modeling process).

Finally, Step 4 (trip assignment) was accomplished using QRS II system defaults and a highway speed table based on functional classification.

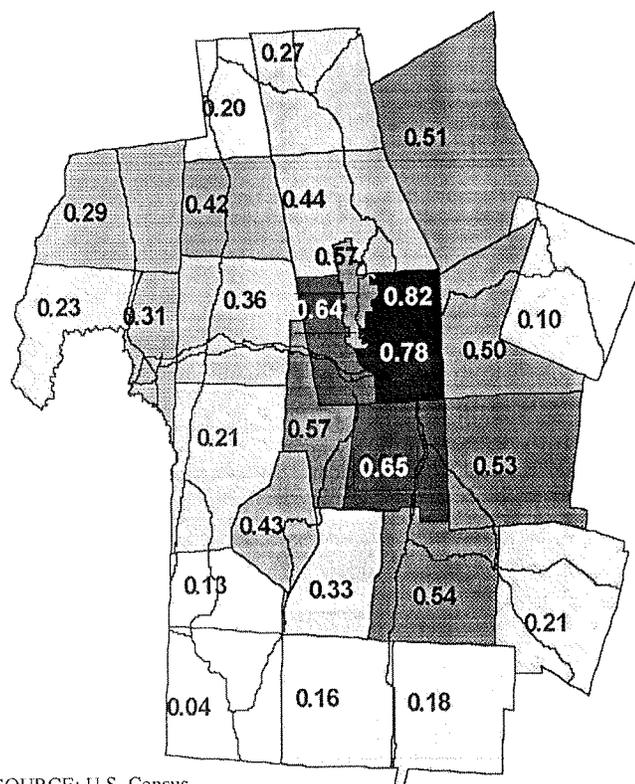
Some key assumptions were made in the course of carrying out the third application. One of these was that the pattern of JTW trips embodied in the CTPP data fairly reflects the pattern of all trips on the regional highway system as a whole on a daily basis. A second was that use of CTPP JTW data would not mask important changes in trip patterns caused by population or employment growth

projected to take place in the region by the model's forecast year.

#### UTILITY OF CENSUS DATA

The utility of census data for transportation could be measured in a number of different ways. For the purpose of this paper, effectiveness has been measured in terms of

1. How crucial the data were to the completion of a project, including whether or not the data were essential;
2. If the data were essential, what made them so; and
3. If the data were not essential, what information might have been substituted to complete the application.



SOURCE: U.S. Census

FIGURE 5 Percentage of workers with journey-to-work destination in Rutland urban core, Rutland region, 1990.

### Application 1

Census data were central to the completion of Application 1. Without the data, the Rutland region would have (a) incurred significant expense and time delay in an attempt to collect this information independently, (b) “borrowed” data from a similar region and chosen to assume that mode choices in both areas were essentially the same (potentially erroneous), or (c) decided to ignore the issue of mode choice and proceeded to plan for the region’s transportation needs on the basis of “guesstimates.”

Recently, consultants working for the VAOT completed a statewide household travel pattern survey that could begin to substitute for the data used in Application 1. However, this information has advantages as well as disadvantages relative to use of census data. Its major advantage is that it incorporates data about all trip purposes, not only JTW trips, and is thus more robust. Its major disadvantage is that it was collected on a statewide basis and represents a very small sample of the Rutland region’s households (~200). Although it is tempting to assume that statewide trip-making characteristics will mirror those found in the region, it is not clear that this assumption is any more valid than the assumption to borrow from a similarly situated geographic region.

### Application 2

Census data were also central to the completion of Application 2, for the same reasons indicated for Application 1. The data allowed policy makers to see and understand the regional pattern of JTW trip making at the same time they were developing a regional transportation plan. Again, without the data the region would have (a) incurred significant expense and time delay in an attempt to collect this information independently, (b) “borrowed” data from a similar region and chosen to assume that mode choices in both areas were essentially the same (potentially erroneous), or (c) decided to ignore the issue of mode choice and proceeded to plan for the region’s transportation needs on the basis of guesstimates until the completion of state-level surveying. And again, a major disadvantage of the statewide survey is that it represents a very small sample of the Rutland region’s households and is not necessarily better than the remaining alternatives.

### Application 3

Census data were not essential to the completion of the trip distribution step of the regional modeling process. However, the information did assist dramatically in improvement of the model (Table 3). Following employment

**TABLE 3 Impact of Census Journey-to-Work Data on Traffic Model Screen Lines**

Screen Line	Deviation from Actual Counts (in Percent) at Conclusion of:		
	Initial Calibration	Fratar with Census data	Final Calibration
A	58.90	19.75	15.45
B	11.52	-17.60	-19.49
C	32.12	0.84	-10.27
D	88.75	33.20	22.45
E	26.51	2.92	-0.61
F	68.83	28.42	20.84
G	23.07	5.68	5.37

Source: U.S. Census, Census Transportation Planning Package

of the fratar technique and the census data, differences between actual and modeled volumes at screenlines dropped from unacceptable to acceptable levels. (Census data were also highly valuable in the trip generation step of regional modeling, although this was not considered to be part of Application 3 as it is summarized here).

In the absence of census JTW data, the Rutland region might have either spent a considerable amount of time continuing to calibrate the traffic model (with no guarantee of success) or simply accepted the model in its earlier iteration, which in hindsight would not have been desirable.

As indicated above, the recently completed VAOT statewide household travel pattern survey might begin to substitute for the JTW data used in the region (6). But both its advantages and disadvantages relative to census data remain. The RRPC might also have waited for the completion of the statewide traffic model and avoided developing a regional model; however, confidence in planning decisions based on the statewide model would likely never have approached that of decisions based on a regional model.

#### ADDITIONAL COMMENTS

The following additional comments are intended to address questions raised by the conference steering committee.

#### Relevance of Applications to Regional or Statewide Transportation Planning Programs

In Vermont, regional transportation planning is taking place as a component of the statewide transportation planning effort. Regions across Vermont are already us-

ing census data in applications similar to those described here and in other ways.

#### Limitations of Census Data

The major limitation of census data for transportation planning in the applications described here is the relatively large or high level of geography for JTW trip origins and destinations (including aggregation of some towns with areas in excess of 20 mi<sup>2</sup>). The region chose to base its traffic analysis zones (TAZs) on the census block groups owing to the availability of this type of data; availability of data for smaller geographies would have benefitted the modeling process. The release of Urban Element data for very small metropolitan and non-metropolitan areas such as the Rutland region should be given serious consideration by the Census Bureau if this data program continues.

#### Problems Encountered

Problems encountered in the data included coding errors most likely resulting from confusion surrounding trips to or from Chittenden County in northwest Vermont and Chittenden town in west central Vermont. The county is Vermont's most populous (>125,000 residents); the town, on the other hand, is very rural (<1,200 residents). A number of trips presumed to end in Chittenden County were mistakenly assigned to end in Chittenden town.

#### Fixes Made

JTW trip data for Chittenden data were adjusted using data from the Vermont DET. Future censuses should in-

clude more rigorous data-checking routines that screen for place-of-work coding errors in states with similarly named county and subcounty geographies.

### Recommendations for Other Areas

Very simply, small or rural regions should take advantage of census data while the information is still available and free.

### Transferability to Other Areas

The applications of census data made in the Rutland region were relatively straightforward. Virtually any region or metropolitan planning organization (MPO) could employ Applications 1 or 2. Virtually any region or MPO developing a regional model could consider employing Application 3.

### ACKNOWLEDGMENTS

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# Small-Area Applications Using 1990 Census Transportation Planning Package: Gainesville, Florida

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The 1990 Census Transportation Planning Package (CTPP) was a valuable resource for the Gainesville Urbanized Area during the recently completed development and adoption of the 2020 Transportation Plan. The CTPP provided detailed information about socioeconomic and travel characteristics that was unavailable from other sources. These data were of value during several stages of development of the plan, which was adopted by the Gainesville Urbanized Area metropolitan planning organization on December 14, 1995. A case study of how the CTPP was used for the Gainesville Urbanized Area in its long-range transportation planning efforts is presented. The focus is on how the CTPP was used to validate the travel demand model in preparation for the development and evaluation of multimodal alternatives for the Gainesville Urbanized Area 2020 Transportation Plan.

**A**lachua County is a mostly rural county in north central Florida with a population in 1990 of 181,600. Of the nine incorporated cities in Alachua County, Gainesville is by far the largest, with a 1990 population of 84,800. Unincorporated Alachua County had a 1990 population of 83,100. Although Alachua County's economy is based on agriculture and correctional facilities, Gainesville is the major urban center in an 11-county region. Gainesville is home to the 35,000-student University of Florida and a major health care and regional state administrative center. The nearest major population centers are Jacksonville and Or-

lando, both more than an hour's drive away. Figure 1 identifies Gainesville and Alachua County within the state of Florida.

Beginning in early 1994, the Gainesville Urbanized Area metropolitan transportation planning organization (MTPO), in coordination with the Florida Department of Transportation (FDOT), embarked upon the development of a countywide travel demand forecasting model in preparation for the upcoming update of the urban-area long-range transportation plan. To coincide with data available from the 1990 census, the MTPO and FDOT chose 1990 as the base year for the model validation effort. The travel demand forecasting model in use before this study had been developed and validated for the Gainesville metropolitan area only. The Gainesville MTPO and FDOT hired JHK & Associates to conduct the countywide model validation. JHK was subsequently hired by the MTPO to prepare the Gainesville Urbanized Area 2020 Transportation Plan.

With development continuing to encroach into rural Alachua County and passage of the Intermodal Surface Transportation Efficiency Act (ISTEA) in 1991, the Gainesville MTPO and FDOT determined that a countywide, multimodal travel demand model would be needed to be able to effectively evaluate the impacts of future growth and to test alternatives other than adding roadway capacity. In addition, with an involved and interested public, the presence of the University of Florida, and very competent professional staff, the Gainesville

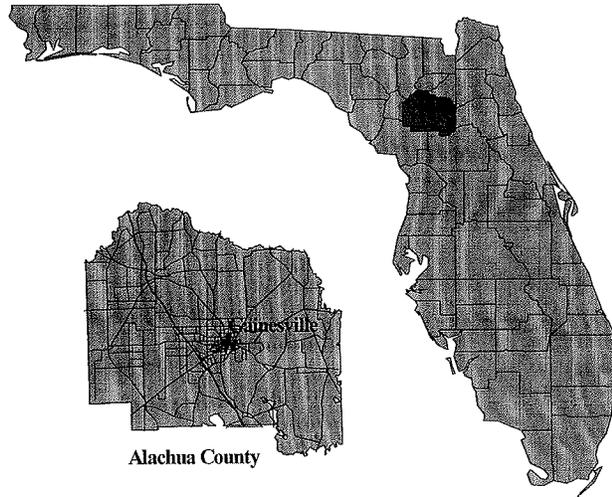


FIGURE 1 Gainesville, Florida, and vicinity.

area has done much to emphasize planning for nontraditional travel modes, including bicycling, walking, and on-campus transit service. As a result, the 2020 Transportation Plan would need to effectively address the need for improvements to these modes.

It should be noted that the staff for the Gainesville MTPO's long-range planning efforts consists of the director of transportation planning and two transportation planners from the North Central Florida Regional Planning Council. FDOT maintains a Gainesville urban office, in which a regional planning administrator and two transportation planners are located. With the small number of staff assigned to various planning studies, there was a strong need for available data sources like the census to provide needed inputs into the development of the Transportation Plan.

## APPLICATIONS OF CENSUS TRANSPORTATION PLANNING PACKAGE

The Census Transportation Planning Package (CTPP) was used for a variety of applications during both the model validation effort and the update of the Transportation Plan for 2020. This section presents a discussion of the main CTPP applications, limitations, or problems encountered with the data and results of the applications.

### Model Validation

The Alachua County model was developed for a base year of 1990 (1-3). Model validation consists of developing and updating travel demand parameters used in the traditional four-step travel demand forecasting process con-

sisting of trip generation, trip distribution, mode choice, and trip assignment. These parameters include trip generation rates, trip length frequency distribution curves, automobile occupancy factors, and so forth.

During model validation, the Topologically Integrated Geographic Encoding and Referencing (TIGER) File was used to develop the network and traffic analysis zone (TAZ) boundaries for the portion of the county outside the Gainesville metropolitan area boundary, which had been the study area for the previous long-range plan. Census data were used for the following major applications:

- Developing socioeconomic data inputs for the travel demand model;
- Calibration of trip generation rates for home-based-work (HBW) trips;
- Reasonableness checks of average trip lengths for the journey to work;
- Providing documentation for HBW automobile occupancy factors; and
- Developing a methodology to estimate the number of bicycle trips made in the urbanized area.

Each of the above items is briefly described below, with more detailed discussions of the calibration of HBW trips and bicycle trips.

### Socioeconomic Inputs

Census data were used by MTPO and local government staff in the development of the socioeconomic data by TAZ for the travel demand model. These data include population by household size and automobiles available and employment information by type (commercial, service, industrial, and total). Preparation of the TAZ-level socioeconomic data was delayed for several months while staff waited for the release of CTPP Urban Element, Parts 1 (Place of Residence) and 2 (Place of Work). In lieu of the CTPP data, local sources were used for the arduous process of developing the data. About halfway through this process, the Census Bureau provided a CD-ROM version of CTPP, Parts 1, 2, and 3.

Upon review of the place-of-residence data, local government staff determined that there were serious flaws in allocation of these data to TAZs, and much of the population information was provided from local sources. Although the Census Bureau did a reasonably good job of coding place-of-residence data to larger geographic areas (e.g., to the University of Florida or to the cities and places within the county), local government staff found that the TAZ-level geocodes were not accurate. However, the CTPP data on automobiles available and household size were used almost without modification, because the CTPP was the only available source for this

information. JHK & Associates made some reasonableness checks of these automobile ownership percentages, and although a few adjustments had to be made, the data were considered accurate.

Employment data by TAZ from the CTPP, Part 2, was the best source of this information for local government planners, so not much was changed. MTPo staff collapsed several categories of employment by occupation into the three required by TRANPLAN, the standard travel demand forecasting software used in Florida. However, some errors were noted during the validation data review process. For example, some 15,000 employees (about two-thirds of the entire complement of the University of Florida's faculty and staff) were coded to a single TAZ located across the street from the university campus, and nearly 1,000 service and commercial workers were coded to the TAZ containing Sorority Row. Several other changes were made in the TAZ allocation of employment data during this review process, but the CTPP data remained largely intact.

It should be noted that because of several inaccurate codings and the problems encountered by local government staff with the information on place of residence, a great deal of effort was spent developing and reviewing the 1990 base year socioeconomic data. In this regard, having the CTPP proved to be marginally helpful because it provided information unavailable from other sources; however, it did not result in any appreciable time or cost savings.

### *Calibration of HBW Trip Rates*

During the validation process, it was noted that the travel demand model was underassigning trips on the highway network for most of the urbanized area. This was particularly evident on the more affluent west and north sides of Gainesville. The last travel characteristics survey for Gainesville, upon which the default trip generation rates are based, was conducted in 1971. On the basis of this review of link volume-to-count ratios, the 1990 CTPP was consulted to determine if changes in work trip rates were justified. As described below, the CTPP was used to calibrate the HBW trip generation rates used in the forecasting process.

HBW trip productions for Alachua County predicted by the model were compared with data obtained from the 1990 CTPP. The census identified the number of people living in Alachua County, the total number of employees in the county, and the number of employees who live and work in the county. On the basis of those breakdowns, the census shows that approximately 16,500 of the people employed in Alachua County live outside the county. In addition, the census identifies the number of one-way journey-to-work (JTW) trips made by Alachua County residents. To account for the trip

from work to home and chained trips, the census JTW trips were multiplied by a factor of 1.85 to obtain estimated HBW trips. This conversion factor was estimated for Alachua County but was based on the procedure used in the Census Applications Workshops case study application showing how to convert census JTW totals into HBW trips.

Based on this comparison, the total HBW productions were estimated to be about 142,000 trips per day. The standard travel demand model trip generation rates for Gainesville resulted in the generation of about 102,400 daily HBW trips. Therefore, the HBW trip generation rate was uniformly increased by 40 percent for all the cells in the cross-classification table to reflect census survey results. Checks of the CTPP tables were made to determine if the increase should vary by household size and automobiles available. These checks indicated no justification to weight the increase by different automobile ownership or household size characteristics. The trip rate adjustment is as follows:

- Alachua County total employment, 93,006;
- Alachua County resident employees, 76,615;
- JTW to HBW adjustment factor, 1.85;
- 1990 CTPP HBW trips, 141,738;
- 1990 model-estimated HBW trips, 102,430; and
- HBW trip rate adjustment factor, 1.40.

The result of this increase in the HBW trip generation rates was a much improved volume-to-count ratio along screenlines. These improvements were most noticeable for northwest and southwest Gainesville. It was believed that additional increases in trip rates were needed to improve model results. Without data justifying increases in trip rates for other trip purposes (such as shopping or school), however, these adjustments were not made. Thus, a limiting aspect of the CTPP is that only JTW trips are included.

### *Automobile Occupancy and Trip Length Reviews*

Because a household survey had not been conducted recently in Alachua County to determine travel characteristics such as automobile occupancy rates, it was necessary to borrow automobile occupancy factors from the CTPP and similar study areas. There are eight trip purposes in the travel demand forecasting model used in the county: home-based-work (HBW), home-based-shopping (HBS), home-based-social/recreational (HBSR), home-based-other (HBO), non-home-based (NHB), truck-and-taxi (TT), internal-external (IE), and external-external (EE). Only the first five of the above-listed purposes are included in the mode choice module of the model chain. The CTPP Statewide Element was used to obtain an automobile occupancy factor of 1.09

for HBW trips in Alachua County, and the other factors were borrowed from other study areas with similar characteristics.

In addition to the trip generation check described previously, this comparison of model results and CTPP data was made for the trip distribution step. All TAZs in the county were aggregated into 10 districts, and district-to-district travel flows for HBW trips were reviewed to determine how well the trip distribution model was performing relative to observed data from the census. However, because of inaccuracies in the coding of census survey responses to TAZs in Alachua County, the CTPP was used only as a benchmark, and not to make specific adjustments in the HBW trip lengths. This exercise was useful in making reasonableness checks of trip lengths and general distribution among districts.

The CTPP reported average JTW travel times of 22.5 min for Alachua County and 15.9 min for Gainesville. These travel times were used to adjust trip impedances for the HBW trips until a better calibration was achieved.

Because TRANPLAN uses a single set of friction factors for each trip purpose, the distribution model assumes that trip length propensities are equal throughout the county. This assumption makes distribution difficult in Alachua County, where the presence of the University of Florida and its related development affects trip lengths on the east and west sides of the urbanized area.

The model is limited in its ability to distinguish between residents living on the east side of Gainesville, who are not likely to make many trips related to the university and the central business district (CBD), and those living on the west and northwest sides of town, where most university students, faculty, and white-collar CBD employees tend to live. In fact, a review of the socioeconomic data from the CTPP showed that there is little in the model inputs to distinguish between university students and less affluent residents of the city's east side. The model socioeconomic categories do not distinguish students from other components of the population. Thus, longer average trip lengths and more congestion on the west side tend to discourage trips into the university and CBD from the west, whereas the opposite conditions on the east side encourage trips to those areas. In addition, more employment opportunities are available on the west side, so trips that might be destined for the university and CBD are satisfied closer to the place of residence.

### *Bicycle Trip Analysis*

One of the unique elements of the Alachua County study area is the relatively large number of trips made by bicycle, particularly in and around the University of Florida. According to census JTW data, about five times more trips are made by bicycle within the study area than are

made by public transit. Thus, the treatment of bicycle trips in the model validation process was an important consideration for this study area.

The process used to incorporate bicycle trips into the model validation process is summarized below. The 1990 census, along with the Bicycle Screenline Survey conducted in 1988, indicated the number and purpose of bicycle trips made in Alachua County. The latter survey was designed to obtain information about bicyclists' travel characteristics in Gainesville. It is important to note that the trip generation step in the standard model chain only recognizes trips made in vehicles (either automobiles or buses). In Florida the household survey data used to develop trip generation rates do not include person trips, such as those made by walking or bicycle. Thus, adjustments to the four-step modeling process to reflect bicycle trips must be made external to the travel demand model process.

The first step in the process was to obtain JTW data from the 1990 CTPP. Table 3-1 in the CTPP Urban Element provides JTW trips by travel mode used (including bicycle) at the TAZ level. These data allowed the identification of the number of reported bicycle trips from the origin or place of residence to the trip destination or place of work. Each trip origin and destination corresponds to a particular TAZ in the county. The CTPP is the only source of bicycle trip origin and destination data for Gainesville TAZs.

The second step involved building HBW and non-work bicycle trip tables in the countywide transportation planning model, which entailed the creation of a matrix showing origin TAZ to destination TAZ and the number of trips made between each. One of the key assumptions for the analysis was that nonwork trip origins were essentially the same as HBW origins. This assumption was necessary because the CTPP data only included work trips. Nonwork trips include trips to school; primary bicycle trip destinations are the University of Florida and Santa Fe Community College. The nonwork trip table was then adjusted for all other trip purposes using 1988 data from the Bicycle Screenline Survey.

The 1988 Bicycle Screenline Survey results (also used in the 1985 model validation) contained the following allocation of bicycle trips by purpose: work trips, 12.8 percent; shopping trips, 6.3 percent; trips to school, 33.2 percent; social-recreation trips, 10 percent; trips to home, 31.3 percent; and other trip purposes, 5 percent.

Next the bicycle trips were multiplied by 2 to reflect the trip from work and school to home. The census provides data only on trips made from home to work, so an assumption was made that a return trip was also being made (it was assumed that trip chaining and other factors used in the 1.85 conversion factor would be less likely to occur for bicyclists than for automobile drivers). The two trip tables (HBW and HBNW) were then assigned to the

travel demand model's 1990 base year network to estimate bicycle volumes on each roadway link.

The Gainesville MTPO conducts an annual count of bicyclists at several key locations around the University of Florida and elsewhere in the metropolitan area. The HBW and nonwork bicycle trip volumes estimated through these steps were compared with the actual bike counts taken from the MTPO's Bicycle Usage Trends Program for 1990. Rather than a comparison of each count station, screenlines were established on major arterial roadways around the campus to allow for variances. Although some variations were noted, accuracy of the estimated volume was within 10 percent. It was therefore not necessary to further adjust the bicycle trip tables to match bicycle counts along the screenlines.

This process resulted in an estimated mode share of bicycle trips of about 6 percent of all person trips, which was consistent with the bicycle mode share found in the census JTW data. The trip generation rate file in the model does not include trips performed by nonmotorized modes of transportation such as bicycles and walking. Therefore, bicycle trips were not used to adjust traffic volumes in the validation year. In other words, traffic volumes were not reduced to account for the bicycle trips.

However, using the information developed for this analysis, bicycle trips were used to adjust the future year 2020 forecast of single-occupancy-vehicle (SOV) trips accessing the University of Florida campus. Two of the needs plan alternatives assumed that many SOV trips would shift to bicycle trips in the future because of increasing parking constraints on campus. Therefore, the non-automobile-oriented needs plan alternatives reduced the SOV trips accessing the university and increased bicycle trips to reflect parking limitations on campus.

### Other Checks

During model validation and the transportation plan update, several other checks were made using CTPP data. Several maps were plotted using CTPP data showing automobiles available per household and persons per household for TAZs in the study area as a way to check the accuracy of the socioeconomic inputs and the trip distribution results. In addition, comparisons were made showing TAZs with comparable bus and automobile average travel times to assist in the evaluation of the mode choice model.

### USEFULNESS OF CENSUS DATA

The availability of detailed socioeconomic and JTW travel characteristics for Gainesville was essential to the development and adoption of the 2020 Transportation

Plan for the Gainesville Urbanized Area. As described in this paper, the CTPP was particularly helpful in providing this information at the TAZ geographic level for the Alachua County model validation study. Several adjustments were made to improve the ability of the travel demand forecasting model to produce reasonable results. The justification for making these adjustments, particularly the increase in the HBW trip generation rates, would not have been available without JTW data. The result would have been a less accurate travel demand forecasting tool.

It should be underscored that the last household travel survey for Gainesville was conducted in the early 1970s. Limited staff and financial resources required that the 1990 census be used to identify key travel parameters to improve the accuracy of the forecasts. Although census data proved to be extremely helpful, the unique trip-making patterns of the Gainesville metropolitan area resulted in a very difficult model validation process. The University of Florida is a major influence on travel patterns, and standardized travel parameters required by the FDOT modeling procedures were not reflective of these unique characteristics. A household travel survey conducted concurrently with the 2000 census would be a tremendous help in assessing the community's travel patterns for the next model validation study, transportation plan update, and future corridor studies.

The ability to use the CTPP lent additional credence to the MTPO's planning effort. The Gainesville MTPO's citizens and technical advisory committees provided close input into the development of the long-range plan and were skeptical of the model's ability to predict future travel patterns. The census data were instrumental in achieving a higher level of support from those committees. The Citizens Advisory Committee was particularly interested in the bicycle trip analysis, and the ability to incorporate that methodology into the development and evaluation of alternatives was key to the success of the project.

Without the census data described in this paper, it can be safely stated that the planning effort would have been less refined, would have had less public support, and likely would have resulted in a different transportation plan than the one adopted. Ultimately, the Gainesville MTPO adopted a financially constrained 2020 Transportation Plan that contains major transit service improvements, emphasizes nonmotorized transportation improvement needs, and addresses economic development issues (4,5).

### SUMMARY

JHK & Associates, under contract to the Gainesville MTPO, developed and validated a countywide multi-

modal travel demand forecasting model for Alachua County using 1990 as the base year. This model served as the basis for the preparation of the Gainesville Urbanized Area 2020 Transportation Plan, also prepared by JHK under contract to the MTPO. The plan was adopted in December 1995. The 1990 census was a key resource in the development of the validated base year model and in the preparation of non-automobile-oriented alternatives for the 2020 Transportation Plan.

Without the availability of the census JTW data and socioeconomic summaries at the TAZ level, the trip generation rate adjustments and bicycle analysis methodology incorporated into the planning effort would likely not have occurred. The only other source of information for those kinds of data is a regional household travel survey, which was not in the funding plans of FDOT or the MTPO.

Limitations of the CTPP data were primarily its geocoding problems, particularly at the place-of-residence end. Although problems were also encountered at the employment end, local planners had little to compare these data with and were much more familiar with the population and housing information at the TAZ level. If not for the geocoding problems, additional uses of the data to further adjust trip length frequencies could have occurred.

The applications presented in this paper are not unique to Gainesville, although only a few small urban areas are host to a major university. Thus, although

some applications of the data were unique to Gainesville, the methods employed and analysis undertaken could easily be transferred to other urban areas.

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# Census Data in Jobs–Housing Balance Studies: San Luis Obispo County, California

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David Polley, *San Luis Obispo Council of Governments*

The San Luis Obispo County Jobs–Housing Balance Study was developed to analyze the relationship among jobs, housing, and work-related transportation for the small urbanized area encompassing San Luis Obispo County. The complexities of defining and quantifying the relationship between jobs and housing required extensive research and analysis of several issues. In this case study the important role that census data played in defining and quantifying this relationship is discussed. In addition, some of the limitations, problems, and problem solutions in working with census data are identified, and the important role of census data in planning for small Urbanized Areas is examined.

**L**ike many metropolitan planning organizations (MPOs), the San Luis Obispo Council of Governments (SLOCOG) relies heavily on census data. SLOCOG serves as the council of governments, MPO, congestion management agency (CMA), regional transportation planning agency (RTPA), and census data affiliate for the county and seven cities of San Luis Obispo County. With all of its responsibilities, SLOCOG, like other agencies planning for small Urbanized Areas, utilizes census data to complete many of its tasks. The census provides a wealth of information covering various demographic topics and is used as one of the primary data sources to conduct analysis and plans at the sub-community, community, county, and Metropolitan Sta-

tistical Area (MSA) level. In many cases data are not available to small Urbanized Areas through any other source. Most national surveys focus on large metropolitan areas. High costs and other resource constraints limit a small area's ability to conduct detailed local surveys. Consequently, the census has become increasingly important in providing accurate, detailed information regarding many issues. For these reasons, the census is one of the most critical data sources available to small metropolitan areas.

SLOCOG was formed as an area planning council through a Joint Powers Agreement among the incorporated cities and the county of San Luis Obispo. In 1968 the area council was designated by the U.S. Department of Housing and Urban Development to provide area-wide planning for housing, sewer, and water, and subsequently became the RTPA for San Luis Obispo County. As a result of the finding by the Census Bureau that the city of San Luis Obispo and the adjacent unincorporated area attained a population of over 50,000, the area was designated an official Urbanized Area on July 1, 1992. At that time SLOCOG became the MPO and the CMA for the region.

In 1992, after the Urbanized Area designation and SLOCOG's designation as the county's MPO, the agency was established as the San Luis Obispo Region census data affiliate. As such, SLOCOG is responsible for responding to census questions, maintaining a collection of Census Bureau reference materials, participating in

the development of Census 2000, and other tasks that help to maintain and disseminate census data.

SLOCOG has provided assistance to many diverse agencies, including government, private, and nonprofit, and to the general public. These agencies have reported that they rely on the census data to receive state and federal funding, conduct planning, identify special needs groups, conduct market analysis, and fulfill additional mandated and nonmandated tasks. In addition to assisting others, SLOCOG relies on the data from the census to complete many of its own mandated and nonmandated programs and functions. A few of the functions and reports that have utilized census data include the following;

Regional housing needs assessment,  
Regional profile report (1),  
Community profiles and data summaries,  
Urbanized Area analysis,  
Regional Transportation Plan,  
Congestion Management Plan,  
Regional Traffic Model, and  
Jobs–Housing Balance Study.

### **JOBS–HOUSING BALANCE STUDY: PROJECT SUMMARY**

The San Luis Obispo County Jobs–Housing Balance Study is an example of a document produced by a small MPO that relies on the census data. Census data were considered and used in almost every facet of the study. This information was critical to the development of the methodology, the collection and analysis of data, and the development of the findings and strategies that conclude the study.

#### **Purpose**

The SLOCOG Jobs–Housing Balance Study was developed to examine the relationship among jobs, housing, and transportation. This relationship has received an increased amount of attention in San Luis Obispo County as changes in the pattern of development in the region have led to inequities between jobs and affordable housing in some areas. As development patterns and local land use policies have changed, many workers live and work in different communities. As a result, there has been an increase in commute distances and work-related travel, resulting in increased congestion throughout the county.

Concerned with the impacts of congestion on air quality, the region's Air Pollution Control District (APCD) recommended that SLOCOG conduct a study to

analyze the relationship between where workers live and where they work within the San Luis Obispo County region. From this recommendation, a Jobs–Housing Balance Study was designed and conducted to meet the following goals:

- To identify issues and recommend strategies that support balancing the economic environment and the supply of affordable housing within the San Luis Obispo County region, and
- To examine commute patterns, times, and means of transportation to work and recommend strategies to reduce the work-related vehicle miles traveled countywide.

### **Methodology**

#### ***Defining Jobs–Housing Relationship***

The jobs-housing relationship is one that is often difficult to define; consequently a number of approaches and methodologies are available. For example, many jobs-housing studies focus on a single ratio of jobs to workers living in an area. This ratio is meant to define the balance among jobs and housing and workers, with ratios of one job to one worker living in an area equating to a perfect balance. Although defining a jobs-housing balance with this direct ratio is an effective means of identifying a gross jobs-housing balance or imbalance, it ignores important causes and effects of the relationship.

Instead of focusing on a single ratio, the SLOCOG Jobs–Housing Balance Study concentrates on three topics to define the jobs and housing relationship. These topics, organized as chapters in the report (2), are housing, employment and economic factors, and transportation. A thorough analysis of each topic was conducted by breaking each one down into several subtopics. The subtopics were chosen on the basis of their ability to help define where and why workers live and work where they do. Some examples of the subtopics covered in the study are residential growth, commute times, income levels of workers, housing costs, and jobs.

The study was able to pursue this methodology because of the data available through the Census Bureau. Detailed data from the census were available for all three of the major focus areas of the study. In many cases census data were added directly into the study as subtopics under the main focus areas. Without the census data the thorough analysis would not have been possible because of excessive costs related to developing such data, and the study would have had to be conducted in an entirely different manner.

Although the census provides a wealth of data, it did not give a complete picture of the jobs-housing relation-

ship. Supplementary data sources were examined to fill areas in which additional information was needed. There were also cases in which census data differed from values presented in other reliable data sources. In these cases the various sources would be compared and the most accurate data (or both) were used.

An example of census data that were supplemented with additional sources was housing value data. When census data (based on owner's estimations of the value) were compared with actual sales data, the census data appeared to be overstated. To remedy this, a private data base derived from county assessors' records was consulted and compared with the census values.

### *Defining Geographic Areas*

Because census data played such an important role in examining the jobs-housing relationship, it was important that the geographic boundaries used in the study be compatible with the census. This was fairly simple because the census provides data at several geographic levels of detail.

County-level census data showed an almost perfect balance between the number of workers and jobs in the region. The near-perfect balance and additional census data showing that over 90 percent of the region's workers were employed within the county focused interest on examining intracounty as opposed to intercounty relationships.

To study the intracounty relationships, the county was broken down into regions with boundaries based on planning areas previously established in the region's Congestion Management Plan and Regional Transportation Plan. These areas were defined on the basis of the natural geographic characteristics of the county and the natural clustering of communities. It was important that the Jobs-Housing Balance Study continue to use these planning areas to ensure consistency with the previously conducted plans; however, the defined boundaries were inconsistent with the designated census areas.

To make the planning area boundaries more consistent with the census areas, planning areas were subdivided, with the study concentrating on cities and Census Designated Places (CDPs) because they are where the majority of the region's residents live and work and they have census-defined boundaries. Breaking the county down to this level of detail allowed the study to utilize census data and the census Topologically Integrated Geographic Encoding and Referencing (TIGER) File. The TIGER File and census attribute data were imported into geographic information system (GIS) software to map, graph, and analyze various characteristics and relationships in the county. When the cities and CDPs did not provide enough detail, block-group and tract-level analysis was conducted. The data from the cities, CDPs, block groups, and tracts were then aggregated to the planning area level, where most of the analysis was focused.

### *Census Data Used in Study*

The study report devotes a chapter to each of the major topics—housing, employment and economics, and transportation. Each chapter begins with an introduction that lists the demographic topics that are presented in the chapter. Included with the list of topics are a definition of how each of the issues affects the jobs-housing relationship and an explanation of how the data are presented in the study.

Following the introduction, each chapter was divided into four sections, one for each of the planning areas in the region. In these sections, data and statistics are compiled for the subtopics listed in the chapter introductions. At the end of each of the sections key findings are summarized, highlighting the main issues identified in the section.

The following is a listing of the topics covered in each chapter:

- **Housing:** This chapter focuses on 10 issues relating to housing, including housing stock, limitations on residential growth, new construction, projected buildout, vacancy status, overcrowding, overpayment for housing, special needs groups, median house price, and total housing units sold. (See Table 1 for a description of each of these topics.)
- **Employment and Economics:** This chapter focuses on nine issues relating to employment and economics, including total jobs, workers living and working in the area, total workers, workers per household, place of work, workers by occupation, workers by industry, and household and family income. (See Table 2 for a description of each of the topics.)
- **Transportation:** This chapter focuses on five issues relating to transportation, including origin and destination of planning-area workers, travel time to work, total workers, mode of transportation, and vehicle occupancy. (See Table 3 for a description of each of the topics.)

### *Findings*

The findings of the analysis are presented in two ways: by individual planning area and by comparisons between planning areas.

### *Individual Planning Areas*

Evaluating the findings by individual planning areas required bringing all of the key issues for each of the areas together. In the previous chapters, the data were presented by topic and examined on the basis of the chapter focus (housing, employment and economics, transportation). In evaluating the data by planning area,

TABLE 1 Housing Issues

Item	Description	Source
<b>Housing Stock</b>	Identifies the number of housing units located by type and describes the increase in total units between the years 1980 and 1990.	1990 Census
<b>Limitations on Residential Growth</b>	Summarizes the government imposed limitations on residential growth.	General Plans & Growth Management Ordinances
<b>New Construction</b>	Lists the number of single-family and multi-family housing units built and permitted.	City & County Building Permit Data, US Department of Commerce Current Construction Reports
<b>Projected Buildout</b>	Estimates the amount of additional residential growth (housing units and population) planned.	General Plans
<b>Vacancy Status</b>	Examines the number of occupied and vacant units.	1990 Census
<b>Overcrowding</b>	Identifies the number of households with more than one person per room and two persons per room.	1990 Census
<b>Overpayment for Housing</b>	Examines the number of households paying over 30% of their income on housing owner and renter occupied.	1990 Census
<b>Special Needs Groups</b>	Identifies the number of households with residents over 65, single parent households, and large families.	1990 Census
<b>Median House Price/Contract Rent</b>	Estimates the median house price and contract rent for housing units.	1990 Census, TRW Redi Property Data (3)
<b>Total Units Sold</b>	Estimates the housing units sold.	TRW Redi Property Data (3)

the relevant data were brought together to define relationships among housing, transportation, and employment for each area and allow each of the planning areas to be studied individually. Through this analysis, the relationship between the number of jobs and workers, the types of workers living in the area, income levels of the various workers, housing affordability, and other key issues were examined for each of the planning areas.

### *Comparisons Between Planning Areas*

In addition to examining the relationship between the key issues in the individual planning areas, comparisons were drawn between the planning areas. This analysis compared areas with job-housing balances and imbalances, areas from which and to which workers commute, how long commuters are traveling, where the

TABLE 2 Employment and Economic Issues

Item	Description	Source
<b>Total Jobs</b>	Estimation of the total jobs.	1992 Economic Census, 1990 Census Transportation Planning Package (4, 5)
<b>Workers Residing and Working by Planning Area</b>	Compares the numbers of workers living and working in each area.	1990 Census & Census Transportation Planning Package (4)
<b>Total Workers</b>	Identifies the number of workers living in each area.	1990 Census
<b>Workers Per Household</b>	Determines the ratio between number of workers and household in 1980 and 1990.	1980 & 1990 Census
<b>Place of Work</b>	Identifies the number and percentage of workers that work in the same community that they live in.	1990 Census
<b>Workers By Occupation</b>	Provides a breakdown of workers occupations by the areas in which they reside.	1990 Census
<b>Workers By Industry</b>	Provides a breakdown of workers industry of employment by the areas in which they reside.	1990 Census
<b>Household &amp; Family Income</b>	Identifies the total very low, low, median, and above median households and families are found in each of the planning area.	1990 Census

TABLE 3 Transportation Issues

Item	Description	Source
<b>Origin/Destination</b>	Identifies the origins and destination of workers broken down by the origin of commute and destination of commute.	1990 Census Transportation Planning Package (4)
<b>Travel Time</b>	Examines the amount of time it takes workers to commute.	1990 Census
<b>Total Workers</b>	Identifies the number of workers living in each area.	1990 Census
<b>Mode of Transportation</b>	Examines the different modes used by workers to commute to work.	1990 Census
<b>Vehicle Occupancy</b>	Analyzes the change in vehicle occupancy between the 1980 and 1990 Census.	1980 & 1990 Census (6)

different income and special needs groups are focused, and how workers commute between the areas.

### Strategies

On the basis of relationships identified in the findings of the final report (2), a number of strategies were developed to help reduce the imbalances between jobs and housing throughout the region. One of the key findings from the study was that a jobs-housing balance is only one of several factors that affect congestion and the negative impacts of congestion. Consequently, the strategies identified in the study went beyond focusing solely on housing and jobs, and concentrated also on transportation, land use, and planning. Strategies were presented both regionally and specifically to individual planning areas. Many of these strategies concentrated more on improving multimodal transportation and reducing congestion than on creating a balance between jobs and housing.

### Problems Encountered Using Census Data

The census provided the most complete and comprehensive data source available to conduct the Jobs-Housing Balance Study. However, focusing on census data for the study did have some drawbacks. The data were not always the most reliable or the most accurate. To deal with that difficulty, additional data bases were utilized. Using the census also placed limitations on the study because the census is only conducted once every 10 years. This limitation will hold off the next update until after the 2000 census or will require the use of projections and estimates if the same methodology is to be used.

Another issue arose while working with the CTPP. San Luis Obispo County was not designated an Urbanized Area or MSA until 1992. Because of this, the CTPP data were not analyzed at the traffic analysis zone

(TAZ) level for the region, which is one of the most useful tools in defining the commute patterns of workers. Lack of CTPP data at the TAZ level forced the study to focus on community-level data, which, although useful, left many unanswered questions in the rural areas of the county.

### CONCLUSION

The Jobs-Housing Balance Study could have been conducted without the census but to do so would have required a different methodology. By using census data, the study was able to provide a detailed view of the relationship among jobs, housing, and work-related travel. Without the census, the study probably would have focused directly on the relationship between jobs and housing using a ratio to define balance and imbalance in the communities in the region. Relying on the census data in such a complete manner did have some drawbacks with regard to the ability to update the study. However, utilizing the data as the study did provided a more complete and comprehensive assessment of the region's jobs-housing relationship.

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# Census Data in Developing New Tools for Capital District Transportation Committee New Visions Process

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John P. Poorman, *Capital District Transportation Committee*

The Capital District Transportation Committee (CDTC) is the designated metropolitan planning organization (MPO) for the four counties that include the Albany-Schenectady-Troy (New York) Urbanized Area. In its three-year effort, New Visions, to produce its next regional transportation plan, CDTC has relied upon guidance from nine task forces of subject-specific stakeholders. Subjects such as land use impacts of transportation policy have taken center stage in the New Visions discussions and have required development or refinement of existing analytic procedures, each with its own data demands. In this work, census information has served a valuable role alongside other data sources in supporting new analytical capabilities. Among a wide range of census data applications, three analytical developments that employ census material warrant particular attention. First, to explore major transit investment possibilities, the CDTC staff developed and calibrated a sophisticated mode choice model in a short amount of time by combining available census demographic and journey-to-work information with Nationwide Personal Transportation Survey data, local household travel survey data, and transit on-board survey information. Second, to support examinations of alternative land use and transportation policies, the CDTC staff used time-series census data along with other information to develop and calibrate a land use pivot model. Third, to allow statistical comparison of community indicators among groups of communities (central cities, villages and small cities, inner suburbs, outer suburbs, rural areas), the CDTC staff packaged readily available census in-

formation with other information into a documentation of Community Quality of Life. These applications are representative of the value of census information in supporting the demands of innovative planning exercises.

The metropolitan area surrounding Albany, New York, is a multicentered region with low- and moderate-density development. The Metropolitan Statistical Area includes six counties and has a population of approximately 900,000. Four counties (Albany, Rensselaer, Saratoga, and Schenectady) contain nearly 90 percent of that population and provide a traditional metropolitan service boundary for the regional transit operator, Capital District Transportation Authority (CDTA); regional planning board, Capital District Regional Planning Commission (CDRPC); and regional transportation planning agency, Capital District Transportation Committee (CDTC). The CDTC is the designated metropolitan planning organization (MPO) for purposes of fulfilling federal transportation law.

CDTC's policy membership includes 18 local elected officials, including legislative and executive officials from each of the four counties and mayors of each of eight cities as well as rotating membership from towns and villages. The New York State Department of Transportation (NYSDOT), New York State Thruway Authority (NYSTA), CDTA, and CDRPC are also voting members of CDTC.

Urban development in the Capital District has its origins in the largely independent development of its four central cities—Albany, Troy, Schenectady, and Saratoga Springs. In the triangle formed by Albany, Troy, and Schenectady there was ample room between cities for suburban development through the 1960s and 1970s. Radial suburban development has been modest in all directions except to the north, along I-87 (the Adirondack Northway) into Saratoga County. Saratoga County has had one of the most rapid growth rates in New York over the past two decades.

CDTC has enjoyed a history of cooperative transportation planning and programming that has allowed it often to expand the envelope of MPO technical activities and policy influence. This history has included successful cooperative ventures with eight suburban towns in developing joint transportation and land use plans (of corridorwide or townwide scope), implementation of formula-based public and private highway financing mechanisms in key areas, broad acceptance of residential and arterial maximum traffic thresholds, and similar initiatives.

## NEW VISIONS PROCESS

In 1993, CDTC completed several years of regional systems planning by adopting a new regional transportation plan that set an ambitious highway, transit, and demand management agenda through the turn of the century. CDTC's major Transportation Improvement Program (TIP) effort that same year committed resources toward implementing priority elements of the new plan. However, it was recognized that these major accomplishments would not fully address the needs of the region, particularly if viewed from a 20- or 25-year perspective.

As a result, even before completing the 1993 plan, CDTC had anticipated the need to grapple with deeper and more fundamental questions and had launched a three-year effort to produce its next regional plan. The need for this extended effort is cited in the 1993 plan:

While focused on year-2000 conditions, these actions [committed in the 1993 plan] do have a lasting effect. Year 2015 congestion is reduced by 33 percent in the year 2015 through the committed actions alone. However, the committed actions cannot be expected to be sufficient to meet the needs and desires of the Capital District for the next 25 years. Without further action, the number of critically congested corridors is expected to grow from the present 14 corridors to 24; transit ridership can be expected to drop nearly 20 percent from 1990 levels; fuel consumption and accident costs climb. (1)

The New Visions effort is designed for adequate time to be spent exploring major long-range region-shaping choices about regional and local land use policy, the role of transit and feasibility of fixed-guideway transit investment, principles for treating growing freeway congestion, and similar subjects—subjects that often receive minimal treatment because of the time pressures of immediate decisions.

The New Visions effort includes the use of nine separate task forces, each focusing on a specific subject: demographics, land use, and growth futures; transit futures; urban issues; arterial management; expressway management; bicycle and pedestrian travel; infrastructure renewal; special transportation needs; and goods movement and freight issues. Over 100 individuals from state and local government; transportation providers and user groups; and environmental, business, and community groups and universities have been engaged in task force work since June 1993.

Task forces have shared a common charge: first, to articulate current and null future conditions; second, to identify issues needing attention; and third, to suggest actions. Each task force has been required to address several overriding considerations in addition to the specific subject area. These considerations include land use (as well as environmental quality, equity, and resource allocation). Both local land use issues (community and site design) and regional land use issues (settlement patterns and urban revitalization) have received great attention in discussions and task force products. The congested-highway, low-density-development, single-occupant-vehicle future of the region has triggered many discussions.

A supporting effort has been a consultant-assisted examination of fixed-guideway transit options. The scope of this work has been to specifically examine the land use benefits of light rail or other transit investments; the scope acknowledges that the Capital District does not expect to grow into a region that warrants fixed transit investment on a traditional cost-benefit basis.

## USE OF CENSUS DATA IN NEW VISIONS PROCESS

The broad and deep New Visions agenda has placed increased burdens on the technical products of the CDTC staff. Subjects such as land use impacts of transportation policy have taken center stage in the New Visions discussions and have required development or refinement of existing technical procedures. The use of task forces to guide technical work led naturally to a heightened need for an adequate information base, performance measures, and analytical tools specific to each task force's area of interest.

For example, traditional measures of levels of service and congestion are viewed by the Arterial Management

Task Force as inadequate measures of the performance of the region's highway system. As a result, CDTC staff created new measures such as a "level of compatibility" for arterial-local access conflict and for residential-traffic conflict. Such new measures demanded new data—in this case, a thorough field survey of driveway spacing on the region's arterial system.

As a result, the New Visions work by the CDTC staff has included much in the way of development of analytical procedures, each with its own data demands. In this work, census information has served a valuable role alongside other data sources in supporting new analytical capabilities.

Examples of the New Visions use of readily available census information packaged, aggregated, or summarized by CDTC staff, CDRPC staff, or NYSDOT include use of

1. Population, household, and vehicle availability data from the 1990 census by census tract and block group for developing traffic analysis zone parameters to use in forecasting future travel activity.
2. Age cohort and mobility impairment measures from the 1990 census for forecasting future special transportation needs.
3. Journey-to-work tabulations by municipal groups by mode and vehicle occupancy from the 1990 census for identification of potential fixed-guideway transit markets. Municipal groups used by CDTC for presentation of journey-to-work information total 20, in contrast to approximately 74 cities, towns, and villages; 473 traffic analysis zones; and nearly 200 census tracts. The groups are assembled from traffic analysis zones and are synonymous with municipalities in most cases, but may include multiple municipalities in outlying zones and cover less than a complete municipality in the city of Albany.
4. Journey-to-work vehicle occupancy information from the 1990 census for fine-tuning freeway queueing simulation.
5. Information from the 1990 census on the incidence of households with no vehicles available to identify prime markets for bicycle and pedestrian accommodations.

In addition, three analytical developments relying on census information are worth describing in greater detail:

1. Use of 1990 census demographic information (aggregated by traffic analysis zone) and journey-to-work information by zone and mode for calibrating a new mode choice model;
2. Use of 1970, 1980, and 1990 census tract household information for calibration of a land use pivot model to test interrelationships between land use and transportation policy; and

3. Use of 1990 census information aggregated by municipality groups (central cities, villages and small cities, inner suburbs, outer suburbs, and rural areas) for discussions of "community quality of life."

In each of these applications, a key ingredient to successful use of census data is the integration of readily available census data with other data: household survey data, Nationwide Personal Transportation Survey (NPTS) data, transit on-board survey data, and other information. Census data alone cannot be expected to be sufficiently comprehensive to serve sophisticated analytical methods adequately.

## Calibrating a New Mode Choice Model

### *Existing Model Structure*

In the 1970s, CDTC and CDTA mutually agreed to not invest in updating the Capital District transit network coded in the New York State Department of Transportation's (NYSDOT's) mainframe travel simulation package. Full network modeling was viewed as unnecessary for consideration of easily reversible bus service actions. From that date to 1995, CDTC did not engage in system-level mode choice network simulation.

Mode choice modeling for specific corridors and commutersheds continued using other approaches in the 1980s. CDTC calibrated curves showing diversion of NYSDOT remote park-and-ride mode share to the Northway (I-87) express bus markets and used the curves to identify potential park-and-ride markets throughout the region (2-4). Each of these models used 1980 census journey-to-work information from the Urban Transportation Planning Package and included calibration against field counts of trip origins and destinations by bus.

In the late 1980s, NYSDOT reduced personnel support for its mainframe models and encouraged MPOs such as CDTC to assume the modeling responsibility. CDTC responded by calibrating a full-scale, 500-zone, 7,000-link traffic model in 1988 and 1989. This model, Systematic Travel Evaluation and Planning (STEP), uses commercial software, TMODEL2, as its framework. The STEP model's strengths lie in the ability to combine the features of TMODEL2 with CDTC staff-developed QuickBASIC programs and algorithms.

TMODEL2 is used as the core engine of the STEP model and provides the gravity model used in the trip distribution phase and the capacity-restrained minimum path algorithm used in the traffic assignment phase. In addition, TMODEL2's screen graphics editor is used for editing and display, and TMODEL2's plotting capabilities are used for report and presentation graphics.

CDTC's extensions to TMODEL2 have included the following:

- Vehicle trip generation algorithms derived from CDTC's household travel survey;
- Trip length distribution programs for calibration of the gravity model;
- User cost (time, operating cost, accident cost) postprocessors;
- MOBILE5A emissions postprocessor;
- Subarea windowing algorithms;
- "Excess" delay postprocessor;
- Municipality, jurisdiction, and corridor aggregation algorithms;
- Safety and bridge and pavement "life cycle" benefit algorithms; and
- Monetary cost algorithms to estimate effects of transportation externalities.

The STEP model is currently the traffic forecasting standard for planning and highway project development in the Capital District. Its traffic forecasts are used by NYSDOT, consultants, and municipalities in addition to serving CDTC's planning and programming functions. Transit usage is an implicit, rather than explicit, consideration in the model. The model produces estimates of vehicle trips using relationships that are sensitive to area type and expected transit usage. (Vehicle trips per employee in transit corridors are fewer than in rural areas, for example.) The vehicle trip model cannot examine the impact of explicit transit policy choices, however.

CDTC's New Visions effort increased the demands on the STEP model for consideration of broad-ranging transportation planning and investment principles. In the transit service arena, these include consideration of fixed-guideway investment.

Because of the irreversible nature of fixed-guideway investment, an appropriate system-level mode choice model is required. Such a model must be sensitive to route connectivity and coverage, differential travel time and cost by automobile and transit for particular trips, and the influence of household income and vehicle availability on mode choice. Ideally, a mode choice model would also be sensitive to urban design issues, pedestrian treatment, service frequency, parking policy, and other factors.

CDTC developed a sensitive mode choice model in a short amount of time by drawing on available data. The model was developed, calibrated, and applied in the fixed-guideways investigation within a matter of months by using the following:

1. A logit model construction in the public domain initially developed by Cambridge Systematics for application in the Washington, D.C., area;

2. Available census demographic information (population, number of workers, household size, vehicle availability, and income) aggregated by traffic analysis zone (this information was extracted electronically from 1990 CTPP files);

3. Available CTPP journey-to-work data by mode by municipality;

4. Average vehicle occupancy data from 1990 census journey-to-work information;

5. Published NPTS summaries of person trip generation (by both vehicle and nonvehicle modes) by income;

6. Capital District p.m. peak-hour person trip generation and vehicle trip generation by household type and vehicle trip distribution (from the 1983 CDTC household travel survey, as adjusted to 1995 conditions);

7. CDTA ridership counts by route;

8. CDTA 1988 on-board survey of ridership by gender, age, trip purpose, and income group;

9. CDTC's existing transit park-and-ride market algorithms;

10. Parking lot counts at all CDTA and private operator park-and-ride lots;

11. Parking lot counts at New York State Office of General Service (OGS) peripheral park-and-ride lots;

12. CDTC's 1987 survey of park-and-ride lot usage by income and vehicle availability;

13. CDTC's existing matrix (from a previous study) of the zonal origins and destinations requiring transfers in order to complete a transit trip;

14. Published information regarding the influence of pedestrian accommodations on vehicle trip generation from Portland, Oregon; and

15. CDTC's 1994-1995 field counts of p.m. peak-hour vehicle occupancy at screenlines and cordon lines.

Using this material, the new model was calibrated and applied without requiring any new data collection. The CTPP provided an integral and readily available data source to allow this effort to be both efficient and defensible.

The model that resulted is sensitive to a wide range of issues although it derives from the existing highway-oriented STEP model. It provides a credible basis for examining demand potential for fixed-guideway and other system-level transit actions and for identifying highway system benefits (reduced delay, operating cost, etc.). In the future, the model can be extended further through better interface with geographic information system (GIS) information about route characteristics, bus stop locations, and other data to provide a more refined route-specific analytic tool.

Census information, particularly journey-to-work information by mode at the municipal level, provided the primary reference points for calibration of the mod-

el's estimates of transit trips by origin and destination. Other information, including on-board surveys and park-and-ride lot counts, served as primary reference points for other calibration exercises. The combination of data allowed calibration of the model from multiple perspectives: Does it produce estimates of transit and carpool use that are reasonable from the perspectives of

- 1990 census journey-to-work transit origins and destinations?
- 1990 census journey-to-work mode choice by municipality?
- 1987 and 1988 surveys and 1990 census journey-to-work transit usage by income group?
- 1995 field surveys of park-and-ride lot usage by location?
- 1995 transit ridership values by route and corridor?
- 1990 census journey-to-work and 1995 field surveys of vehicle occupancy?

The form, equations, and calibration of CDTC's mode choice model are described in greater detail in CDTC's model documentation (5).

### *Application*

The primary application of the new mode choice model has been in the arena of testing the effectiveness of fixed-guideway investments. The model was used by the Transit Futures Task Force to test a wide range of bus-in-mixed traffic, bus-on-exclusive lane, light rail, commuter rail, and automated-guideway transit systems. Because of the model's construction, applications included sensitivity to a wide range of factors including traffic congestion, highway and parking pricing, feeder bus and transfer efficiencies, and site design. Primarily, the model was used to identify priority corridors and estimate an order-of-magnitude system-level transit demand that would result from specific combinations of transit, land use, and pricing.

CDTC combined the mode choice model with a new land use pivot model (discussed in the next section) to determine the system-level benefits of combining an Albany-Schenectady fixed-guideway system with an urban reinvestment scenario.

The results of the exercises led the task force to cite four potential fixed-guideway applications for public review, along with estimates of their costs and benefits. Beyond the fixed-guideway findings, the application of the mode choice model led to a series of task force transit recommendations related to bus service redesign, transit and highway pricing, and transportation-land use integration. Without reliance upon available census and

other secondary data, the CDTC staff could not have produced defensible measures of effectiveness within the timetable and budget of the New Visions process.

The products of the task force's work are documented elsewhere (6, p. 34; 7). Table 1 is a reproduction of Table 6.3 from the fixed-guideways report showing some of the products of the mode choice model applications.

## Calibrating a Land Use Pivot Model

### *Purpose*

In the area of land use, New Visions questions had the effect of extending CDTC's work from the community-level and corridor-level successes of its cooperative planning efforts with individual communities to more regional interactions. Specifically, the Demographics, Land Use and Growth Futures Task Force raised questions such as these:

- Would a major linear capacity expansion in the Northway (I-87) Corridor into Saratoga County encourage further development until the Northway was "filled up" again?
- Is it feasible to shape regional land use patterns given the home rule nature of land use decisions in New York and can transportation investment help shape patterns?
- What are the advantages and disadvantages of alternative settlement patterns from an efficiency standpoint?

Much of the task force's effort focused on broad concepts and principles, such as the desirability and feasibility of establishing an "urban service boundary." However, the task force and CDTC staff also saw a need to quantify at least some of the transportation-land use interrelationship.

As a result, the CDTC staff used a time series of census tract data and census-based traffic analysis zone data along with other available data covering the 1970-1990 period to calibrate a land use model to test the effect of alternative land use and transportation policies.

### *Form of the Model*

The land use model developed by CDTC follows a standard construction similar to others in the Lowry-Garin family. As such, an abstract transportation accessibility serves as one component of the developmental attractiveness of a particular traffic analysis. Also, the model operates in such a way as to allocate employment and households to zones in a stepwise fashion, working from an externally established distribution of "basic" employment by zone.

TABLE 1 Comparison of Fixed-Guideway Applications with Reference Alternatives, 2015 (6)

	PM Peak Hour				Low Daily Transit Riders	High Daily Transit Riders	Annual HC Emissions (kg x 1000)	Daily Excess Delay (veh hr)	Pct of Trips Accessible	Pct with Transit Advantage
	Vehicle Trips (x 1000)	Transit Trips (linked)	Mode Share (pct.)	Park & Ride users (remote)						
Null (reduced freq)	255.0	4,990	1.7	610	46,000	-	4,200	35,335	13.7	0.6
Null (same frequency)	254.6	5,300	1.8	650	48,000	-	4,180		14.2	0.6
Null w/free fare	252.3	7,160	2.4	700	57,300	-	4,169	35,000	16.4	0.6
Best bus (feeder)	250.6	9,060	3.0	1,210	66,350	99,600	4,110	32,683	24.7	2.6
Fixed G'way Alt 1 (full)	248.0	12,700	4.3	1,880	84,400	123,200	4,020	29,746	34.5	11.1
Application 1 (LRT)	251.5	8,150	2.8	970	62,250	76,490	4,141	33,584	21.3	5.5
Application 1 (LRT) Urban Reinvest.	247.8	8,340	2.8	844	63,200	81,110	4,036	31,272	21.4	5.7
Application 2 (LRT)	252.0	7,623	2.6	1,725	59,615	71,654	4,154	34,317	22.2	5.6
Application 3 (LRT)	251.9	7,760	2.6	960	60,300	74,565	4,148	34,084	19.5	4.5
Application 4 (CR)	252.5	7,396	2.5	1,500	58,481	75,674	4,160	34,180	20.1	5.6
NOTES	1	2	3	4	5	6	7	8	9	10

Notes: Year 2015 trend land use with parking pricing unless otherwise noted.

1. Vehicle trips based on 298,300 PM peak hour person trips. Trend conditions do not reflect reduced trip making.
2. Transit trips as estimated through CDTC's mode choice model, based on frequency, directness and fares. Trend conditions do not reflect auto pricing changes.  
Transit trips include CDTA, OGS shuttle, and Upstate Transit usage.
3. Mode share is transit trips as percentage of total PM peak hour person trips.
4. Remote park and ride usage does not include peripheral OGS shuttle lot usage.
5. Low daily ridership extrapolated for service improvements at 48,000 + 5 times growth in PM peak hour ridership.
6. High daily ridership reflects effects of improved site design.
7. Hydrocarbon emissions are derived from MOBILE5A emissions model based on levels of vehicle travel, speed and congestion.
8. Excess delay values are derived from CDTC's STEP model and represent excess person hours in congestion.
9. Trips are accessible if trip can be made within a reasonable time, relative to the auto travel time (door to door).
10. Trips have a transit advantage if they can be made faster by transit than by auto (door to door).

The CDTC model differs from standard land use models in three respects:

1. It uses measures of developmental attractiveness for residential development by zone that are derived from a multivariate linear regression analysis of residential growth patterns in the Capital District between 1970 and 1990, as reflected in census household counts and historic CDRPC employment counts by zone. The statistical analysis identified four zonal characteristics that correlate well with incremental household growth by zone: the amount of additional units that can be accommodated on "developable" land at acceptable densities; the ratio of median price of owner-occupied housing in the zone to the regional median; the ratio of property taxes per \$1,000 of full value assessment in the zone to the regional mean; and the number of households in the beginning year (the total potential number of new households that could be built in Zone  $j$  given the developable land remaining and expected dwelling unit density). [Developable land in Zone  $j$  excludes existing developed land and undevelopable land. Undevelopable land is defined from CDRPC's criteria (which exclude areas with steep slopes, prime agricultural land, park land or protected open space, water bodies, floodplains, and wetlands). In 1980 approximately 100,000 acres in the four counties were considered developable. The approximate dwelling unit density per gross acre of land that would be expected in Zone  $j$  was calculated by dividing the number of 1980 households by 1980 acres of residential land.]

2. It operates as a "marginal" model rather than an abstract equilibrium model. That is, the model fixes in place the majority of dwelling units and a large portion of existing employment. It uses the Lowry-type model formulation to allocate the location of only a portion of existing households and employment, along with all of the region's household and employment growth. (In contrast, an abstract equilibrium model frees up all residential locations and most employment locations for allocation by zone according to the model's formulation.)

3. It is calibrated to the CDRPC forecasts of households and employment for the year 2015. CDRPC develops its baseline forecasts using Bureau of Economic Analysis and New York State regional control totals and uses a shift-share process and local knowledge to allocate regional growth to municipalities and then to traffic analysis zones. The CDTC model begins with the assumption that the CDRPC forecasts are correct given that travel times remain constant from 1990 to 2015, relative property taxes and property values do not change, and the availability of public sewer and water infrastructure is consistent with existing and currently committed systems. A "calibration factor" is computed for each zone to ensure that the model, when applied to

1990 conditions to estimate 2015 conditions, produces the CDRPC forecasts of households and employment by zone under those assumptions. The calibration factor is derived from the ratio of CDRPC forecast household growth for the zone to the modeled household growth for the zone. The calibration factor is determined once, after all increments have been allocated for the 2015 period, assuming 1990 travel times, property taxes, property values, and developable land.

The CDTC land use model can therefore be best described as a "pivot model." It does not attempt to estimate overall regional control totals for households or employment nor does it attempt to develop a reasoned allocation of households and employment to traffic analysis zones. Rather, it uses changes to baseline assumptions of travel time, property values, property taxes, and the availability of sewer and water forecasts to estimate the resultant shifts in households and employment.

The form, equations, and calibration of CDTC's Land Use Pivot Model are described in greater detail in CDTC's model documentation (8).

### *Application*

Because the CDRPC baseline household and employment forecasts by zone do not reflect the impact of increased congestion (particularly increased congestion on the Northway Corridor serving the growth area of the region), an initial examination involved using the calibrated model with expected year-2015 peak-hour travel times to reallocate the marginal amount of households and employment in a way that reflects the increasing congestion levels. This application resulted in a conclusion that unmitigated congestion in the Northway Corridor would result in a decrease of 1,300 (about 7 percent) in the expected growth in households in Saratoga County and a slight increase in employment formation in that county. This finding is consistent with that in the literature. Deakin (9, p. 342) contends that the "wide-ranging body of work suggests that, all other things being equal, transportation investments that lower the costs of travel should decentralize housing and centralize employment but at the same time stimulate countervailing pressures for housing near the employment center and for service employment near the housing. Conversely, worsening transportation services will favor decentralization of jobs but support higher densities of housing in more central locations, although the relationships are not a simple mirror image because of precedent conditions in the developed areas." The small scale of shift predicted by CDTC's pivot model to result from increased congestion is also consistent with Deakin's finding that land use models (9, p. 340) "show that transport variables are no more critical to location deci-

sions than such factors as housing type, size and cost suitability; crime rates; and, for families with children, schools. Moreover, life-style and life-cycle variations have been found to be as important as (in some cases, much more important than) transportation as determinants of location and land use choices."

Use of the locally calibrated model in testing the impact of congestion on settlement patterns has steered task force discussions away from viewing congestion as a potentially significant land use policy.

A second use of the model was to test a "Southern Crescent Scenario," that is, a scenario of encouraging development in the southern part of the region through expanded water and sewer services and higher allowable suburban densities. This scenario was tested by modifying the developmental capability values of traffic analysis zones in those areas and allowing the land use pivot model to reallocate service employment and households. The result was an additional 4,000 households allocated to five southern towns with a diversion away from Saratoga County of 2,300 households. Variations on this scenario were also tested. The model allowed the task force to sense the order of magnitude influence that might result from this policy action.

A third use focuses on the intangibles captured by the calibration factor. Issues of perceived school quality, crime, social conflict, age of housing stock and infrastructure, and other factors are not captured explicitly in the model but are covered by the calibration factor for each zone. An urban reinvestment scenario was tested by removing the calibration factor, reflecting a successful urban reinvestment campaign that effectively eliminates a bias against urban locations. This application of the model shifted 9,000 jobs and a similar number of households to the region's cities. When combined by the Transit Futures Task Force into a scenario of high-quality transit service, the urban reinvestment scenario produced estimates of significantly decreased overall transportation costs in the region.

As with the mode choice model, the ready availability of census data (in this case, time-series data) allowed merger with other available data to fashion a defensible method of testing policy options in a short amount of time.

The products of the task force are contained in its report (10); as an example of the products of the land use model applications, Table 2 is reproduced from Table 4 in that report.

TABLE 2 Household and Employment Distribution Used in Urban Reinvestment Scenario (10, Table 4)

MCD Groups	CDRPC Numbers				Urban Reinvestment Scenario			
	1990 HH	1990 EMP	2015 HH	2015 EMP	Forecast HH	Forecast EMP	HH Change	EMP Change
Albany County	116026	216296	130596	239644	138556	244054	7960	4410
Rensselaer County	57612	44667	65413	50177	66717	49612	1304	-565
Saratoga County	66425	48437	87077	55990	78362	54371	-8715	-1619
Schenectady County	59181	61934	63961	70087	63410	67853	-551	-2234
<b>All Locations</b>	<b>299244</b>	<b>371334</b>	<b>347047</b>	<b>415898</b>	<b>347045</b>	<b>415890</b>	<b>-2</b>	<b>-8</b>
<b>3 Central Cities</b>	<b>90832</b>	<b>171831</b>	<b>92767</b>	<b>182357</b>	<b>94222</b>	<b>189866</b>	<b>1455</b>	<b>7509</b>
<b>12 Inner Suburban Towns</b>	<b>102483</b>	<b>119549</b>	<b>126575</b>	<b>143349</b>	<b>129052</b>	<b>137120</b>	<b>2477</b>	<b>-6229</b>
<b>12 Outer Suburbs</b>	<b>33131</b>	<b>16283</b>	<b>44614</b>	<b>20760</b>	<b>41403</b>	<b>18461</b>	<b>-3211</b>	<b>-2299</b>
<b>Eight Cities</b>	<b>118202</b>	<b>201302</b>	<b>120975</b>	<b>213609</b>	<b>124781</b>	<b>222516</b>	<b>3806</b>	<b>8907</b>
<b>23 Rural Outlying Towns</b>	<b>23107</b>	<b>7030</b>	<b>30880</b>	<b>8024</b>	<b>26478</b>	<b>8182</b>	<b>-4402</b>	<b>158</b>
<b>22 Villages</b>	<b>22321</b>	<b>27170</b>	<b>24003</b>	<b>30156</b>	<b>25331</b>	<b>29611</b>	<b>1328</b>	<b>-545</b>

1. The three central cities included above are Albany, Schenectady and Troy. The category "eight cities" includes these three central cities plus the five cities of Cohoes, Watervliet, Rensselaer, Mechanicville and Saratoga Springs. The inner suburban towns included are Bethlehem, Colonie, Guilderland, Brunswick, East Greenbush, North Greenbush, Clifton Park, Halfmoon, Waterford, Glenville, Niskayuna and Rotterdam. The outer suburban towns include Coeymans, New Scotland, Sand Lake, Schaghticoke, Schodack, Ballston, Charlton, Malta, Milton, Moreau, Stillwater, and Wilton.
2. The household and employment distribution for the Urban Reinvestment Scenario was developed by letting the CDTC Land Use Model run with year 2015 travel times, no calibration factors, and ensuring a CDRPC level of employment in the Town of Colonie by preloading 1990 levels.

## Use of Census Data in Describing Community Quality of Life

### *Purpose*

The text in this section is drawn largely from a CDTC report primarily authored by Younger (11). CDTC's New Visions task forces shared a common mission, which included contributing to and concurring with a list of core performance measures against which to test the effect of alternative policies and investments. Through several revisions of the draft list, CDTC's participants continually reinforced a belief that not all aspects of transportation can be reduced to measures of cost. Some aspects have more to do with equity and distributional effects (who is helped and who is hurt?) and others are more abstract (are we building a community of which we will be proud?).

The Urban Issues Task Force took on the task of defining the "Community Character Index" cited in the list of core measures. Each task force was also encouraged to identify supplemental performance measures specific to its subject. As a result, much of the CDTC staff and task force technical effort related to the Urban Issues Task Force involved assembling a wide range of measures that directly or indirectly describe the nature of different communities in the region.

### *Structure*

The task force members determined early in their discussions that no single measure could fulfill the objective of a "Community Character Index." Instead, the task force members encouraged the staff to articulate a wide range of measures that describe community character. Further, the members agreed to summarize information by community group rather than for each municipality. Groups constructed by CDRPC were used by the task force: central cities (Albany, Schenectady, Troy), small cities and villages, inner suburbs, outer suburbs, and rural areas.

The task force report (12) does not presume that the transportation system alone determines community quality of life. Correspondingly, transportation-based strategies alone will not be sufficient to preserve and enhance existing quality of life in the future. This report focuses on the transportation system because it contributes to the regional transportation plan for the Capital District. The importance of transportation to quality of life is thus highlighted, but its role is as a contributor.

Developing the community quality of life measure was hampered by a lack of data—recent and historic data, data collected at an appropriate scale, data that speak to what quality of life is composed of. However, an examination of various socioeconomic factors, com-

ponents of regional mobility, real estate, and road ownership patterns in conjunction with a "nonmeasurables" discussion paints a picture of the Capital District in the mid-1990s. Among the most readily available and useful information was that contained in census reports and the CTPP.

The resulting picture is one of a region with many assets—a compact growth pattern, a well-educated work force, and a relatively stable economy. Compared with many places, the Capital District currently enjoys a relatively high level of mobility, particularly by automobile. However, trend projections provide some important warning signals.

The measure of community quality of life is intended to gauge how the transportation system (in existing and alternative future scenarios) affects land use and other conditions within a defined community. Together with the amount of open space, dislocations of existing residences and businesses, and the land use-transportation compatibility index developed by the Arterial Corridor Management Task Force, the external effects of how the transportation system affects land use can be documented.

The measure of community quality of life developed by the Urban Issues Task Force is a discussion of a set of numbers rather than of a single number. It attempts to paint a picture of how transportation, and its interaction with land use, has influenced the quality of life at the community level. The absolute values of the components of the measure are less important than the direction and magnitude of change under trend conditions and different future scenarios.

However, much of what makes up community quality of life is not measured, or maybe even measurable. It was a struggle to define quantifiable components of such an illusive thing as quality of life for which defensible data had been collected at a relevant level of detail. Planners are only beginning to understand the impact of landscape and urban form on the psyche. The difference in "quality" felt on Main Street or in a neighborhood shopping district and a strip shopping mall is partially explained by street width, setbacks, location and amount of parking, proximity of residential neighborhoods, presence of trees, and general "pedestrian friendliness," but the difference is more complex than that. It has to do with the reassurance of stability that Main Street or the corner store provides, the social interactions it fosters, and the lifting of the spirit that a special place produces.

### *Level of Analysis*

"Community" can be defined at many levels, including neighborhood and municipal, or by grouping similar areas, such as central cities, inner suburbs, outer sub-

urbs, small cities and villages, and rural towns, as the CDRPC does in some of its analysis. Neighborhood-level analysis is not the appropriate scale to use for the regional transportation plan. The advantage of using the municipality as the unit of analysis is that individual differences are highlighted (the advent on certain routes of fixed guideways, for example, may not affect Troy's quality of life in the same way as Albany's). Disadvantages include the possibility of negative reaction by the public or press to the characterizations assigned. The advantage of grouping similar municipalities is that the debate can stay centered on a more generic level (impact of policies on urban areas versus rural areas in general). Disadvantages include the loss of a level of detail. Data are currently collected at the municipality level regardless of how the data are grouped. The Urban Issues Task Force opted to present community group-level analysis in its initial development of the community-quality-of-life measure.

This grouping was not its first choice, however. "Urban" areas in reality are less defined by municipal boundaries than by density and the availability of basic infrastructure and services. By this definition, there are areas within the city of Albany that are not "urban" and places in Colonie that are. Although the numbers that currently compose this measure are based on census data available at the level of census tract and traffic analysis zone, the tools to analyze and present the information at that level of detail are not ready for CDTC use. With the introduction of GIS and advanced mapping techniques, it is hoped that the next iteration of measurement of community quality of life will use a density-service provision definition of urban rather than the conventional grouping defaulted to here.

### Application

"Abstract as it may be, the quality of life is one of the primary characteristics by which communities identify themselves" (13, p. 16). For the purpose of this exercise, community quality of life is a product of the activity levels in different arenas. The areas chosen are not all-inclusive. Availability of data played a large role in determining what specific factors are presented in this analysis. A lot of information on important components of quality of life is either not collected at all or not collected at a level of detail appropriate for this use. Time limitations forced the CDTC staff and task force to use existing data sources, and so the breadth of the presentation is correspondingly limited.

To make it easier to present the information, data are grouped into four subject areas: socioeconomic

factors, mobility measures, real estate-land use indicators, and cultural and nonmeasurable components.

The specific data examined by municipality type under each category are as follows (those factors measured primarily through the use of census data or forecasts based on census data are shown in italics):

- Socioeconomic factors
  - Household characteristics, 1990*
  - Income levels of resident households, 1990*
  - Capital District population shifts, 1970-2010*
  - Capital District employment shifts, 1970-2010*
  - City/county ratio of population, 1950-1990*
  - City/county ratio of family income, 1950-1990*
  - Population by race, 1990*
  - Location of Capital District poverty populations, 1990*
  - Location of Capital District elderly populations, 1990*
  - Number and location of college-educated Capital District residents, 1990*
- Mobility measures
  - Percent of jobs within 10 and 30 min, 1993, 2015 with TIP commitments
  - Person trips accessible by transit, 1993, 2015 with TIP commitments
  - Journey to work by mode, 1990*
  - Worker destinations by mode, 1990*
  - Number of people who live and work in the same municipality, 1990*
  - Vehicle-miles traveled, 1993, 2015 trend, 2015 with TIP commitments
  - Vehicle-miles of delay, 1993, 2015 trend, 2015 with TIP commitments
  - Number of vehicles per household in the Capital District, 1990*
  - Location of mobility-limited populations in the Capital District, 1990*
- Real estate-land use indicators
  - Property values, 1992
  - Median value of a single family home, 1990*
  - Overall property tax rates per \$1000 assessed valuation, 1993
  - Building permits for new construction, 1994
  - Permits for additions and alterations, 1994
  - Capital District office market summary, fall 1994
  - Retail activity, 1972, 1992
  - Centerline road miles by ownership, 1993
- Cultural factors and nonmeasurables
  - Cultural amenities
  - Social interactions/privacy
  - Service availability
  - Diversity

The components measured to determine community quality of life in the report follow this general organization. The general trends that can be expected in each of these areas if present conditions persist are then discussed, with a focus on the role of transportation provision. A set of transportation-focused strategies to protect community quality of life is then presented. These strategies are based on a set of guiding planning and investment principles that make connections between economic health, quality of life, and transportation.

Although the community quality of life exercise differs significantly from the model-based application of census data described earlier for mode choice and land use models, the value of census data to this important policy discussion was no less critical. By combining available census information with other data, a picture of the unique and valuable characteristics of the different community groups was painted in an objective fashion. This led to broad discussions of "win-win" strategies that could help preserve the diversity of community types, reinforce strong community characteristics, and address community weaknesses. Census information contributes many vital aspects to this picture.

Table 3 from the community quality of life report gives an example of the material presented in the quality of life discussions.

## CONCLUSIONS

The challenges of addressing serious planning issues raised in the context of a participatory planning process such as CDTC's New Visions center on timeliness. The commitment and patience of nontraditional participants such as shippers, neighborhood representatives, developers, and other stakeholders will last only as long as the professional staff appears to be responsive and timely with information. Further, the ability of professional staff to turn what might otherwise be a battle of unsubstantiated philosophies into an objective discussion hinges on the quality of analytical tools.

CDTC's New Visions process has been just such an undertaking. Not only have dozens of stakeholders been empowered to raise issues and explore options, but they have been supported by significant technical work by CDTC staff, much of which required new tools.

The ability of CDTC to respond to these challenges is rooted in its tradition of cooperative decision making and reliance upon objective information, in its capable and willing staff, and in the availability of adequate data to support new tools. Census information—both published data and CTPP data—serves an irreplaceable role alongside locally generated data in supporting the New Visions analytical tools. As documented in this paper, a new mode choice model, a new land use pivot model, and a new approach to examining community quality of

TABLE 3 Location of Capital District Poverty Populations, 1989 (12)

	Number At or Above the Poverty Level	Number Below the Poverty Level	% Below the Poverty Level
Central Cities	169,690	34,742	17.0%
Villages, Sm. Cities	109,222	10,806	9.0%
Inner Suburbs	257,377	9,022	3.4%
Outer Suburbs	87,237	4,054	4.4%
Rural Areas	61,207	4,701	7.1%
<b>REGION TOTAL</b>	<b>684,733</b>	<b>63,325</b>	<b>8.5%</b>

Source: 1990 Census, U.S. Department of Commerce — CDRPC Community Profiles.

life were possible in the short time permitted by the participatory New Visions process largely because census data were readily available.

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# Census Data Use in Illinois by Small Metropolitan Planning Organizations

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Ed J. Christopher, *Chicago Area Transportation Study*

This paper is one of a series in these proceedings documenting the uses of census data by the transportation community in Illinois. The focus in this paper is on uses of census data, specifically the Census Transportation Planning Package (CTPP), by the smaller metropolitan planning organizations (MPOs), those serving areas other than Chicago and St. Louis. The other papers in this series discuss census data uses by the Chicago Area Transportation Study (a large MPO), by transit planners, and by the research and academic community. The use of the CTPP has not been extensive in the state's smaller MPOs. The data are used most often for the development of trip generation models and to provide descriptive statistics on various demographic and travel trends. One major reason for this lack of use was the timing and delivery of the package, which has yet to be delivered in personal computer form. The smaller MPOs cannot process the data tape packages. For example, in 1980, other than the two largest MPOs, Chicago and St. Louis, only one smaller MPO, Peoria, even purchased the package. In all fairness it needs to be pointed out that the smaller MPOs, which for the most part are part of larger comprehensive planning organizations, are indeed heavy users of census data as they relate to their other planning functions. There is also a strong expectation that once the Urban Element has been distributed on CD-ROM, the MPOs will begin to explore its uses and begin applying the data. All the MPOs in the state noted that the CTPP was an important component to their transportation model development, which is ongoing at this time.

There are currently 12 metropolitan planning organizations (MPOs) either partially or totally within the borders of Illinois. Two MPOs, East West Gateway (St. Louis) and the Chicago Area Transportation Study (CATS), are considered large and excluded from the discussion in this paper. Also excluded is the Beloit area MPO, located just across the Wisconsin border north of Rockford. Presented here is an examination of the use of census data within the nine remaining MPO areas in Illinois. Throughout this paper these areas are identified by their core cities, which include Bloomington-Normal, Champaign-Urbana, Decatur, Dubuque (Iowa), Kankakee, Peoria, Rockford, Rock Island-Davenport(IA)-Moline, and Springfield. Figure 1 is a map showing the relative locations of these MPOs.

For this analysis telephone interviews were conducted with the nine MPOs. Each person interviewed was asked a similar set of questions. The intent of the interview was to gain a brief understanding of the MPO and explore its use of the census packages, specifically the Census Transportation Planning Package (CTPP). In all cases the actual individual or individuals who worked with or processed the data were interviewed. As such, the information provided does not represent the endorsement of any of the agencies and only reflects the information as synthesized from the respondents.

The interviews were conducted in a conversational and informal manner by the author, who had met many



FIGURE 1 Illinois metropolitan planning organizations.

of the individuals before the interviews. To adapt to the variety of differences among the agencies, the interviews were open ended and contained a great many follow-up questions. To help keep the interview focused, the following set of questions was developed and used as a guideline:

Has your agency used the 1990 census data, and if so, which products?

Have you used the CTPP?

What types of things have you done with it?

Feel free to talk about both routine and unique studies.

How critical were the census data for these applications?

What made the census data essential?

Could the work have been done without the census data?

Would it have been done without the data?

The list of agencies contacted and the persons interviewed are shown in the appendix to this paper. This listing is presented to provide a point of reference for any future follow-up and to help maintain an up-to-date list of users. This list is also useful as an adjunct to the directory of MPOs published by the U.S. Department of Transportation.

## BACKGROUND

It is worthwhile to set the stage by reviewing some CTPP activities that were external to these MPOs but at the same time influential. The Illinois Department of Transportation (IDOT) provides a focal point for the CTPP through a variety of activities.

At the national level IDOT has maintained an involvement through the activities of CATS and some of the other large MPOs. As an original user of the 1970 data, CATS staff has had a rich history of use of the 1970, 1980, and 1990 CTPP through which a national presence has evolved, which has been supported by IDOT.

This support has come in several forms: financial, with the purchase of the CTPP; political, through letter writing to support the transportation questions in the decennial census and the long-form questionnaire itself; educational, through sponsorship of a National Highway Institute CTPP course; and marketing, by keeping the issue of the CTPP current with the MPOs.

Each year IDOT hosts a planning conference for the MPOs in the state consisting of 1.5 days of presentations on different topics by the MPOs. Through this process CATS staff has presented the concepts and supported the use of the 1990 CTPP for three separate years. During the first conference at which use of the CTPP was explained, the concept of submitting traffic analysis zone (TAZ) equivalency files was promoted and the plans for the release of the CTPP were discussed. At the next conference the CTPP content was reviewed, and finally, at the third presentation, the year 2000 efforts were reviewed as well as the upcoming release of the Urban Element on CD-ROM.

In addition to those efforts, IDOT has also put a process in motion that will likely build in a certain reliance on the CTPP data. It began several years ago when IDOT began an initiative to equip the smaller MPOs with the capability to do travel demand modeling and forecasting. This was facilitated by arming each MPO with the latest version of TRANPLAN, the personal computer on which to run it, and some set-up support. Currently, IDOT has a consultant under contract who is working with most of the MPOs to develop their own travel models and data sets and to get the models up and running. This effort began about 1.5 years ago, and in most areas the calibration phase in their model development is nearing.

## INDIVIDUAL MPO REVIEWS

A synopsis of the results from each of the interviews follows. As will be seen, there is both a certain degree of commonality among the MPOs as well a degree of difference among them.

### Bloomington-Normal

The staff of the Bloomington-Normal MPO wear multiple hats. The parent agency, the McLean County Regional Planning Commission, is responsible for comprehensive planning on a countywide basis. Within that county is the MPO that deals with the cities of Bloomington and Normal and several smaller adjacent towns; its area of operation encompasses approximately 100,000 residents.

In terms of census data, the MPO has been a heavy user and consumer for over two decades. In 1970 the organization went through a large-scale travel demand modeling process for which the Urban Transportation Planning Package (UTPP) was used quite extensively. Although the 1970 effort was considerable, it was not continued.

In terms of current heavy census data use, three general activities are under way. First, the MPO is heavily invested in providing statistical support and background information to those who request it locally. Data summaries and tabulations have been prepared for local school districts, administrative departments, and others.

Second, the MPO is active in using the census data for its planning work. Specific tasks have included processing of household and population forecasts. Custom data summaries that deal with specific planning questions have also been prepared at various geographic levels. An example was a special analysis dealing with mobility limitations.

Through the interview it was ascertained that although the MPO is a heavy user of census data, there has been little experience with the CTPP. The products that are routinely used are the Summary Tape Files (STFs). The CTPP data in use consisted of a paper-based tabulation by TAZ that was produced through an outside contract with Ron Treadway of Illinois State University, who has done census-related work for several of the smaller MPOs.

The third area of activity that promises to make greater use of the CTPP is implementation of the TRANPLAN model, development of which is under way. The MPO has developed its own unique TAZ structure, which will be used with the TRANPLAN model.

The census data are believed to be essential since they are the only data available for many of the issues of concern. To date, the CTPP has not really been used because of staff, equipment, and time limitations. However, there was general optimism concerning the release and use of the Urban Element on CD-ROM. The staff has recently been equipped with PCs, and they are heavy CD-ROM users.

This agency has not considered the potential of losing the data from Census 2000, but the staff wondered what the agencies that rely on it to satisfy federal mandates would do. No local travel surveys are currently planned, but the need for some was cited as critical. One person in this MPO is responsible for transportation-related issues.

### Champaign-Urbana

The MPO for the Champaign area is the Champaign Urbana Area Transportation Study (CUATS), housed within the Champaign County Regional Planning Commission. Its residential population is in the range of 150,000 covering three cities including Champaign, Urbana, and Savoy. This region includes the University of Illinois at Urbana-Champaign.

CUATS has done a fair amount of work with census data but has not worked with the CTPP. The staff is currently exploring a nine-track tape version of the CTPP, working with a doctoral student at the University of Illinois. One difficulty has been identified and is being worked on. Apparently the equivalency file (which was a paper map) has been lost, and CUATS is working on linking their census TAZs and planning zone system. It was noted that the Urban Element CD-ROM may be helpful with this exercise. The MPO's TAZ structure is in their local geography, which was designed to support the local travel models. The census tract default zones were not used.

One of the major activities under way is moving the census data to the in-house geographic information system (GIS), which is based on the Arc/Info package; the census data are coming from a third-party vendor, Wesex. The Wesex data base is drawn from data contained in STF 3. The flow data in the CTPP (Part 3) have yet to be explored.

Among the smaller MPOs, CUATS is at an advanced level when it comes to travel demand modeling. They have had a working version of TRANPLAN up and running for several years. In the development of the model components, both the 1990 census data and employment data supplied by the state were used. CUATS is part of the larger IDOT contract for development of TRANPLAN, and their model development work is ongoing.

Interestingly, a regionwide door-to-door household travel survey was conducted in the area in 1991. Headed by John Kim of the Urban and Regional Planning Department at the University of Illinois, Urbana-Champaign, the survey boasts a 4 percent sample. However, the data are believed to have some methodological deficiencies and concerns, and only the work-related travel data have been successfully used.

In one respect the census data are believed to be critical to the work that the MPO is pursuing. However, no thought has been given to replacing the census data should they not be available for the year 2000. It was

not surprising that there was a lukewarm reaction to the issues of the 2000 census since this MPO has yet to avail itself of the flow (Part 3) and employment (Part 2) data of the CTPP.

During the interview two other census-related efforts of interest surfaced. The first was an undertaking to remedy the problems associated with the Topologically Integrated Geographic Encoding and Referencing (TIGER) File. To this end, a major update was undertaken, which included acquiring address ranges and local information from the 911 operator. Another project, working with the enhanced TIGER File, dealt with geographic determination of the true level of transit service coverage in buffer areas.

### Decatur

Decatur is an area of roughly 100,000 people. The MPO, the Decatur Urban Area Transportation Study (DUATS), is housed within the Macon County Department of Transportation Planning and Zoning. However, the transportation planning work of DUATS, for example, work with the IDOT consultant on travel demand model development, is handled by staff from the city of Decatur.

One individual works specifically with the CTPP. From the way it was described, it sounded as though the agency has one of the CD-ROM versions of the CTPP in which the data are in raw form. Unfortunately, neither the agency nor the city has the equipment, computer skills, or wherewithal to process the data in that form.

When DUATS first received the CD-ROM version of the CTPP, Treadway from Illinois State University produced some tables that could then be further analyzed. The tables included household-related summaries and data on workers, vehicles, and modes. The data were summarized at the local TAZ level and developed primarily to support model development.

The modeling work for the area is now being developed. However, from a modeling perspective, the CTPP data have been critical components of the work, being the only data available. For modeling, the census data are being supplemented with local employment and land use data. A localized household survey was not made in the area, but some specialized surveys may take place as the area moves toward its model calibration phase.

In terms of special projects, an atlas-type document was produced using data from STF 3a. It represents an extraction of the demographic portions of the data for residents at the tract and, in some instances, the block level. At the present time the issue of bicycle usage is being studied, and the Nationwide Personal Transportation Survey data in conjunction with the census data are being used.

Interest was expressed in seeing the Urban Element CD-ROM when it is released. In a larger sense, this

agency was at a loss with the CTPP because of an inability to work with the raw data. Other census products used are the reports and paper tabulations.

### Dubuque

The MPO that covers the area of Dubuque, Iowa, also covers the city of East Dubuque, which is in Illinois. The MPO is responsible for approximately 70,000 residents. It is housed within a parent agency, the East Central Intergovernmental Association (ECIA), which covers a five-county area.

ECIA is a full-service planning agency that uses census data quite extensively. This agency is responsible for planning for local development, developing and completing the area's Community Block Development Grants, performing economic development studies, providing general information in response to requests, and doing the MPO's transportation planning.

The main census data used are the various STF products. The agency itself is PC based, but when needed it can find support from IDOT through a subcontract with a local university. However, for their data needs ECIA does its own processing.

ECIA did not use the CTPP, primarily because of its lack of timeliness. The Census Bureau could not produce the data in time to fit the local planning time frame. Moreover, a direct need for the CTPP has yet to be realized. Around 1990, ECIA conducted an update of their travel demand model (TRANPLAN) and was satisfied with information gleaned from the STF products, which was information at the place of residence. For employment information, ECIA relies on data supplied by the Iowa and Illinois Department of Employment Securities.

The MPO did turn in TAZ equivalency files and is very interested in seeing the Urban Element CD-ROM once it is available.

### Kankakee

The Kankakee County Regional Planning Commission houses the activities for the area's MPO, which is oriented around the cities of Kankakee, Bourbonnais, Bradley, and Aroma Park, making up a population of 100,000. In a way, the MPO is relatively new. Up to two years ago planning activities were handled through an outside consultant. Since then, the MPO has had its own full-time staff and now has a transportation planner and a transportation engineer.

In terms of census data, the staff uses secondary printed reports heavily and is now developing its computer expertise with the use of CD-ROM technology. One of their major products consisted of a data summary book containing a variety of data items summa-

rized by various levels of geography at the place of residence. The MPO staff also drew upon census data for the development of population forecasts for their long-range plan. These forecasts were done at the TAZ level, which at the time was the census tract.

For ongoing travel modeling, the MPO is a party to the TRANPLAN scheme. In the interview it was learned that originally the Census Bureau default for TAZ, the census tract, was used. Since that time a new locally defined TAZ system has been developed and the Census Bureau produced a special data tabulation to bring the CTPP into the new zone system. Because of its proximity to northeastern Illinois, CATS included this area in its CTPP data base and has been working with the data at the TAZ tract level that was defined by the earlier contract staff.

At the urging of some of the staff at Northern Illinois University, this MPO sent a letter to Congressman Rogers in support of maintaining the long-form questionnaire in the census. Earlier in the year letters were sent to the Illinois senators from CATS, and IDOT urged the MPOs to do the same.

### Peoria

The MPO for the Peoria area is the Tri-County Regional Planning Commission, which handles the transportation planning for the Urbanized Area of Peoria, Tazewell, and Woodford counties. The MPO area population is 250,000.

Peoria, along with the other MPOs, is now in the process of developing a travel demand forecasting tool. This process began some time after the 1990 TAZ equivalency files needed to be submitted to the Census Bureau. Originally, this region did not submit any unique TAZs and instead accepted the default of having their CTPP data aggregated at the tract level. Since that decision was made, the MPO has made a commitment to develop its TRANPLAN modeling capability and was faced with the issue of defining a more refined zone system. Unfortunately, the zone system was developed far too late to be submitted to the Census Bureau for the CTPP tabulation.

To remedy this, the MPO staff (with the help of their GIS) established an equivalency file that they have used to reaggregate the needed data from the census STF products. They have used the STF products to provide the basic inputs for model development. In effect, the staff created their own miniature Part A CTPP. Interestingly, the MPO had checked with the Census Bureau about running a special tabulation and found that it would cost them a few thousand dollars. Apparently, they were unable to gain enough local support to purchase a special tabulation.

The MPO also provides a great deal of census data in response to both staff and outside requests. It is a heavy

user of the CD-ROM versions of the STF products. Because the agency also has comprehensive planning commission responsibilities, it works very closely with the towns in the area on the development of their comprehensive plans. This work draws heavily on census data.

During the interview, staff noted that they are primarily a PC-based agency. They do have one work station, but it is relatively new and has not reached maturity in its use. It was also pointed out that the census data are important and should be expanded for 2000. There was a suggestion that the census should collect complete origin-destination information on all trip types and purposes, whereas there was also a concern that the CTPP itself was difficult to use. It seemed that the main frustration with the CTPP was tied to the lateness in delivery of the CD-ROM data. When using the STF, the staff does have the technical skills to pull the needed data directly from the file as opposed to using the extraction software.

In addition, this MPO has made extensive use of the TIGER File for their TAZ work and in allocating employment and other data. Currently, a rural address check is being made using Arc/Info as the GIS.

## Rockford

The duties of the Rockford area MPO are handled within the city of Rockford by staff in the Community Development Department. The population of the planning area is approximately 207,000 and encompasses the city of Rockford, portions of Winnebago County, and several smaller towns and cities.

The MPO has done relatively little with the various census products. The CD-ROM versions of the STFs have been used but not the CTPP. Within the transportation group the census data played a major role in the analysis and preparation of their Title 6 report.

On another project, a great deal of effort was spent mapping the basic demographic data, all of which came from the STF products on CD-ROM processed in a PC environment. The desired data were extracted from the CD with DBase, processed in QuattroPro, and mapped with MapInfo. This analysis was used in support of their plan and plan development. Another project used census data to analyze the population distribution for the purpose of examining the metropolitan area's size and boundaries.

In terms of travel demand models, the Rockford MPO is currently running T-Model, and TRANPLAN is under development. Census data are really not used in the operation of T-Model. The trip generation rates were established some 30 years ago. Other information used in this process includes dwelling unit data, which are locally maintained, and employment data, which come from the state.

For the TRANPLAN work it was thought that many of the basic inputs, like the old trip generation rates,

would be used. No direct survey work is planned, and staffing levels were cited as the single most important reason for not doing more census data analysis. However, it was pointed out that the land use and neighborhood planners are heavy users of census data. The transportation planners interviewed were unaware of any of the activities surrounding the 2000 census and of the BTS version of the CTPP.

## Rock Island-Davenport

The MPO for the Rock Island area is the Bi-State Regional Commission. Aside from the Chicago and St. Louis MPOs, this is the largest in the state. It straddles two states (Illinois and Iowa), covers a quad-city region made up of Davenport, Bettendorf, Moline, and Rock Island, and has 350,000 residents.

The MPO staff considers itself a large user of the census products, but has not used the CTPP. Census data uses range from producing statistical summaries to estimating parameters for travel models. Both of these efforts draw heavily upon the STF and Public Law data sets. In terms of statistical summaries, community profile tabulations, data to support a variety of grant applications, and information to help attract development have all been mined from the STF products. For the travel models, input variables include household size, workers per household, and vehicles per household.

For model development, it should be recognized that the MPO did its own allocation of census block and block group data to their planning zone geography. Once the CTPP data are available, MPO staff will have to decide how they want to deal with this issue. Census data were believed to be critical for all their work. The staff could only speculate about what they would do if no census data were available.

Within Bi-State two basic media are relied on for census data: printed reports and the CD-ROM series. The complete data processing capability is PC network based. It was noted that the CTPP had been received, but since it is on a nine-track tape, it has just sat on the shelf. Also, although the staff was aware of and had a copy of the Statewide Element on CD-ROM, no one has used it. They were finding that it was too slow to run and that it took much room on their computers. Since it was not in their local geography, they did not see a real need to overcome these hurdles. They are anxiously awaiting the release of the Urban Element on CD-ROM.

Although this region is rather large, Bi-State as a travel demand modeling agency is relatively new. Until three years ago all the technical development work was done for the area by IDOT. There are no plans for a regionwide household travel survey. There is a rather large-scale bridge crossing analysis under way that will produce a great deal of information for the commission's use.

## Springfield

The MPO in Springfield, the state's capital, is housed in the Springfield-Sangamon County Regional Planning Commission. The commission is a full-service comprehensive planning agency, whereas the MPO deals with transportation planning issues. The MPO is responsible for a population of 125,000 residents and is focused on the Springfield Urbanized Area.

To date, the MPO staff have not been big users of the CTPP. However, they are part of the TRANPLAN process and have asked Treadway to provide them with paper-based tabulations of the CTPP data.

The timing of the TRANPLAN development and the need to provide TAZ equivalencies for the Census Bureau was just slightly less than ideal. Originally, the MPO was the test site for the original TRANPLAN purchase. As such, a zone system was developed early and equivalency files were submitted to the Census Bureau. However, as luck would have it, there were changes. With a new consultant to develop the TRANPLAN model, the TAZ zone system was changed. Fortunately the MPO staff was able to submit the new zone system to the Census Bureau just in time—well past the original deadline but before the Census Bureau staff had done the data processing for the area. Even with the new zone system there may be some TAZ allocation problems, which are currently under study.

## GENERAL FINDINGS

The smaller MPOs in Illinois, for the most part, have yet to fully experience the CTPP or its predecessors. In fact, only one of these MPOs purchased the 1980 package, and widespread use of it was not perceived. The MPOs are aware of the data in the 1990 CTPP, have seen examples of its use, and have attended the NHI CTPP training class. Although use of the CTPP has been minimal, reliance on and use of census products in general have been high.

In most areas use of the CTPP with trip generation and planning work was reported, but not to the degree that was expected. There was a strong sentiment that the data, as received, were not really accessible, and staff looked forward to the CD-ROM Urban Element and its use. As a result of discussions during the telephone interviews, five MPOs were sent different materials, including State-wide Element CD-ROMs, CTPP workbooks produced by FHWA, and a variety of CATS reports (1-3).

As one would expect, the MPOs have small staffs (with often only one planner), limited technical resources, and a broad spectrum of issues competing for time that restrict the data mining that could take place. Offsetting this, all the MPOs are now PC equipped and capable of data processing in that environment. In fact, several are well advanced and are beginning to develop GIS capabilities.

Although each MPO presents a rather unique case, many are part of larger comprehensive planning agencies and commissions. Because of this larger planning role, most agencies were well versed in the use of census data for providing descriptive data summaries from the STF products.

Throughout the interviews it was clear that census data play an important role in the local processes. For small-area data (tracts and blocks), the census is considered, and is, the only source. In short, the census data were thought to be critical and essential. However, it was virtually impossible to get anyone to ascertain if their work would have been done without the census data.

Finally, there was genuine enthusiasm about getting the CTPP data. The MPOs represent a bastion of brand-new users. They are currently an untapped market that has been well primed. For these MPOs it is an exciting time as they grow in the development of their new forecasting ability and begin to explore the various dimensions of the CTPP.

## CONCLUDING COMMENTS

Throughout Illinois there has been a recent groundswell of activity in the transportation planning community. Around 1990 the state transportation department purchased the travel demand modeling package TRANPLAN and a computer to run it for each MPO. Following up on this, the state has hired a consultant to develop the localized models and get them up and running. This in turn has caused many of the local areas to focus differently on the CTPP than they may have done without the travel demand modeling capability. The census data and the resultant CTPP represent the only data available in these metropolitan areas. In an almost rhetorical way, these are the only data suitable for the use.

In the smaller MPOs the use of the CTPP has not been as extensive as one might expect. The greatest use has been in the development of trip generation models and to provide descriptive statistics on various demographic and travel trends. One major reason for a general lack of use is the timing and delivery of the package. As of the writing of this paper, the MPOs have yet to receive their Urban Element in a form that matches their processing capabilities.

It needs to be pointed out, however, that the smaller MPOs, which for the most part are part of larger comprehensive planning organizations, are indeed heavy users of census data as they relate to other planning functions. There is also a strong expectation that once the Urban Element CD-ROM is distributed to these MPOs, they will begin to explore its uses and begin applying the data. All MPOs interviewed noted that the CTPP was an important component in their transportation model development, which is ongoing.

For the most part the CTPP has been widely used but has yet to be tapped to its fullest potential. Many individuals had ideas about the use of the CTPP and would like to be able to work with the package but acknowledge a general lack of human resources and in some instances a lack of equipment. In one sense for the CTPP to be more widely used the data would have to be available when the questions and needs that would require its use arise.

Finally, there was general agreement that the window of opportunity to expand the base of CTPP users is continuing to close as the CD-ROM version of the

Urban Element is delayed. In 1980, other than the two largest MPOs, Chicago and St. Louis, only one smaller MPO, Peoria, purchased the package. The other MPOs did not have the resources for the purchase nor did they see the benefits from using it. For 1990, however, many believed that once this new group of users got the census information and began to explore it, they would integrate it into their local planning processes. As noted, midway through 1996, the 1990 data had yet to be received, and consequently any growing support for the product was on the wane.

## APPENDIX: Illinois Small-Area Metropolitan Planning Organizations

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Verale Williams

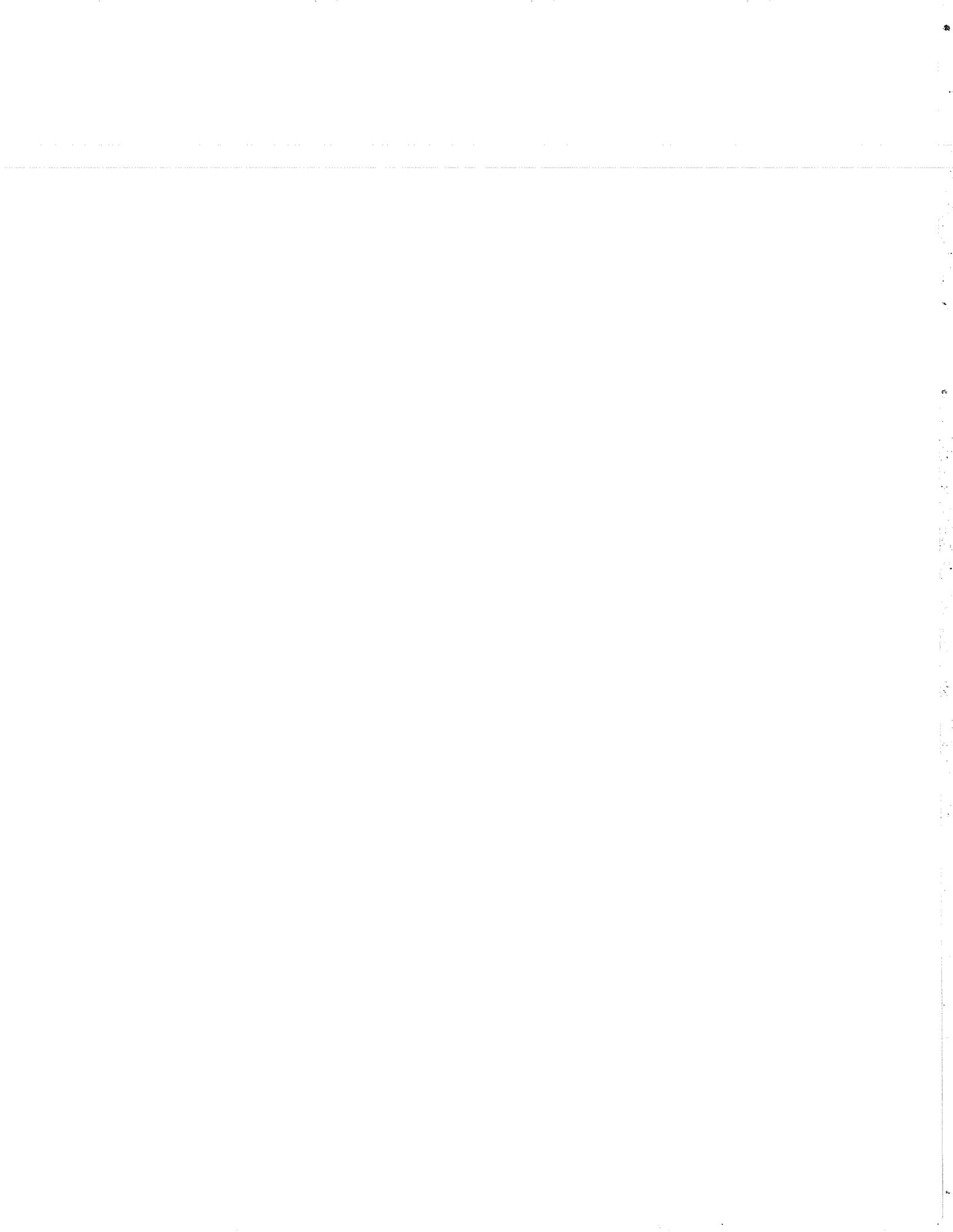
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# STATE DEPARTMENTS OF TRANSPORTATION

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# Wisconsin's Translinks 21 Multimodal Plan: Implications for Census Data Needs

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Randall Wade, *Wisconsin Department of Transportation*

This case study provides the intercity elements of Wisconsin's Translinks 21 Multimodal Plan. The intercity passenger and freight forecasting techniques utilized are described in some detail. The case study is used to highlight data needs met by the decennial census and other Census Bureau data-gathering efforts. The discussion concludes by stressing the importance of the timely provision of census data to support ongoing state-level modal and multimodal planning activities.

In November 1994, the Wisconsin Department of Transportation (WisDOT) released its Translinks 21 Multimodal Transportation Plan. The Translinks 21 Plan responds to Section 135 of the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) mandating the preparation of a statewide transportation plan considering "all modes of transportation." These ISTEA requirements have forced state transportation agencies to seek out and utilize a wide variety of new data sources, including socioeconomic data provided by the Bureau of the Census. Although statewide highway and airport system plans had been prepared for Wisconsin, WisDOT had no previous experience with statewide multimodal transportation planning. For Wisconsin as well as the many states that in the past have prepared only "policy level" statewide plans, the data requirements associated with the new ISTEA mandate have been challenging.

In this case study the intercity elements of Wisconsin's Translinks 21 Multimodal Plan are provided and the intercity passenger and freight forecasting techniques utilized are described in some detail. The case study is used to highlight data needs met by the decennial census and other Census Bureau data-gathering efforts. The discussion concludes by stressing the importance of the timely provision of census data to support ongoing state-level modal and multimodal planning activities.

## TRANSLINKS 21 OVERVIEW

The Translinks 21 Plan was unique in that it was the first statewide multimodal transportation plan prepared by the Wisconsin Department of Transportation (1,2). The Translinks 21 Plan is multimodal in that all modes were analyzed simultaneously, and interactions among modes were specifically accounted for. The multimodal approach taken in the planning process was facilitated by the development of integrated sets of passenger travel and freight shipment data for all intercity modes: passenger rail, freight rail, intercity bus, automobile, truck, air passenger, air cargo, and waterborne freight.

For passenger travel, a multimodal travel demand model was developed to analyze transportation improvements called for in the adopted Translinks 21 Plan. On the freight side, alternative commodity shipment forecasts for each mode were analyzed with the advice of

a Freight Expert Panel made up of private-sector transportation leaders and experts from throughout the state. The results of these multimodal forecasting efforts are described in the following discussion.

## PASSENGER TRAVEL FORECASTING METHODOLOGY

The multimodal passenger travel forecasts used in the Translinks 21 Plan were developed using a TRANPLAN-based intercity travel demand model. This model was used to simulate the impact of the introduction of new passenger modes, as well as service improvements in existing modes (2).

The travel forecasting model was developed by KPMG Peat Marwick, McLean, Virginia. It is an integrated two-stage model system that forecasts both total travel demand and mode share. The total travel demand component of the model forecasts "natural" growth stratified by trip purpose (business, recreational) resulting from changes in one or all of the following: population, employment, and income. It also forecasts "induced" or constrained demand resulting from changes in the combined level of service provided by all modes. The zonal network used consists of 157 zones; 112 zones are made up of whole counties and portions of counties within Wisconsin and 45 zones are in adjacent areas of neighbor states (in particular the Chicago and the Minneapolis-St. Paul metropolitan areas).

The mode-share component of the model forecasts the share of the market captured by each intercity passenger mode: automobile, conventional rail, high-speed rail, integrated bus and rail, intercity bus, and air. Travel survey information was used to capture both revealed and stated travel preferences by mode. Origin and destination surveys on Wisconsin highways as well as on-board and terminal surveys of Amtrak, air, and intercity bus travelers were used to capture data on existing revealed travel choices. These surveys generally included questions on trip purpose, origin, destination, and mode of travel. This information was used to develop estimates of existing base-year intercity travel volumes by mode, origin-destination, and trip purpose.

A mail-back survey was distributed at selected highway sites as well as on board trains and at terminal sites for Amtrak, intercity bus, and automobile modes to capture stated mode preferences. This information is essential for forecasting travel on modes not currently available. Travelers were asked to respond to future mode-choice scenarios with varying travel times (speeds), frequencies, and fares. The survey included questions on trip purpose, origin and destination, travel party size, trip frequency, and trip duration. Traveler information regarding home location, household size, automobile ownership, and household income was also gathered. A total of 6,860

preference surveys were distributed with a return rate of 24 percent. A nested logit model was developed using data from this survey to produce mode-share forecasts. A schematic description of the overall model structure is shown in Figure 1.

It must be emphasized that the model predicts intercity passenger trips only, generally those trips that cross county lines. For example, intercity automobile forecasts do not include local trips, and intercity bus forecasts do not include bus transit trips in urban areas. It also should be recognized that the intercity forecasts provided by the model relate only to trips within the state and to adjoining counties including the Chicago and Twin Cities metropolitan areas. For example, an air trip from Milwaukee to Kansas City was not included in the model forecasts.

## CENSUS DATA USED IN PASSENGER TRAVEL FORECASTS

Bureau of the Census socioeconomic data were used to develop independent variables used in the total travel demand component of the model (3). Population data from the Census of Population and Housing was used by the Wisconsin Department of Administration Demographic Services Center to develop county population forecasts consistent with zonal detail of the model. Bureau of the Census County Business Patterns employment data were used by the WEFA Group, Burlington, Massachusetts, a WisDOT subcontractor, to produce total employment forecasts at the county level. Given that the statewide model forecasts intercity trips using a county-level zone structure, journey-to-work and similar data for Urbanized Areas contained in the Census Transportation Planning Package were not directly utilized.

## PASSENGER TRAVEL FORECAST RESULTS

During the Translinks 21 process, WisDOT used the intercity travel demand model to compare a set of "plan forecasts" reflecting the passenger travel recommendations in the Translinks 21 Plan with a set of "trend forecasts" (4). The Translinks 21 Plan recommendations included the introduction of high-speed rail (HSR) (125-mph) passenger service between Chicago, Milwaukee, Madison, and the Twin Cities of Minneapolis and St. Paul (5). This recommendation was for 12 round trips per day of HSR service enhanced with pulsed feeder bus connections serving low-density markets and conventional (79-mph) rail service between Green Bay and Milwaukee (see Figure 2). The plan called for intercity bus improvements including essential bus service (two round trips per day) for all com-

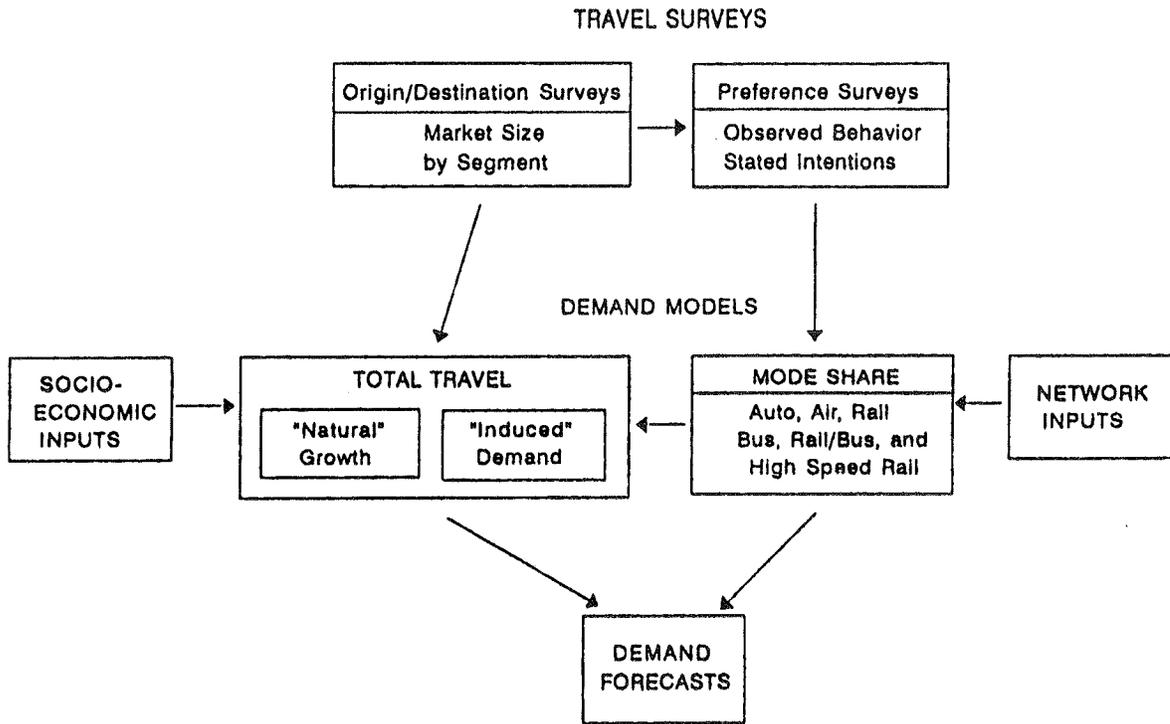


FIGURE 1 Demand modeling and forecasting approach: Translinks 21 intercity passenger analysis.

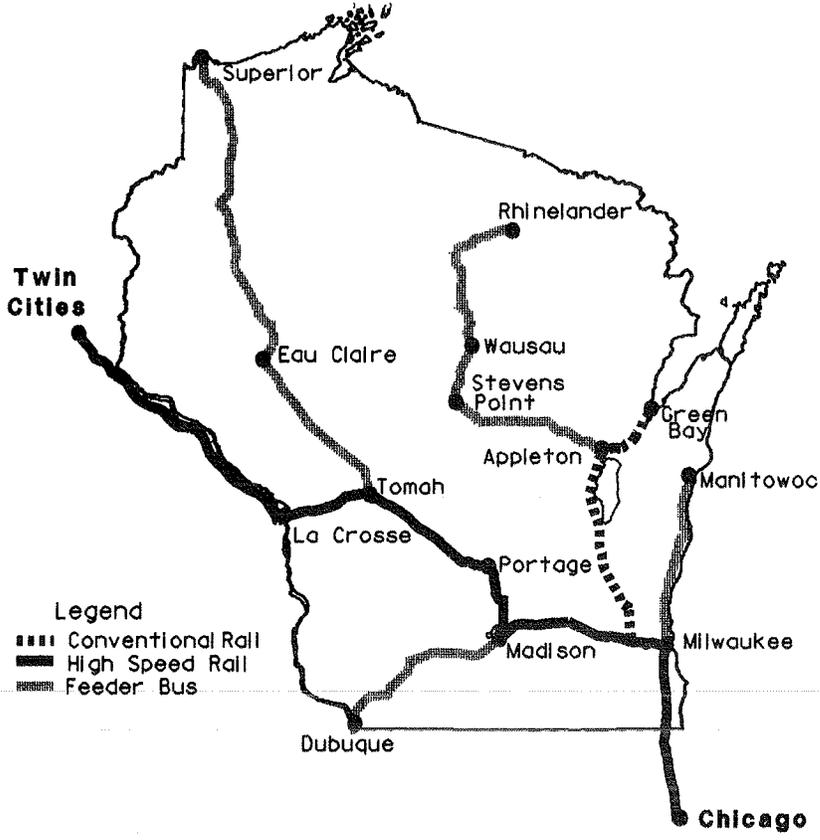


FIGURE 2 Translinks 21 intercity passenger rail plan.

munities in Wisconsin greater than 5,000 in population (see Figure 3) (6). The plan also called for completion of the Corridors 2020 rural multilane highway network. In addition, the plan provided modest enhancements to the state airport program, which were not modeled. The trend forecast reflected a scenario in which existing rail, intercity bus, and air programs are maintained and the Corridors 2020 highway system is completed as planned.

In comparing trend and plan forecasts (see Table 1) to base-year 1995 trips, the most notable change was the magnitude of ridership associated with the addition of HSR service between Chicago and the Twin Cities (7). HSR will support 5.4 million riders in 2020. When compared with the trend forecast (see Table 2), the plan forecast also showed 801,000 fewer air trips, or a 59.0 percent reduction. This reduction was largely the result of the diversion of air passengers in the Chicago-Twin Cities corridor to HSR service in response to fare savings, more competitive trip times, and easy access to downtown terminals. (Note that the base and forecast

figures for air travel include only trips within the state and to adjoining metropolitan areas, which represent only a subset of total trips taken. For example, in 1993 WisDOT figures show over 7.2 million departures and arrivals from Wisconsin airports.)

The plan forecast also showed a reduction of about 2.7 million intercity automobile trips when compared with the trend forecast (see Table 2). This was a result of passenger rail as well as intercity bus improvements and was less than 1 percent of the intercity automobile trend forecast.

Figure 4 shows the results of an analysis of potential intercity passenger travel diversions from highways to other intercity transportation modes. These estimates are based on the department's comparison of the impact of the plan and trend forecasts on the Corridors 2020 highway network.

Forecast reductions of intercity automobile traffic as a percent of intercity automobile traffic and as a percent of total traffic range from 0.3 and 0.1 percent, respectively, at Whittenberg on Highway 29 between Wausau

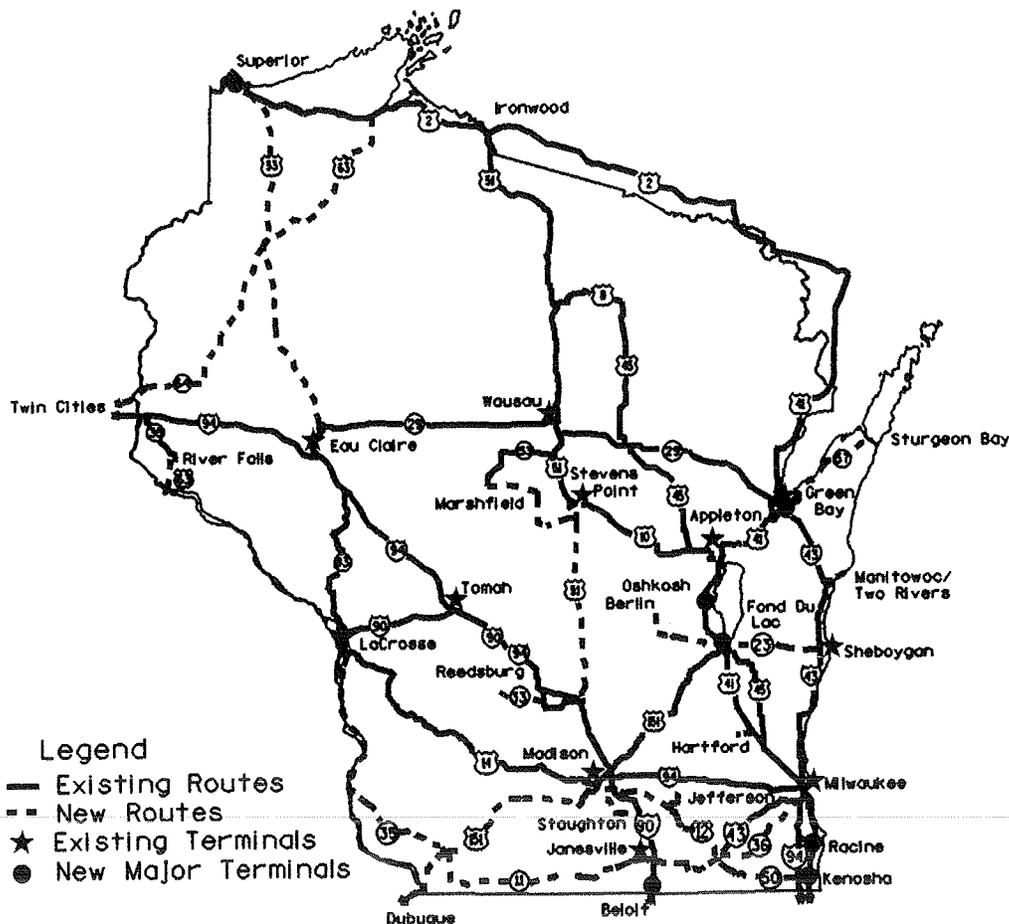


FIGURE 3 Translinks 21 intercity bus service plan (communities over 5,000).

TABLE 1 Translinks 21 Travel Demand Forecasts: 2020 Intercity Passenger Trips

Mode	1995	2020 Trend			2020 Plan		
		Trips	Difference	% Increase	Trips	Difference	% Increase
Auto	327,832,000	405,063,000	77,231,000	23.6	402,365,000	74,533,000	22.7
Air	1,064,000	1,358,000	294,000	27.6	557,000	(507,000)	-47.7
High Speed Rail	0	0	0	0.0	5,400,000	5,400,000	*
Conventional Rail	421,000	522,000	101,000	24.0	400,000	(21,000)	-5.0
Feeder Bus/Rail	0	0	0	0.0	52,000	52,000	*
Intercity Bus	460,000	550,000	90,000	19.6	527,000	67,000	14.6
<b>Total</b>	<b>329,777,000</b>	<b>407,493,000</b>	<b>77,716,000</b>	<b>23.6</b>	<b>409,301,000</b>	<b>79,524,000</b>	<b>24.1</b>

\* New Service

and Green Bay to 12.4 and 6.5 percent on Interstate 90-94 at Mauston between Madison and the Twin Cities. Data on these and other segments are shown in Table 3. In summary, intercity passenger transportation services, such as conventional Amtrak trains, HSR, or intercity buses, will have limited potential to significantly reduce intercity automobile traffic on most highway routes.

Continuing the analysis of travel forecasts for the remaining modes, conventional rail ridership was lower in the plan forecast when compared with the trend forecast (see Table 2) as a result of upgrading existing conventional rail service in the Chicago-Milwaukee corridor to high-speed service as called for in the Translinks 21 Plan (8). Some, but not all, of this reduction is offset by new conventional rail service being provided in the Milwaukee-Green Bay corridor (see Figure 2).

Intercity bus travel increased under both trend and plan forecasts (see Table 1). However, overall bus ridership was lower in the plan forecast even though it is

based on a new essential bus service program for all communities with populations greater than 5,000. This lower bus ridership is the result of a diversion of bus travelers on existing high-density routes to new passenger rail services also called for in the plan. The separate feeder bus-rail forecast (see Tables 1 and 2) is for ridership on a new feeder bus service associated with planned rail service improvements.

Total passenger travel increased 24.1 percent in the plan forecast and 23.6 percent in the trend forecast relative to 1995 (see Table 1). In 2020 there were about 1.8 million more trips under the plan forecast than under the trend forecast (see Table 2) as a result of new trips induced by the provision of new modes and services. The induced travel in the plan forecast was largely the result of new HSR service allowing individuals to take trips they otherwise would not have taken. New conventional rail and intercity bus service had similar effects, although not of the same magnitude.

TABLE 2 Modal Interaction Comparison: Plan Versus Trend Forecasts (2020 Intercity Passenger Trips)

Mode	Year 2020		Difference	% Change
	Trend Trips	Plan Trips		
Automobile	405,063,000	402,365,000	(2,698,000)	-0.7
Air	1,358,000	557,000	(801,000)	-59.0
High-Speed Rail	0	5,400,000	5,400,000	*
Conventional Rail	522,000	400,000	(122,000)	-23.4
Feeder Bus/Rail	0	52,000	52,000	*
Intercity Bus	550,000	527,000	(23,000)	-4.2
<b>Total</b>	<b>407,493,000</b>	<b>409,301,000</b>	<b>1,808,000</b>	<b>0.4</b>

\* New Service

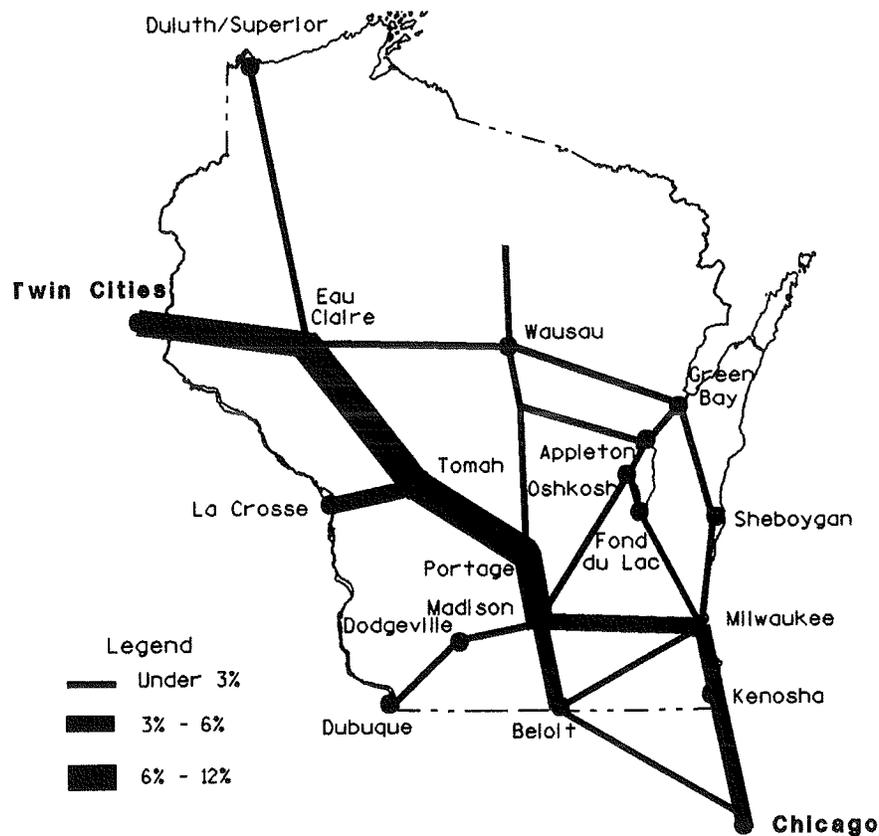


FIGURE 4 Impact of adopted plan on trend automobile forecast, 2020: percent reduction in intercity automobile volume.

**FREIGHT COMMODITY ANALYSIS  
METHODOLOGY**

The multimodal freight commodity shipment analysis undertaken during the Translinks 21 planning process relied on the input of a Freight Expert Panel made up of private-sector transportation leaders and experts rather than on a deterministic model. The resulting multimodal

forecasts were market driven in that they reflected private-sector industry trends and were not based on specific public-sector service improvement investments as was the case with passenger travel (8).

The intercity freight planning effort began with the development of a county-level commodity flow data set for all modes. This commodity flow data set was prepared by Reebie Associates, Greenwich, Connecticut,

TABLE 3 Impact of Adopted Plan on Trend Intercity Automobile Forecast, 2020

Route		Reduction in Trend Forecast	
		Intercity (%)	Total Traffic (%)
I-90/94	Madison to Portage	6.6	4.2
Hwy 18/151	Madison to Dodgeville	0.5	0.3
I-94	Madison to Milwaukee	5.5	4.4
I-90/94	Portage to Tomah	12.4	6.5
I-94	Kenosha to Milwaukee	2.9	1.9
I-90	Beloit to Madison	5.1	3.9
Hwy 29	Wausau to Green Bay	0.3	0.1
Hwy 41	Fond du Lac to Milwaukee	1.3	0.6
Hwy 51	Portage to Wausau	2.5	1.4

and analyzed by Wilbur Smith Associates, Columbia, South Carolina. The commodity flow data base was built up from federal sources such as the Interstate Commerce Commission (railroad) waybill sample, the U.S. Army Corps of Engineers *Waterborne Commerce of the United States*, "Waterborne Commerce Statistics," and FAA *Airport Activity Statistics of Certified Route Air Carriers 12 Months ending December 31, 1992*, supplemented with proprietary truck data from Reebie Associates Motor Carrier Data Exchange.

The resulting data set provided commodity information at the three-digit Standard Transportation Commodity Classification (STCC) level of detail. The data set also provided origin, destination, and trip length information among 106 county zones in Wisconsin and neighboring states and 68 regional zones variously made up of states, Canadian provinces, and Bureau of Economic Analysis (BEA) analysis areas. Year 2020 forecasts of these commodity flows were developed using county-level two-digit Standard Industrial Classification (SIC) employment forecasts developed by the WEFA Group. These trend forecasts based on forecast economic activity, however, did not explicitly recognize changes in modal preference by shippers.

The plan forecast used in the Translinks 21 Plan was based on a truck-rail intermodal scenario developed with the advice of the Translinks 21 Freight Expert Panel. In this case, trend forecasts of truck and rail modes were refined to specifically address rapidly emerging truck-rail intermodal partnerships. Through these partnerships, state and national rail and trucking companies have entered into agreements to shift the linehauls of long-distance truck moves onto rail, utilizing intermodal container, trailer-on-flat-car, and new RoadRailer technologies.

A survey of the expert panel members and other commerce and shipper organizations throughout the state was used to identify future changes in truck-rail intermodal use; haul-distance break points; service frequency characteristics necessary for diversion from truck to rail; and the relative divertability of specific commodities in the commodity flow data base. This survey was used by the expert panel to establish 500 mi as the minimum distance for future intermodal moves. The panel also established a minimum frequency threshold of four departures and arrivals per day for intermodal trains consisting of at least 50 containers or trailers per train moving 1.3 million tons per year. On the basis of survey results, the divertability of specific commodities in the data base was classified as high (100 percent), medium (75 percent), low (25 percent), or not divertable (0 percent).

The commodity flow data base was then analyzed to find truck moves with trip lengths greater than 500 mi with origins and destinations in Wisconsin. These

movements were diverted to the rail mode as applicable by applying the above percentages to specific commodity groups. Geographic locations were then identified where counties or groups of counties within Wisconsin would generate the 1.3 million tons of intermodal shipments per year (see Figure 5). These locations were then used to identify future intermodal trade lanes, and the diverted tonnages were assigned to specific rail lines in Wisconsin using a TRANPLAN assignment methodology. Similarly, truck commodity flows were assigned to the state trunk highway network and converted to equivalent truck volumes to assess the impact of intermodal diversion on future highway needs.

This information was used to develop a freight rail classification scheme (see Table 4 and Figure 6). This classification was used along with unit costs to estimate private- or public-sector investments required through year 2020 to improve the current state freight rail system to meet the specific standards (9).

#### CENSUS DATA IN FREIGHT COMMODITY ANALYSIS AND FORECASTS

Data gathered by the Bureau of the Census were critical in development of the Translinks 21 multimodal freight analysis. Data developed in the last comprehensive Census of Transportation in 1977, especially the 1977 Commodity Flow Survey, were particularly critical because these data provided a benchmark for the development of state-level multimodal commodity flow data sets such as that used in Translinks 21. The 1993 Commodity Flow Survey currently being prepared as a part of the 1992 Census of Transportation, Communications, and Utilities is the first comprehensive update of these data since 1977. This survey is being funded by the U.S. Department of Transportation through its Bureau of Transportation Statistics (BTS). Like the 1977 survey, the data are being developed for substate regions, in this case 89 National Transportation Analysis Regions (NTARs) representing one or more BEA economic areas. The 1993 Commodity Flow Survey and regular updates to follow will be essential in preparing, maintaining, and updating state-level multimodal plans like that prepared by Wisconsin as well as conducting a variety of other modal and policy-level freight planning activities.

In developing the county-level commodity flow data base and forecasts used by Wisconsin in the Translinks 21 Plan, Reebie Associates used a wide variety of Census Bureau data. Current Industrial Reports were used to confirm the year-to-year growth of selected industries. The Annual Survey of Manufactures was used to obtain information on industrial activity by state. Trade data

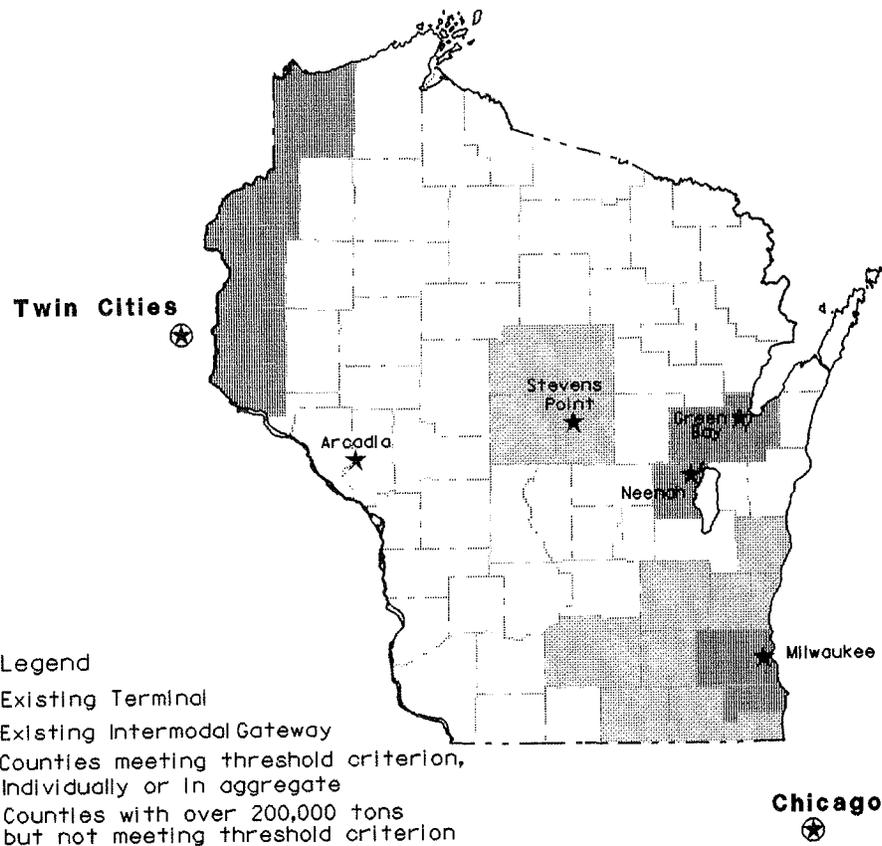


FIGURE 5 Counties with potential new intermodal traffic in 2020: traffic in excess of 200,000 tons (500-mi case).

TABLE 4 Translinks 21 Freight Rail Route Standards

Category	Type	Description	Standards
Backbone	Main Line	Main lines connecting gateways: Chicago, Twin Cities, Green Bay, Superior, Sault Ste. Marie.	40 MPH. Traffic > 25 mil. gross tons/yr; double or single track with long sidings; basic train control systems. Active grade crossing warning devices.
	Intermodal I	Serving WI regions generating ≥ 1.3 million net intermodal tons/yr. by 2020.	60 MPH. Frequency ≥ trains per day @ 50 units/train; add sidings; basic train control systems. Active grade crossing warning devices.
	Intermodal II	Serving WI intermodal container facilities ≤ 1.3 million tons/yr.	40 MPH. Same capacity and safety improvements as Intermodal I.
	Passenger Rail	Existing or planned routes.	60 MPH. Basic train control systems. Add sidings ≥ 4 trains/day. Active grade crossing warning devices.
Secondary	Local 1	Carrying ≥ 25,000 carloads and connecting to Main lines.	40 MPH.
	Local 2	Providing in-state service and/or carrying 86 - 25,000 carloads.	10-25 MPH.
	Local 3	Providing in-state service and/or carrying ≤ 85 average annual carloads.	10-25 MPH.



FIGURE 6 Translinks 21 freight rail route classification.

from the Bureau of the Census for the United States, Mexico, and Canada were used to obtain up-to-date statistics on volumes, commodities, and geography of international import-export activity. Information was derived from both the traditional foreign trade data sets and the newer surface trade data collected by the Census Bureau and provided under a special agreement and with funding from BTS. Data from the 1990 Census of Population and Housing was used to make allocations of consumption. Data from the Bureau of the Census County Business Patterns was used by the WEFA Group to develop county-level employment forecasts.

## FREIGHT COMMODITY RESULTS

The intercity freight commodity forecasts used in the Translinks 21 Plan were market driven in that they reflected private-sector industry trends and were not based on specific public-sector service improvement investments, as was the case for passenger travel. The Translinks 21 Plan forecast that over all modes, 485.3 million tons of freight would be shipped in 2020 (see Table 5). This tonnage represents a 58.4 percent increase over 1992. The truck mode had the largest share

of total commodity shipments, with year 2020 shipments of 237.5 million tons, an increase of 49.8 percent over the planning period. Freight rail had the second highest share of total shipments but a higher forecast growth rate of 72.8 percent between 1992 and 2020. The waterborne mode was a distant third with forecast shipments of 51.4 million tons shipped in 2020. The high-value cargo shipped by air was the smallest in tonnage but had the highest forecast increase of 214.6 percent.

A comparison of the initial trend forecasts with the plan forecasts used in the adopted Translinks 21 Plan illustrates the interaction of the expert panel and the commodity flow analysis methodology.

As shown in Table 5, the initial trend forecast growth rates for truck and freight rail were 53.1 and 68.3 percent, respectively. They were driven by independently forecast growth rates of state industry sectors and reflected no explicit change in modal preference. The plan forecasts for truck and rail based on the previously described intermodal analysis and reviewed by the Freight Expert Panel and selected for the Translinks 21 Plan were 49.8 and 72.8 percent, respectively.

The impact of forecast truck-rail intermodal activity on forecast modal shares is shown in Table 6, where

TABLE 5 Translinks 21 Freight Tonnage Forecasts by Mode: 2020 Tonnage

Mode	1992	2020 Trend	% Increase	2020 Plan	% Increase
Truck	158,512,000	242,664,000	53.1	237,515,000	49.8
Rail	113,463,000	190,910,000	68.3	196,059,000	72.8
Water	34,254,000	51,363,000	49.9	51,363,000	49.9
Air	123,000	225,000	82.9	387,000	214.6
<b>Total</b>	<b>306,352,000</b>	<b>485,162,000</b>	<b>58.4</b>	<b>485,324,000</b>	<b>58.4</b>

trend forecast modal shares are compared with those under the plan forecasts.

The rail share of forecast shipments increased from 39.3 percent under the trend forecast to 40.4 percent with the plan forecast. The truck modal share decreased from 50.0 to 48.9 percent. This relatively modest impact on aggregate shares is due to the fact that the majority of freight traffic travels too short a distance to make economical use of intermodal transportation services. Similarly, on a state-wide basis, the plan forecasts showed that truck-rail intermodal movements would capture a relatively modest 2.1 percent of what had been previously truck-only moves.

The Translinks 21 analysis also identified those specific corridors in which intermodal activity is most likely to increase through the year 2020. As shown in Figure 7, the impact of forecast intermodal trends is concentrated on highway corridors in the southern and eastern portions of the state where truck traffic moving from Green Bay through Chicago to the east and from Green Bay through Beloit and Dubuque to the west would be diverted on rail to Chicago-area intermodal gateway terminals. After a rail-to-rail interchange in Chicago, the shipments would then move either east or west. In these intermodal corridors the impact on truck volumes was more significant than the aggregated totals.

Translinks 21 estimates of reductions in truck vehicle counts in these corridors as a percent of total intercity truck and total traffic volume range from 6.9 and 0.7 percent, respectively, on Highway 26 from Janesville to Waupun to 14.1 and 1.5 percent on I-43 from Beloit to Milwaukee. Table 7 provides more specific information on these and other corridors, both in terms of percent

reductions in truck traffic and in terms of reductions in total traffic. It is important to recognize that on major Wisconsin highways truck counts as a percent of total traffic range from 10 to 20 percent. Thus, although the expansion of intermodal activity may have a relatively significant impact in terms of reduced truck traffic, it will generally have a much smaller impact in terms of total traffic as is demonstrated by the data in Table 7.

The initial trend forecast for air cargo was similarly refined using forecasts developed in a concurrent statewide air cargo study conducted by WisDOT. This refined forecast was based on a more detailed analysis of emerging air cargo trends. The resulting plan forecast predicted a 214.6 percent increase in air cargo tonnage through 2020 (see Table 5). Although this is an extremely high growth rate, air cargo maintained a share of less than 1 percent of total tonnage under either forecast, as shown in Table 6.

The Translinks 21 Plan forecast for the waterborne mode was a trend forecast of 49.9 percent over 1992 levels. The expert panel agreed that underlying industry and sectoral economic trends driving this forecast were the best indicators of the future growth of this mode. Its share of total tonnage was 10.6 percent, as shown in Table 6.

## SUMMARY AND CONCLUSIONS

Summarized in this paper is the intercity forecasting methodology used in Wisconsin's Translinks 21 Multimodal Plan; associated Bureau of the Census data needs are highlighted. From this case study it is clear that a wide variety of Census Bureau data is required to produce a state-level multimodal plan that captures the interactions between and among modes.

Bureau of the Census data needed for statewide multimodal planning include

- Census of Population and Housing;
- County Business Patterns;
- Census of Transportation, Communications, and Utilities (in particular the Commodity Flow Survey);
- Selected Current Industrial Reports;
- Annual Survey of Manufactures or Census of Manufactures;

TABLE 6 Share of Total Freight Shipments, 2020

Mode	Trend (%)	Plan (%)
Truck	50.0	48.9
Rail	39.3	40.4
Water	10.6	10.6
Air	0.0	0.1
<b>Total</b>	<b>100.0</b>	<b>100.0</b>



FIGURE 7 Impact of adopted plan on trend truck forecast, 2020: percent reduction in intercity truck volume.

- Foreign trade data; and
- Surface trade data.

Because state-level plans focus on intercity travel, which is dominated by business and recreational travel instead of travel within Urbanized Areas, state multimodal plans are less likely to directly utilize the journey-to-

work and similar data included in the Census Transportation Planning Package. However, because ISTEA requires that statewide plans incorporate the results of metropolitan planning organization plans in Urbanized Areas, these more detailed data are also ultimately essential to comprehensive statewide transportation planning.

TABLE 7 Impact of Adopted Plan on Trend Truck Volume Forecast, 2020

Route		Reduction in Trend Forecast	
		Intercity Truck (%)	Total Traffic (%)
I-43	Beloit to Milwaukee	14.1	1.5
I-43	Milwaukee to Green Bay	8.3	0.9
Hwy 41	Milwaukee to Fond Du Lac	7.4	0.5
Hwy 41	Fond Du Lac to Oshkosh	8.8	0.2
Hwy 26	Janesville to Waupun	6.9	0.7
Hwy 26	Waupun to Oshkosh	11.0	1.1
I-94	Illinois Line to Milwaukee	11.4	1.0

## ACKNOWLEDGMENTS

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# Uses of Census Data in Kansas

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The recent uses of decennial census data within the Bureau of Transportation Planning of the Kansas Department of Transportation are overviewed, and one project pertaining to travel times in the Wichita metropolitan area is presented in detail as a case study. The presentation of the projects, which includes the identification of the census products and software tools used, serves as the foundation to discuss problems and possible solutions encountered in processing census data. The paper is divided into three parts. First is a quick overview of projects for which census data have served as the main source. Second is the presentation of the Wichita travel-time case study, which is an excellent example of both the use of the census data in transportation planning and the difficulties involved in processing census data. Last is a general discussion of tools needed to access and present census data, which census products are found pertinent to transportation planning, and what products the planning staff at Kansas Department of Transportation would like to see in the future, including content and format of the 2000 census as well as accessibility to past census data on CD-ROM. The paper concludes with a list of recommendations.

**T**he uses of decennial census data in the Bureau of Transportation Planning within the Kansas Department of Transportation (DOT) include both travel modeling and numerous small research and data-gathering activities. Since other case studies have con-

centrated on the use of decennial census data as input parameters for travel models, this paper focuses on how census data are used in other aspects of transportation planning.

As frequent users of census data, the staff of the Bureau of Planning responded eagerly to the request to submit a paper pertaining to use of such data for transportation planning in Kansas. While seeking to identify an appropriate case study, staff quickly concluded that the census data served frequently as either the sole source or the most accessible source of information for numerous projects and small reports. To demonstrate, a list of recent projects was compiled in which census data have served as the primary source of information for analysis purposes. This list, given in the next section, demonstrates the wide range of uses for the census data apart from modeling. Much of the effort in using census data was given to data conversion and presentation, limiting any efforts with census data to those that warranted the time necessary to overcome the formatting problems frequently encountered.

The case study chosen for presentation in detail was a travel-time report prepared for the Wichita-area planning office. The study was performed just before the writing of this paper and reflects the current mode of operation in terms of tools, data sources, and methodology of the Bureau of Transportation Planning. Great detail is given to the tools and methodology in the hope that other planning organizations that are similarly fiscally

limited when it comes to software and hardware tools will gain some insight from this experience or be able to share solutions for these problems. A general discussion is given in the last section pertaining to types of census products the planning staff would like to have in the future, a discussion of geographic information system (GIS) tools in view of the difficulties with using census data, and comments concerning the 2000 census.

## GENERAL USES OF CENSUS DATA

After a review of the proceedings from the 1994 Conference on Decennial Census Data for Transportation Planning (1), it became obvious that examples showing specific uses of the census data would be useful to show the breadth and depth of applications that can benefit from census data in general and would serve as a basis for describing some of the problems and difficulties experienced by the Kansas Bureau of Transportation Planning. For these reasons, a list of projects from the preceding year was constructed for which census data have served as the primary source of analysis. Listed for each entry are what data were used, the purpose they served, and alternative data sources available, if any. (The projects listed include small projects apart from the office's central mission of transportation planning that the staff is called upon to perform because of their experience and expertise in formatting and displaying geographically related data.)

**1. Shawnee County voting district map:** The Shawnee County planning office was given the task of exploring voting district boundaries for possible redistricting. After hand calculating a few scenarios, the staff inquired if the Bureau of Transportation Planning had any tools to help speed the process. Using the Urban Element, Part A, of the 1990 Census Transportation Planning Package (CTPP) for the Topeka area, an electronic map was produced showing population by census block. By overlaying existing voting district boundaries on the map, the Shawnee County staff were able to quickly see the effects of shifting established district boundaries. Data for this project were available from other sources, but the CTPP data combined with the 1994 Topologically Integrated Geographic Encoding and Referencing (TIGER) File formed the easiest source from which to obtain a useful map.

**2. Needs of the mobility disadvantaged within Lawrence, Kansas, metropolitan area:** The Urban Element of the CTPP was used extensively in the background research for the 20+ year plans developed for the metropolitan areas within Kansas in compliance with the regulations of the Intermodal Surface Transportation Efficiency Act (ISTEA). In particular, the census data were used to study the needs of the mobility

disadvantaged. In the case of Lawrence, both the Summary Tape Files and the CTPP Urban Element were accessed to evaluate the transportation needs of the non-automobile-oriented community. Such data are difficult to obtain short of sponsoring an independent survey.

**3. Native American reservation population:** This project originated as a simple data-gathering effort but later contributed to a debate concerning the collection of fuel taxes on reservations. Statewide CTPP data were used in conjunction with the TransVU CTPP Edition, Version 1.1, to produce simple maps showing the ethnic distribution of reservation inhabitants.

**4. Statewide trip exchange matrix:** Again using the CTPP Statewide Element, Part 3, a work trip exchange matrix was created to study the movement of employment-related traffic between counties and other places throughout Kansas. No sources were available other than census data.

**5. Donor-borrower relationship between Lawrence and Kansas City:** Lawrence is typically thought of as a bedroom community for the Kansas City metropolitan area. Analysis of the journey-to-work data in either the Statewide or Urban Element of the CTPP dispelled this myth, showing that Lawrence attracted as many work-related trips to the region as it contributed outside the region. No other source of data besides the CTPP was available.

**6. Municipal airports in Kansas in relation to population centers:** This is a pending study to evaluate the relation between the location of municipal airports and the distribution of population. Statewide population statistics will be plotted alongside airport locations.

**7. Downtown Wichita travel-time study:** The Wichita planning office performed a travel-time study from downtown Wichita to major intersections on the periphery of the downtown area. The planning office staff requested that the state planning office provide 1970, 1980, and 1990 mean and median travel times for Wichita and Sedgwick County to augment the study. The requested information was provided using the Wichita CTPP and Urban Transportation Planning Package (UTPP) data plus traffic analysis zone (TAZ) specific travel times. This project was selected as the case study to present in more detail because it not only reflects the uniqueness of the census data, but it also demonstrates the difficulties and obstacles that need to be remedied.

In addition to the projects just cited, census data have been used on numerous occasions in site-specific studies for major developments, road improvements, or both, as a quick check on surrounding development or to confirm existing data from other sources.

Summing up some of the important aspects as reflected in the examples above, first, granted that the census data are not the sole source for much of the data used in terms

of economics and population, but they are the most comprehensive and the easiest to access. If census data were not available, a good portion of the information upon which an analysis is based simply would not be collected. The second important aspect is the journey-to-work information. It simply is not available or would be fiscally unpractical to collect for most areas were it not for the census data and related products.

## WICHITA TRAVEL-TIME CASE STUDY

The case study described here reflects not only how the data are used, but also many of the difficulties that are encountered. Included in this case study are details concerning which census product was used (or not used), what computer tools were necessary, and the difficulties encountered. A general discussion of the census products and computer tools is reserved for the next section.

The Wichita planning office requested information to supplement a travel-time study they had performed (Table 1). The travel times and speeds given in Table 1 are for trips originating in downtown Wichita at the intersection of Douglas and Broadway to major intersections on the fringe of town. [The map of Wichita in Figure 1 shows some of the locations referred to in Table 1. (The end points shown on the map reflect 1995 travel-time studies. Insufficient information was available to pinpoint exact end points for the routes with data from

1980 only.) The intersection of Broadway and Douglas is labeled "Downtown."]

The planning office specifically requested the mean and median regionwide travel times for Wichita City and Sedgwick County from the 1990, 1980, and 1970 census data. Data from the 1990 CTPP, Part A, Tables 38 and 39; Part B, Tables 20 and 21; and Part C, Tables 6 and 7, were used to construct tables relating 1990 travel times to means of transportation to work. The data were extracted from electronic data-base files stored on a personal computer at the office. These data bases were originally constructed by parsing and formatting census text files downloaded from census data tapes on the agency's mainframe computer (a time-intensive task involving three separate software programs). After the data base was queried for the appropriate information, it was uploaded to a spreadsheet and formatted into tables.

Data from the 1980 UTPP, Part 1, Table 17, and Part 3, Table 6, were used to construct similar tables for 1980 travel times. The 1980 UTPP data were available on hardcopy printouts stored in the office. Data from the appropriate sections were transcribed from hardcopy into a spreadsheet and formatted into tables. Additional data equivalent to the 1990 Part C were available but were not gathered in part because of difficulty in accessing the data manually. The 1970 journey-to-work data were no longer available in the office and therefore were not gathered.

In addition to the data requested by the planning office, a map based on Wichita TAZs was constructed that would provide additional insight into the Wichita travel-time study. Using the 1990 CTPP Urban Element for Wichita, maps were constructed using TransCAD Version 3.0 Pre-Release for Windows. These maps are labeled with the average of the mean and median travel times from each TAZ to the four TAZs near the center of the downtown area at the intersection of Broadway and Douglas. The data were taken from Part C, Tables 6 and 7. One such map is the one shown in Figure 1, formatted to a smaller size. It is shown here only as an example of the type of output generated at a larger scale. Again the data were obtained from electronic data-base queries and ported electronically into TransCAD for display. The information contained in Part C, Tables 6 and 7, of the 1990 CTPP is not directly comparable with the travel times collected by the planning staff. The Wichita travel-time study was from intersection to intersection, whereas the CTPP data were door to door, including terminal times for both ends. Nevertheless they do provide a means of comparison that would otherwise not be available.

The 1980 UTPP data contained the information necessary to construct similar maps, but since the data were stored in hardcopy rather than electronically, the time

TABLE 1 Wichita Travel-Time Survey

Routes	Distance	1995		1980	
	(Miles)	Travel Time (min-sec)		Travel Speed (mph)	
1 I35	7.90	13.23	15.25	35.42	30.75
2 North Meridian	8.70	18.38	21.12	28.01	24.64
3 West 21st North	9.40	21.20	-	26.44	-
4 West Central	8.20	-	19.55	-	24.70
5 West Kellogg	8.50	15.51	-	32.18	-
6 Airport 1	7.20	14.59	-	28.83	-
7 Airport 2	7.20	11.53	-	36.35	-
8 K-42	8.10	15.16	18.05	31.83	26.88
9 South Seneca	7.20	15.21	-	28.14	-
10 South Broadway	6.80	13.54	16.56	29.35	24.09
11 K-15	6.40	13.48	17.50	27.83	21.53
12 South Oliver	7.50	-	-	-	-
13 East Pawnee	8.80	18.18	-	28.85	-
14 East Kellogg	8.70	-	19.34	-	26.68
15 East Central	6.4	21.11	24.2	18.13	15.78
16 North Rock 1	9.7	-	25.15	-	23.05
17 North Rock 2	9.9	15.52	-	37.44	-
18 North Oliver	7.5	18.41	-	24.09	-

Summary of results of timed trips originating in downtown Wichita at the intersection of Broadway and Douglas to various intersections on the periphery of the city.

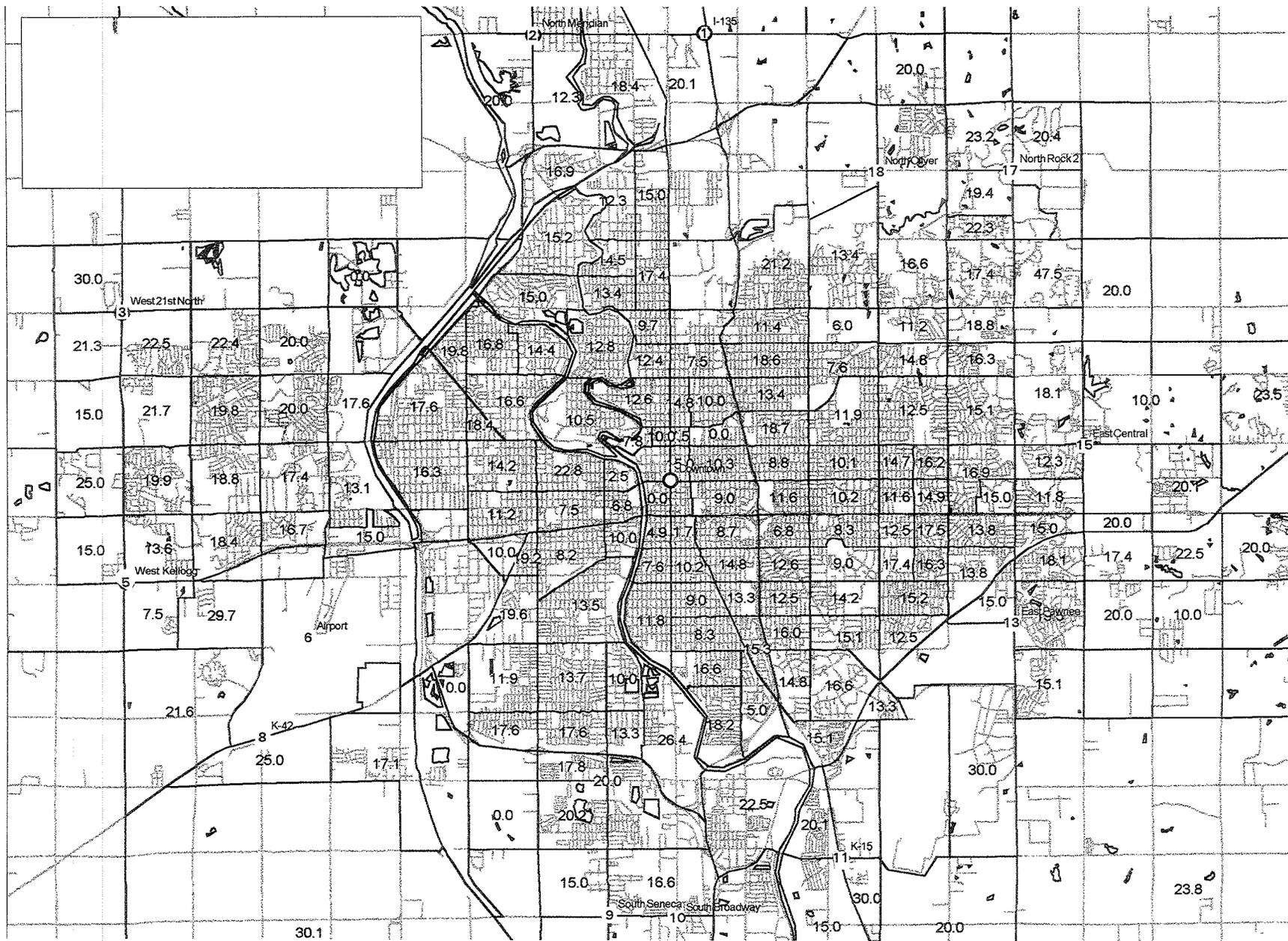


FIGURE 1 CTPP travel times: average of median travel times in minutes from each TAZ to TAZs near intersection of Broadway and Douglas for single-occupant vehicles for all times (1990 Wichita CTPP, Part 3, average C06C002 to TAZs 62, 64, 74, and 77).

required to transcribe all the necessary data made their use infeasible.

The data used to perform this study could only be obtained through a comprehensive survey of the Wichita metropolitan area. If the CTPP and UTPP portions of the census were not available, it is doubtful that sufficient planning funds would be committed to such a data-gathering effort. In this case the planning office would be limited to their simple (but arguably effective) approach for assessing regionwide travel times to downtown Wichita. If the scope of their study broadened to include suburb-to-suburb travel times, the resources for collecting data would quickly be exhausted. The CTPP portion of the 1990 census (as well as the similar portion of the 1980 census) contains the data to carry out a comprehensive travel-time study from any area within Wichita to any other area in Wichita.

## TOOLS OF THE TRADE

Much of the analysis performed in transportation planning is inherently graphical (or two-dimensional) in nature. Much of the information, including most of the census data, is only meaningful when viewed in relation to surrounding geographical attributes. This graphical nature is especially true for any type of transportation modeling but also carries over to many of the small studies mentioned earlier. As a result, the end products of most studies are maps labeled with the appropriate attributes.

Available software tools that possess robust graphing and mapping features combined with robust data-base capabilities are needed. The Kansas DOT currently uses TransCAD Version 3.0 Pre-Release for Windows combined with DBase III+ to carry out much of this work. (TransVU Version 1.1 is also used when appropriate.) Data are transferred from the original source and format (ASCII data files in the case of census data) into a DBase III+ file format. Base maps within TransCAD are constructed from the TIGER File obtained from the U.S. Geological Survey and distributed on CD-ROM. Attributes contained in the data fields of the TIGER File, such as TAZ zone numbers, allow for quick linking to DBase III+ files within TransCAD. TransCAD also contains several GIS tools for analysis, such as merging areas and their associated data-based geographic attributes.

One noteworthy problem encountered in the current practice of using DBase III+ files within a TransCAD environment is a result of building base maps from the TIGER File. At large scales the high resolution of the TIGER File detail slows the operation of TransCAD, produces large files for storage, and stresses the ability to obtain output. For example, a single county boundary in Kansas may be composed of hundreds of line segments.

For planning purposes the same county could be represented by fewer than a couple of dozen line segments with no detriment to the end product. This is not a TransCAD problem nor is it a TIGER File problem. It is a fundamental aspect of geographical data that needs to be addressed. An autoscale feature, common in many mapping programs, is used to control whether or not a certain map layer is activated depending on the current map scale. As the map scale increases, the highly detailed layers are switched off and the less detailed map layer depicting the same features is turned on. In the case of the base maps constructed from the TIGER File, no "less detailed" map layers exist for larger scales. These layers can be created manually by tracing over the TIGER File base maps, which is very labor intensive. Earlier versions of TransCAD supported a function called "squeeze," which more or less performed this function electronically. Unfortunately, it was never fully developed and was excluded from the latest beta release for Windows.

The Kansas DOT planning staff evaluated a few GIS software packages (more were not evaluated because of time and budget constraints), and from this experience found that most GIS software either originated in the data-base world and lacks robust graphing and mapping tools or originated in the CAD and drafting world and lacks robust data-base tools. TransCAD appears to be a good tradeoff between the two extremes. MicroStation's MGA/MGE is an example of a GIS package originating from the CAD world. MicroStation is the standard road and bridge design tool within the department. Using the MicroStation GIS tool would allow seamless sharing of output devices as well as access to existing maps and drawings. The graphics were found to be exceptional, as expected from the software's roots in the CAD world. However, even though the data-base links were available, it required much manual effort to link a base map with an associated data base. The ability to use the TIGER File to construct base maps was absent. An attempt was made to exploit the DFX file format to port maps, using the "tag" attribute to transfer either attributes or indices from one application to another. This met with limited success because of various interpretations of the DFX file format.

The entire planning bureau is currently in the process of changing several large flat file data bases into relational formats to ultimately interface with a GIS system. It is hoped that GIS systems will evolve with robust interfaces to both the mapping and data-base world to facilitate easy integration. No doubt many of the lessons learned will be transferable to the census data effort, and vice versa. Also during the past 5 years the agency has been shifting from mainframe-based applications to PC and client-server types of applications. Before about 1994, the size of the census data files was such that they could not be efficiently processed on a PC, requiring any

type of analysis to be done with the help of a mainframe programmer. The PC is now the main analytical tool for census data, allowing access by more individuals while at the same time stressing existing tools that run on a PC.

Kansas DOT currently accesses and uses the 1990 CTPP urban and statewide data sets, Summary Tape Files, and PL94171 census products electronically. Hard copies of the 1980 UTPP and other census products are available in the office. Part C of the 1990 CTPP urban and statewide data sets that relate trip ends is the most critical to the Kansas transportation planning mission and the most difficult to replace. Population and economic data are most easily and economically available through the use of census data, but could probably be estimated from other sources, albeit with less accuracy and at greater expense.

A major aspect of the planning work at Kansas DOT involves trend analysis as reflected in the travel-time case study in Wichita. In the same vein, the content of the 2000 census journey-to-work data should at a minimum be consistent with 1980 parameters in order to facilitate trend analysis. Having past census data released on CD-ROM would greatly enhance the ability to perform trend analysis. It could be argued that 1980 census data are even more valuable today than when first released in 1980, partly because of trend analysis but also because the capability to analyze and process data has grown to the point at which research that once required a team of programmers and analysts can now be done by one person with a desktop PC. The end result is that even past data can be more thoroughly analyzed today than when released years ago.

In addition to review of previous years' data, a more appropriate data format is needed to transmit census data. With more processing power available at the user's end, the Census Bureau no longer needs to cross-tabulate data in exhaustive detail. The use of a relational data-base format combined with some form of freely distributed data compression software would greatly ease the burden of conveying the census results. Also, much of the current census data has a built-in redundancy that is not needed. For example, a population will be listed as total, male, and female. Any two of the above categories uniquely determine the third. The general comment to the Census Bureau is to concentrate on providing as much base-level data as possible, leaving some of the tabulation responsibilities to the end user.

## CONCLUSIONS

Census data have proved valuable not only as the base for socioeconomic data for transportation modeling, but also for numerous smaller studies as demonstrated by the list given earlier. The data are invaluable as quick reference for socioeconomic and travel-related factors for

smaller communities in which no other source exists. They also serve as one of the primary sources of data to perform trend analysis over significantly long periods of time. The case study involving travel times for the Wichita-Sedgwick County area showcases the typical way that census data are used and processed on a PC.

Recommendations for future census products and GIS tools as a result of experience with census data to date are as follows:

- Older census data increase in value with time because of their value in trend analysis as well as the continually increasing ability to process and analyze large volumes of data. For this reason previous years' census data (in particular for 1960, 1970, and 1980) should be redistributed on CD-ROM.

- With the increase in computing power at the end user's fingertips, the need for specialized cross-tabulation output in ASCII format disappears. For this reason, the Census Bureau should concentrate on providing as much base-level information as possible, output in a machine-readable, compressed format. A relational data-base format distributed on CD-ROM in a publicly available file compression format appears to be the most logical choice at this time.

- Because trend analysis is such an important feature in planning work, consistency between the 2000 census and previous censuses is essential to evaluate changes over time. This is not to discourage new and different types of information from being collected nor to discourage omitting outdated questions, but simply to ensure that the format allows for backward compatibility in key areas.

- The largest obstacle to using census data at present is the available software tools to display and manipulate geographical information. Prerelease TransCAD 3.0 for Windows is a first-generation tool that is truly a GIS in that it has robust mapping and graphical capabilities as well as powerful data-base tools. Transportation planners do not wish to spend time authoring new maps or indexing old ones. Additional tools to overcome these deficiencies in current products are needed.

- The most critical part of the 1990 census data has been Part C of the CTPP urban and statewide data. Parts A and B, residence and work-end data, respectively, of the CTPP are available or can be estimated from other data sources but at significantly greater expense. Part C data, which relate to trip ends, are not available from any other source apart from comprehensive, and expensive, local travel surveys.

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# Application of Census Data to Transportation Planning at New York State Department of Transportation

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The use of census and transportation data products by the Planning Data Analysis Group (PDAG) at the New York State Department of Transportation is examined. PDAG's experience as both data provider and data user, the types of outreach efforts employed, typical data requests, and products developed and how they helped end users are described. The importance of census data to planning activities is highlighted through specific application examples that address travel access to a primary urban core, the use of census data for regional comprehensive planning, and the use of census data and geographic information systems for transit planning.

This paper focuses on the work of the Planning Data Analysis Group (PDAG) at the New York State Department of Transportation (NYSDOT) and its experience and use of census and transportation data products. The approach of PDAG as both a provider and a user of census data products is described, along with three applications focused on different aspects of planning at NYSDOT. Each application illustrates how crucial the census or transportation data are, why these data are essential, what problems are encountered with their use, and suggestions for their improvement. In all cases, if the data were not available, the analyses described would not, in all likelihood, have been possible, because no other primary or secondary data source was available.

In the first section PDAG's approach and experience in working with the various census and transportation data products are examined and issues such as software and packaging problems and the ease of using these products are explored. Next two applications derived directly from user requests are described in which census and transportation data were assembled to assist the end user in a specific undertaking. Last, the experience of a planning department starting on the process of melding a geographic information system (GIS) and census data is outlined. The focus is on the GIS as a tool to understand complex spatial relationships important in assessing transit market areas.

## NYSDOT CENSUS DATA EXPERIENCE

NYSDOT consists of a main office and 11 regional offices executing the department's programs. In addition to the department's regional offices, there are 12 metropolitan planning organizations (MPOs) in the state with transportation planning responsibilities. PDAG serves as a data clearinghouse and an analysis resource for NYSDOT's Planning and Program Management Division, providing assistance to the department, its regions, and the MPOs. PDAG is responsible for the management and development of the congestion, pavement, and traffic management systems; pavement and bridge condition forecasting; and estimation of vehicle miles of

travel (VMT), as well as serving as the planning GIS coordinator. PDAG, with the New York State Department of Economic Development (NYSEDED), participates in the Census Bureau's Data Affiliate Program. In its role as an affiliate, PDAG has access to many census data products and resources from the Census Bureau and from other New York State affiliates.

PDAG functions as both a census data provider and a census data user. As a provider, it frequently makes census data available to users who are involved in a variety of activities, such as statewide planning, metropolitan planning, trend analysis, travel model simulation, small area and project assessments, surveys, market analyses, and various other transportation planning applications. As a census data user it is often involved directly with users in undertaking the census and transportation analysis components of their project.

To address regional and MPO requests, PDAG has available both magnetic tape and CD-ROM census and transportation data products, such as Summary Tape Files (STFs), the Public Use Microdata Sample (PUMS), the Economic Census, the Census Transportation Planning Package (CTPP), the Nationwide Personal Transportation Survey (NPTS), and other data products available from the Census Bureau, NYSEDED, FHWA, and the Bureau of Transportation Statistics (BTS). The Statewide and Urban elements of the CTPP were available to PDAG on magnetic tapes before the CD-ROM versions. As the CTPP became available, first at the statewide level and then at the MPO level, PDAG provided general information on product availability, along with copies of the data dictionaries for CTPP Parts A, B, C, and 1, 2, 3, and distributed CTPP CD-ROMs and TransVU software to both regional offices and MPOs. PDAG also developed a series of reports called *FACTS* (analytical and data) to provide key census and transportation data and offered its assistance in preparing any particular summarizations or reports from census products.

### Census Transportation Planning Package

The 1990 CTPP represents a watershed in transportation census data products because for the first time a comprehensive nationwide data set of tabulations on residence, work place, and work flow was available from the state to the census place level and within urban areas to the block group or traffic analysis zone (TAZ) level. In 1980, individual states or MPOs had to purchase such data themselves. The CTPP is the only source of data at this level of geographic detail in the state. No other survey since the major urban area surveys of the mid-1960s is as useful a data source for

work flow travel primarily because of its comprehensive and uniform availability for all locations in the state. Perhaps most important is the provision of this information in CD-ROM format.

### End-User Outreach

In attempting to perform its function and provide meaningful assistance to its clients and to improve data dissemination and assistance, PDAG sought to assume a proactive and multifaceted role. For a data provider, it is easy to recognize areas in which work is needed to assist users who have little familiarity with census and transportation data products, computer resource limitations, frequent questions about data, and need help in breaking down their problems to focus the data requested on the actual data required. This breakdown moves the user to the critical second and third questions that are really the focus of their data request.

The most common data requests were found to focus on area profiles, trend analyses, or a combination of both, and on future forecasts. Area profile requests attempt to gather all of the relevant census data for a geographic area associated with a project service area. Trend analysis requests are for census data to explore many of the following questions: How have conditions changed? Why have they changed? What are current growth rates? Are there any emerging trends? Often these questions are associated with comparable requests for flow data between geographic areas, volume, speed, classification, VMT, pavement condition, and congestion. Many users are interested in the cross-sectional and cross-temporal review of sociodemographic conditions and their impact on operational measures. Forecasts of sociodemographic data during a project study period of typically 20 to 30 years pose the greatest difficulty. Often the only solution is to use the historical census trend data that can be assembled.

To increase knowledge and awareness about census data and available products, PDAG uses several different approaches, including training courses about basic census information; National Highway Institute (NHI) training for the CTPP, reports on topical transportation information called *FACTS*, graphical data sheets, and PDAG analyses focused in areas of greatest end-user concern. Experience suggests considerable enlargement of the practitioner-based examples as instructional aids is needed. FHWA, along with the Census Bureau and BTS, must develop better overview materials about the census transportation products that focus on what the products are and how to use and apply them in everyday work.

## NHI CTPP Training

To increase awareness and use of the CTPP by the Main Office and regional and MPO staff, two NHI courses were sponsored. A review of the course materials suggested them to be comprehensive in coverage of the CTPP and overwhelming in length, but lacking in the number and variety of practitioner-based examples.

Experience with the NHI course suggested several areas in which change would benefit the student:

1. The journey-to-work (JTW) Statewide and Urban elements of the CTPP on CD-ROM need to be available at the time the course is conducted.

2. The number of practitioner-based applications spanning state, metropolitan, and small area analysis needs to be significantly increased.

3. Historical census data must be provided to address the obvious questions about change between the decennial censuses, such as how the means of transportation work, the work flow at the county, town, and place level, and the use of carpooling or transit have changed.

4. The obvious potential for misinterpretation of data brought about by CD-ROM ease of access needs to be addressed.

## Sample Data Requests

From experience with end users, PDAG staff have observed that census information requests take several forms, for example,

- Sociodemographic data requests by different geographic levels;
  - JTW TAZ matrices requested by an MPO;
  - Workplace travel for employment, JTW, modal choice, and air quality assessments for conformity in capital projects;
    - Market access requests for origins and destinations and JTW means of transportation for a specific tract, block group, or block;
    - Feasibility studies for ferry service;
    - Comparison of 1970, 1980, and 1990 census data, especially travel data;
    - Travel data by occupation and average vehicle occupancy (AVO) for the Employee Commute Option (ECO) program;
    - Determination of internal and external trips;
    - Block-group-to-block-group travel time data;
    - Bicycle and pedestrian planning;
    - Intracounty travel;
    - Income; and
    - Projections of population, employment, households, income, automobile registrations, and travel.

## Utilization

To increase end-user knowledge about the various census and transportation data products, reports entitled *FACTS* were prepared to address common data and key issues such as the following:

1. Basic census concepts and definitions: This report clarifies designations such as CMSA, PMSA, MSA, urban, urbanized, CDP, and so on, and summarizes population for each area by area and county for 1980 and 1990 (1).

2. Comparing different census products: This report provides a discussion of the CTPP and the PUMS, methods of data extraction, comparison of tables, tables not available in the CTPP (Statewide Element) that can be created in PUMS, and standard error and statistical differences (2).

3. JTW data: This report presents county-based JTW data from the Regional Economic Information System (REIS) and compares them over time (a companion document, *FACTS* Number 10, examines JTW data by residence county) (3).

4. Transportation-related sociodemographic data: population, households, vehicles available, population density, and so on, by region, county, and town from Summary Tape File (STF) data (4).

5. Population estimates and projections: population projections by county from 1980 to 2020; current population estimates from 1990 to 1994 by county and town; and analysis of household characteristics for 1980 and 1990 (4).

Distributing these reports to the regional offices and MPOs has increased their awareness of census and transportation data that are available and has led to requests for more detailed information.

## Data Products and Software

From undertaking the *FACTS* reports and working with transportation analysts and their data applications, much was learned about census data and software products. The accessibility of census data via CD-ROM and the Internet enables PDAG staff to easily examine many more complex questions concerning how New York State compares with other states. However, in doing so several areas were identified in which end-user experiences suggest improvements in software that would benefit users. Some of these are noted below:

- All Census Bureau products are issued with user-friendly access software to find and extract a table at some level of geographic detail. A special type of soft-

ware called "extract software" exists that enables the user to find the same data for more than one area. This program should be included with all products.

- The PUMS CD software allows questions to be asked of either the household or the person file, but not if the question straddles both files. Census Bureau data products that are based on multiple file structures should facilitate this type of cross-sectional analysis.

- All software products should support spreadsheet or DBase output formats.

- STF data are summarized by table for geographic level. PUMS contains sample survey data. A comparable CTPP product is needed to support a user-specified cross-sectional analysis.

- End-user utilization of CD-ROM products would be enhanced with additional documentation describing what each field means and how these data items compare with similar data items in other products and providing interactive data dictionaries and, where appropriate, several simple, moderate, and complex data extraction examples.

### CTPP and TransVU Software

When the CTPP Statewide Element CD-ROM became available, NYSDOT's regional offices were issued the CD-ROM, a CD drive, TransVU software, and the extracted LandVU portion of the regional geography. Each MPO was also given a copy of the CTPP CD-ROM and the TransVU software. From the use of this product, the following approaches for future products of this nature are recommended:

- FHWA and BTS should form an end-user beta test committee to evaluate all software for functionality and simplicity of use. The committee should be afforded the resources necessary to have timely modifications made in the event that problems or useful features need to be resolved or incorporated. The committee should also focus on the interrelationship of the various census data products and their software.

- In using TransVU it has been found that the inclusion of filtering criteria to more narrowly or precisely select localities within census-level geography (and items within the tables) would greatly improve the accessibility of the desired data. The ability to replace the column heading codes with acronyms for the data would improve data extraction. The inclusion of thematic mapping capability with the CTPP software would bring a very helpful descriptive tool to the CD-ROM data.

### Specific CTPP User Problems, Issues, or Questions

Documentation of the census questionnaire and comparability between decennial censuses on the CD-ROM

would be helpful. It would also be advantageous to include documentation to assist users who may be unfamiliar with the products. Frequently asked questions that should be addressed include the following:

- Does the CTPP cover all work trips or only those to the primary job?

- Which work place is used if a person has more than one job?

- Is the number employed the same as the number of workers?

- How are school trips coded?

- If the CTPP asks where an individual works, does his or her residence-workplace travel time include trip chaining?

- If you leave your house for work and it takes 45 min to get to the daycare center and then 5 min to get from there to work, did you make a JTW trip?

- Why do walk JTW trips from California to Manhattan exist?

Use of census data products such as the CTPP raises the following concerns:

- The user should be able to identify the mode of transportation correctly (it is possible that commuter, subway, and heavy rail may be confused in the New York City or Chicago area).

- Segmentation of transit trips should be ensured to improve the reliability of data regarding the means of transportation.

- It is important to know that survey definitions vary between the NPTS and CTPP, for example, that for home-based-work (HBW). Age summary categories vary among CTPP, NPTS, and STFs, and these should be standardized.

- The REIS CD-ROM provides county work flow data from 1960 to 1990. In 1980 and 1990 the unallocated origin and destination flow was allocated on the basis of the employment site data from the census. However, this was not done for 1970 or 1960. It is important that a uniform approach exist within the data.

- As with other states that border Canada or Mexico, New York State has several international crossings. Knowing the origin and destination of cross-border travel with Canada is important in analyzing travel.

- In giving MPOs TAZ-level coding, the Census Bureau eliminated the ability to identify the block or block-group data that make up the TAZ. The Census Bureau should provide both TAZ and census geography and not aggregate the file to TAZ level. The CTPP data must remain compatible with the data from STF3 and should be available for other uses outside the simulation model. In addition, errors in origin-destination trip allocation to TAZ and changes or adjustment to TAZ boundaries can then be corrected.

## APPLICATION 1: TRANSPORTATION ACCESS TO NEW YORK CITY (MANHATTAN) CORE

Application 1 deals with the selection and prioritizing of capital projects in the New York City metropolitan area. Census and transportation data were utilized to compare and illustrate the flow and type of travel from the suburban counties to the city core, Manhattan, and between the suburban counties.

### Overview

The New York City metropolitan area is the largest in the country and is represented by two NYSDOT regions and part of a third, as well as by one large and two smaller MPOs at its periphery. For clarity, New York City consists of five boroughs, each also a county: Manhattan (New York County), the Bronx (Bronx County), Brooklyn (Kings County), Queens (Queens County), and Staten Island (Richmond County). Each has a central business area. Four of the five counties have populations of between 1.2 million and 2.2 million, and if they were separate cities, they would rank as the third-, fourth-, seventh-, and ninth-largest cities in the nation. The Metropolitan Transportation Authority (MTA), the Port Authority of New York and New Jersey, New York City (NYC), the New York Metropolitan Transportation Council (NYMTC), and NYSDOT are the major stakeholders in this transportation analysis area. Allocation of financial resources in an equitable fashion, balancing the infrastructure needs of highways with those of transit, and providing for the improved mobility of the resident population while reducing congestion are all difficult tasks. Often many competing needs exist, and choices have been made more difficult because of declining funds.

Recently, the department's planning groups (Corridor Management, Program Management, and Data Analysis) undertook a major study to categorize metropolitan travel in the proper context (i.e., access to the urban core, Manhattan; noncore travel to other counties in the metropolitan area; and multimodal highway versus rail travel). The intent was to examine the current mobility and congestion situation and assess the proposed solutions. The effort relied greatly on the CTPP and the NPTS to help describe the travel backdrop for the MPO area.

The primary focus of the study was on work trips by means (mode) of transportation from the noncore counties to Manhattan (New York County) and between the noncore counties. Data showing the county of residence, employment, and the work flow to and from each county to Manhattan were assembled and were subdivi-

vided by means of transportation to work. These data were graphically presented to visualize the proportional county contributions.

The CTPP was used for the county JTW data and the NPTS for the resident-based total travel picture. In 1990 the NYMTC, the MPO, purchased an NPTS add-on, bringing the number of samples in the 12-county study area to approximately 1,700. Approximately 1,000 were in the five counties of NYC, 500 in the eastern counties of Nassau and Suffolk, and the remainder were in the northern suburban counties. The NYC sample taken together is large enough to be considered highly reliable. However, the data from individual counties are much less reliable.

Comparisons have been developed contrasting the study area, the nation, NYC, the suburban counties, and Manhattan. Transit shares were examined for those transit modes operating on fixed guideway and those operating on the highway. Because the CTPP data were only readily available on CD-ROM for 1990, preparing a comparison of how the region had changed over time was difficult. The REIS CD-ROM contained the county work flow data for 1960-1990 and showed how residence to workplace county core travel (to Manhattan) and noncore travel had grown during the period. Unfortunately, these data were not broken out by means of transportation to work.

### Data Summaries

The illustrations in the following represent typical examples of the data summaries and graphics used in the analysis:

1. The question arose of how NYC compared with the rest of New York State and the nation on the means used to travel to work. Figure 1 shows the CTPP means (mode) of transportation to work for NYC (the five boroughs), New York State with and without NYC, and the nation as a whole. Except for NYC, the state is similar to the rest of the nation in the means used to travel to work. However, transit usage in NYC represents 50 percent of the means of transportation to work, and this usage is equal to one-third of the entire transit usage in the nation. Notwithstanding the high percentage of public transit usage in NYC, walk trips to work exceed public transit trips in upstate New York.

2. Figures 2 and 3 show the distribution of JTW trips from the residence counties to the core of NYC, Manhattan (New York County), and from those counties to all other counties in the study area. The data demonstrate that Manhattan is clearly the paramount focus of work travel, especially by transit. However, nearly two-

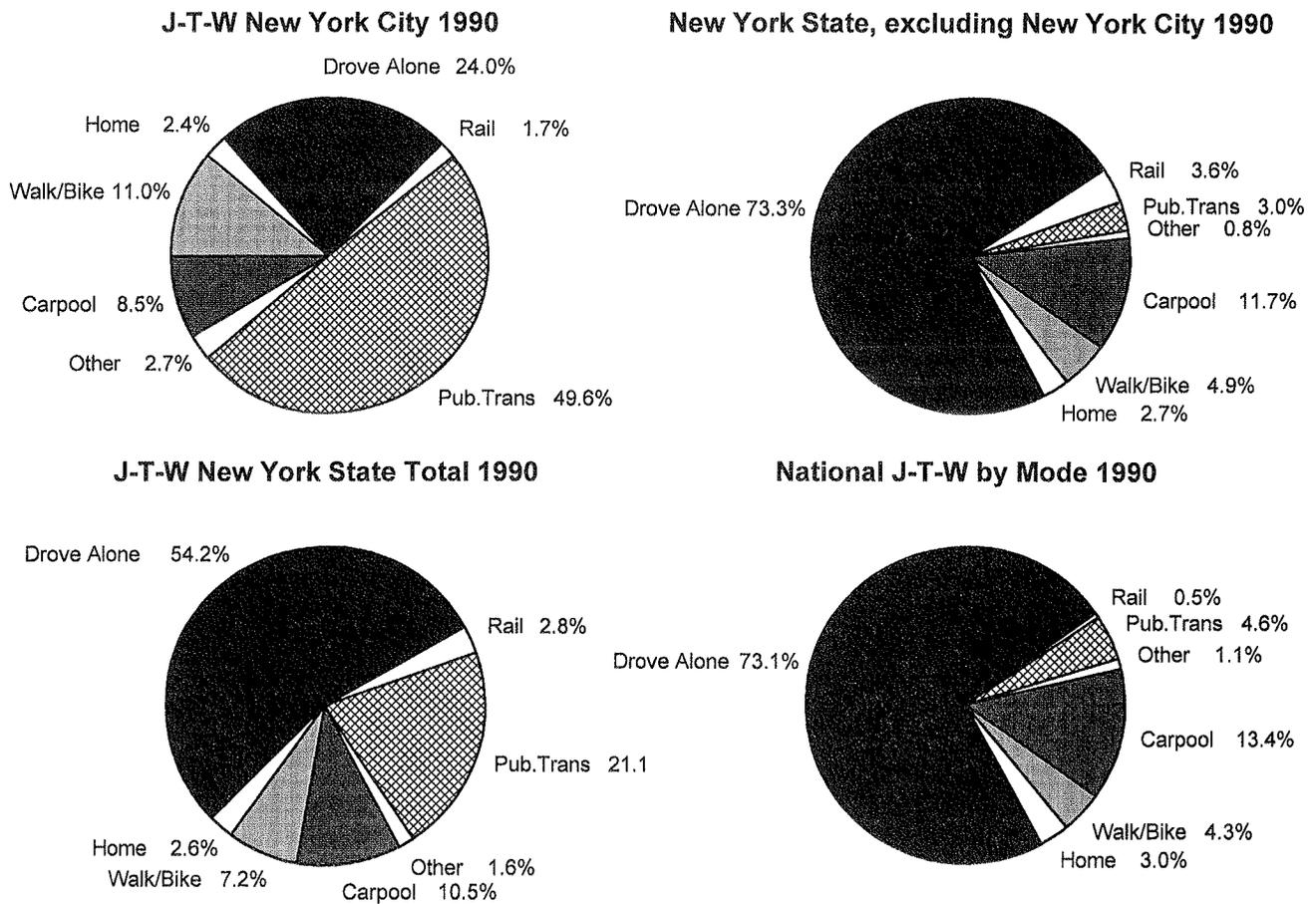


FIGURE 1 Journey to work by mode of choice, 1990 (source: 1990 STF3).

thirds of all work trips that occur in the study area do not involve Manhattan. These trips are typically made by highway, and this point is even more important when one realizes that work travel for NYC is only 25 percent of all travel.

3. A more detailed examination of where resident workers are employed shows that for the five boroughs of NYC, one-third or more of the residents work in the resident county, with 12 to 25 percent working in a county other than Manhattan. Outside NYC, 17 to 31 percent of the area's county residents work outside the county, with the exception of 63 percent in Putnam County. In NYC, 92 percent of the city residents work in one of the five boroughs, with 49 percent of the city's residents working in Manhattan.

**Observations**

The CTPP and the county work flow data (REIS) are the only resources available with comprehensive national detail by state collected with a high degree of accuracy over time. If these sources were not available, no data

would exist except from the various disparate travel surveys collected over time within the region. The CTPP's high sampling rate is most important, especially when comparing data with other reference material, studies, and plans.

The presentation of significant tabular data is often difficult to comprehend readily. Graphical presentation of data in colored thematic maps, graphs, or pie or bar charts is more readily understood. Clearly, new ways for graphical analysis of data need to be explored.

The CTPP represents work trips to the primary work place, and not work trips to all work places. As such, the number of workers in the 1990 CTPP deviated somewhat from the number of persons holding jobs. Also, the lack of detail on the multiple modal segments that make up trips in this complex urban area seriously limits understanding of how the JTW modes are interrelated for travel from different sections of the area. For example, a 1-hr public transit trip from Staten Island (Richmond County) to downtown Brooklyn (Kings County) might typically contain a walk of less than 5 min to the bus, a 15-min bus ride (or an automobile commute to the ferry), a walk of less than 5 min to the ferry, a 20-min

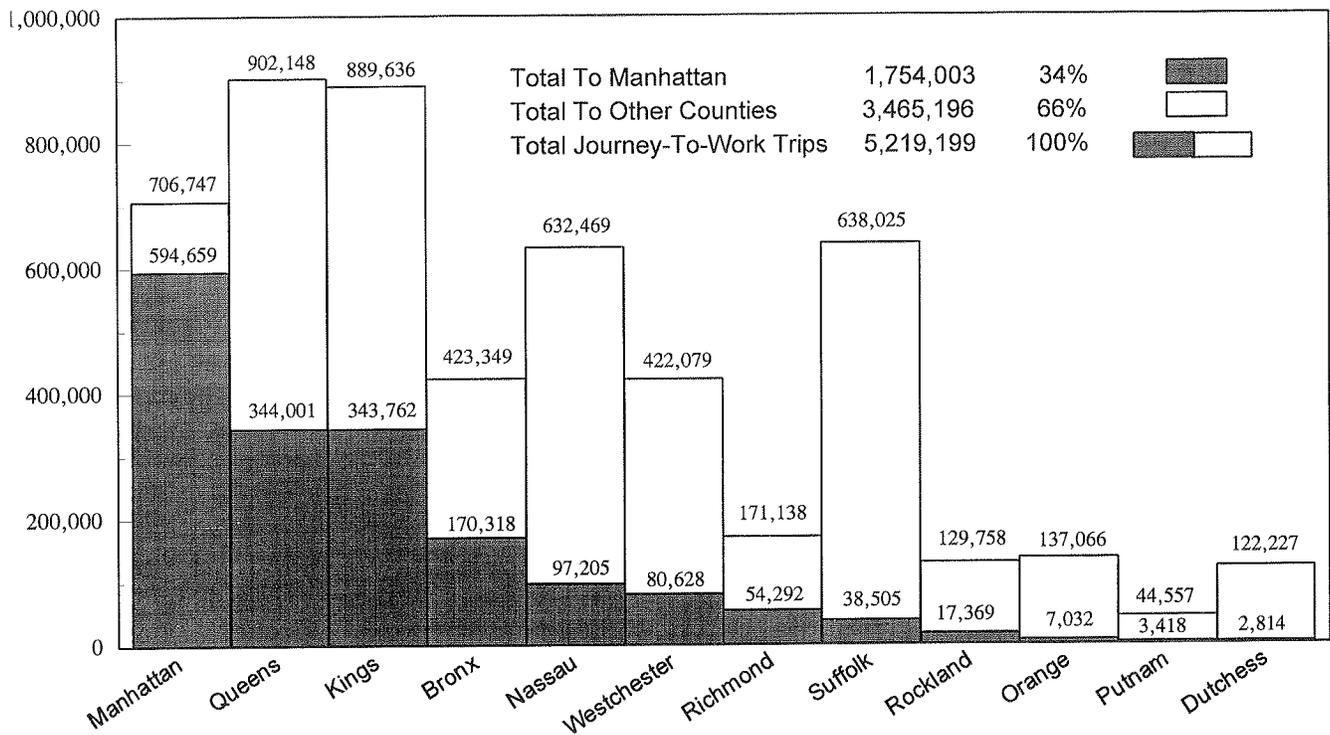


FIGURE 2 NYMTC area JTW trips from residence counties to Manhattan and residence counties to all other locations (source: 1990 CTPP).

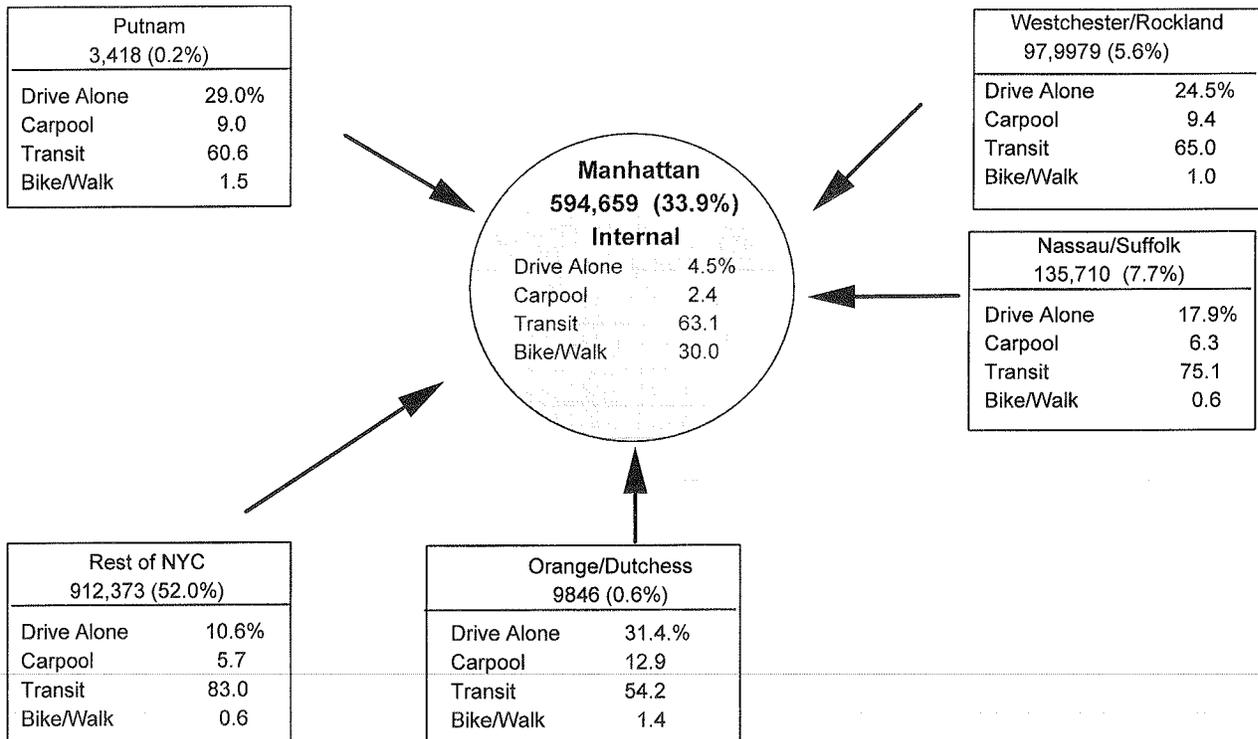


FIGURE 3 Means of transportation to work: workplace county = Manhattan (total work trips = 1,754,003) (source: 1990 CTPP).

ferry ride, a walk of less than 5 min to the subway, a 15-min subway ride, and a walk of less than 5 min to the destination. Transportation planners are clearly interested in the mode, the modal interface, and exchange points and their impact on access for both the highway and transit systems.

The CTPP JTW data demonstrate that the transit and highway systems primarily support access to the core of the NYC urban area. The CTPP also suggests that the potential for deficiencies in access within individual counties or across counties may exist for both transit and highways. The resident-based travel data from the CTPP and NPTS imply a sense of community and urban form within the counties, suggesting that trip and employment needs are more often met locally. This finding, in turn, implies that a priori assumptions for simply shifting travel among modes are not always feasible. Most transportation investments are focused on peak-period congestion or JTW travel activity, yet the work trip is only 25 percent of total travel during the day. Even in a very dense, highly transit-oriented environment, there is still a need for necessary highway improvements and a balanced transportation system. One should not forget that 75 percent of all trips are not work trips and occur throughout the day and that the combination of trips often determines the mode chosen.

## APPLICATION 2: REGIONAL DATA PROFILES FOR REGIONAL COMPREHENSIVE PLANNING

NYSDOT in cooperation with the MPOs and other local governments is responsible for seeing that regional transportation needs are identified and met through the department's Statewide Transportation Improvement Program (STIP). To help the planning and prioritization of needs, a Regional Comprehensive Plan (RCP) is under development for each NYSDOT region. The RCP focuses on the 20-year vision for the region, suggesting how that future might be achieved and providing guiding principles that must be emphasized in developing the region's transportation systems. The RCP includes demographic, economic, and transportation information to help reveal regional trends that must be supported or overcome. County profiles have been developed to describe the current environment affecting travel within and through the regions.

Development of regional data profiles began in early 1995, with the NYSDOT region in Rochester. A draft document was prepared for this region, and on the basis of the feedback, the model data profile was reproduced and sent to the other regions to obtain their comments. Currently regional data profiles are being prepared for

the department's other regions. The regional profiles contain the following information:

- Demographic and economic data from STF3: population characteristics, workers by category of work, income, revenue, workers, employment, unemployment, household income, persons, and automobile availability.
- County business patterns from STF3, REIS, and CTPP: household vehicle availability, JTW by county of residence and work place, JTW by county and means of transportation, JTW travel time by county, and residence of those employed in each county.
- From the Economic Census: county data by industry, agriculture, retail and wholesale trade, manufacturing, and service sector.
- From NYSDOT data files: highway infrastructure, jurisdictional ownership of the highway system, centerline and lane miles, pavement condition, motor-vehicle-related data, driver's licenses, vehicle registrations, urban and rural daily vehicle miles of travel, Highway Performance Monitoring System data, and transit system usage and fares.

The regional profile is essentially a tabular and graphical presentation at the county level of readily available information. It contains both a statewide and regional overview and presents basic county-level socioeconomic data. The data profile relies upon the CTPP for travel time, detailed residence and work place JTW by county within the NYSDOT region, and workers within and outside the residence county. Tables that illustrate population changes, travel over time from the REIS, and highway system system extent are included, along with appendixes that illustrate detailed data within each county and the region as a whole. The profile also includes regional summaries from INFO New York, a data product produced by the New York State Department of Economic Development. INFO New York contains most of the available STF data over time, including data from the Economic Census at the county level.

It is interesting to note how regional staff dealt with information during the development of the regional profile. When PDAG originally polled the regional offices to determine what information was required, it was difficult to identify specific items. After copies of a draft regional data profile were sent to all of the regional offices, it became a shopping catalogue for data. This has generated many special requests from the regional offices for components of the profile in greater geographical detail. By placing a regional profile in the regional office, PDAG has enabled the regional staff to examine in tabular and graphical detail background information from which they can better formulate a problem-solving approach or a policy position. If the profile falls short, it does so

only because it is unable to adequately describe total travel from a sociodemographic standpoint. Many questions are asked regarding total travel that cannot be answered by the CTPP.

A composite view may be obtained from three different regional offices as to the most useful census data included in their regional data profile for use with their RCPs (5-10). Given their location in the state and the local issues they must address, each region may choose to package and present this information in slightly different formats.

### APPLICATION 3: CENSUS DATA, GIS, AND TRANSIT MARKET AREA ANALYSIS

The department recently obtained software from the Environmental System Research Institute—ArcInfo and ArcView—to use as the GIS platforms in New York State. GIS implementation and application have begun for the department and the MPOs. Many traditional uses of linear GISs have been developed to improve program and resource management. This improvement includes association of transportation facility data with cartographic base maps for the purpose of constructing maps on flow, condition, and categorical routes, such as the National Highway System and truck routes. More recently PDAG has worked to relate census data with highway and cartographic map coverage. Three primary activities are involved in this process: development and processing of census data coverage, association of census data with this coverage, and provision of data to a transit market research project. Using the GIS, NYSDOT's Public Transportation Division is identifying market opportunities as an input to bus route and service planning activities. The Public Transportation Division developed the transit bus route coverage and PDAG provided the demographic, economic, and travel data from the STFs and the CTPP, along with the Topologically Integrated Geographic Encoding and Referencing (TIGER) File base map.

#### Tiger File Base Map for Census/GIS Coverage File

In undertaking this activity, a number of technical issues were identified.

- Differences existed among the highway system coverage designed to cartographic standards, the simplicity of the TIGER File coverage used by the Census Bureau, and the MPO simulation TAZ boundaries.
- When the Census Bureau has information that does not fit into a place within the town geography, it identifies a place called "remainder of the town." Existing

coverage that represents the mapping of cities, towns, and villages does not account for the remainder concept.

- It became apparent that the geographic levels of block group and block were essential for any analysis requiring census and TAZ data. TIGER File block and block group coverage was subsequently purchased from another state agency.

#### Linking Census Data with Coverage Polygons

PDAG staff had trouble matching the Federal Information Processing Standards (FIPS) place codes used by the Census Bureau with their coverage. Somewhere in the process during the development of the TIGER File coverage purchased, the FIPS place codes had been subjected to "text to numeric to text conversions" and leading and lagging zeros were missing in the left-justified fields. It was necessary to add the New York State code to the base map polygons, since the NYC urban area spans more than one state; however, for New York State map making, it is not important. In addition, it was discovered that TransVU was using the Census Bureau place codes. This meant that data extracted from the CTPP were incompatible with the FIPS place codes being used for linkage to STF3 data. An equivalency table was developed for the two codes.

#### Census Data Bases for GIS Applications

The most important question in relating census data and GIS coverage was what type of census information should be included because of its importance to transportation planners. Working with the Public Transportation Division, PDAG selected the most obvious transportation items from STF3. In developing data transformations for their application, it was discovered that the GIS product was not as robust as spreadsheets were for this purpose. There was also no indication in the GIS of the best way to store the data (data normalization) other than in flat file format. Storage of data requires consideration as to how data will be displayed. In the GIS, data can be displayed at a geographic level using a selection of colors to describe the ranges of interest for the number of workers. However, to show shares by mode of travel, totals and proportions need to be constructed. Using proportional data, a much more meaningful graphical display can be created. The GIS is limited to providing two dimensions, geography and the spatial context in color, for the variable being examined. Multidimensional tabular data are difficult to present beyond area and color. In addition, displaying automobiles available per household and population density simultaneously is difficult.

## Using GIS in Transit Service Planning

To define the market for new or reoriented transit services, the analyst must first address questions concerning the geographic patterns of travel, demographic attributes, and economic activity. In particular, where do people travel and by what means? Where are there concentrations of population that present opportunities for transit service? How many households do not own an automobile or have persons over age 60? Are clusters of work trip origins destined for work destinations concentrated in a particular zone or zones?

As is the case for most spatial analyses of travel, the STF and the CTPP are the only data sources available short of undertaking primary survey research. To analyze the geographic distribution of existing and potential transit markets, population age characteristics, household income, and automobile ownership characteristics were selected from STF3 to define the relationship between the fixed bus routes and where service demand may exist. To analyze existing transit market shares, CTPP Urban Element JTW by TAZ was examined.

Most TAZs used in the simulation network of the Albany area MPO, the Capital District Transportation Committee (CDTC), often do not mirror census block groups very well. By relating TAZ to census blocks, CTPP transit usage can be linked to the population and household data from STF3. Background sociodemographics may then explain why two similar origin zones with trips to a common destination zone have differing levels of JTW transit usage. Relative modal JTW travel times from the CTPP may offer possible explanations for differing modal usage.

### Population Density

Population density is a commonly used gauge of transit market viability. The standard transit industry rule of thumb is that frequent service can be supported by population densities of 3,000 persons per square mile. By overlaying the Capital District Transportation Authority (CDTA) bus routes onto block groups, transit supply and demand issues can be examined.

### Zero Automobile Households

Households without an automobile available are another indicator of the potential for transit usage. It should be noted that variations exist in size and compactness of urban and rural census block groups. A concentration of 10 households without automobiles available in an urban block group is enough to allow bus service. The same number of households without auto-

mobiles available may be miles apart in a suburban or rural block group.

Color can be used to denote the number of households present within a block group; a proportion like density can address measures of uniformity. There is a need to visually display both quantity and uniformity to get the complete demographic picture. By using shades, patterns, or color with the numeric value and creating indexes by multiplying the household number by population density and shading the product, several measures can be displayed.

### Bus Transit Market Share by TAZ

Figure 4 shows the CTPP JTW transit bus share for CDTA by TAZ. The highest market share can be observed in areas with the greatest population density and transit service. This level of detail in the data enables a visual comparison of relative transit service in demographically similar TAZs.

### Transit Share Versus Automobile Ownership

Figure 5 contrasts the CDTA transit market share of a group of TAZs by color with the number of households without automobiles for the nearest census block group. The TAZs used by the CTPP are not 100 percent consistent with the block groups contained in STF3. Both are based on combinations of blocks, but block group boundaries are frequently crossed by TAZs. The result is difficulty in correlating CTPP and STF3 data for these areas. With the GIS, a visual comparison is obtained by overlaying the two sets of data. However, since the Census Bureau did not include both TAZs and block groups, inconsistent data definitions preclude the analyst from drawing direct correlations.

### Recommendations

- Recommendations based on the experience of others as to data, structure, and tricks of the trade would be very helpful to those just getting into work with census data and the GIS.
- A one-to-one consistent geographical linkage across all census and transportation survey data and software products should be maintained (e.g., census data should not be aggregated to TAZ if it means the loss of block group and block level linkages).
- A CD-ROM containing self-extracting TIGER File coverage for the geographic areas contained on each CTPP CD-ROM would be very useful.

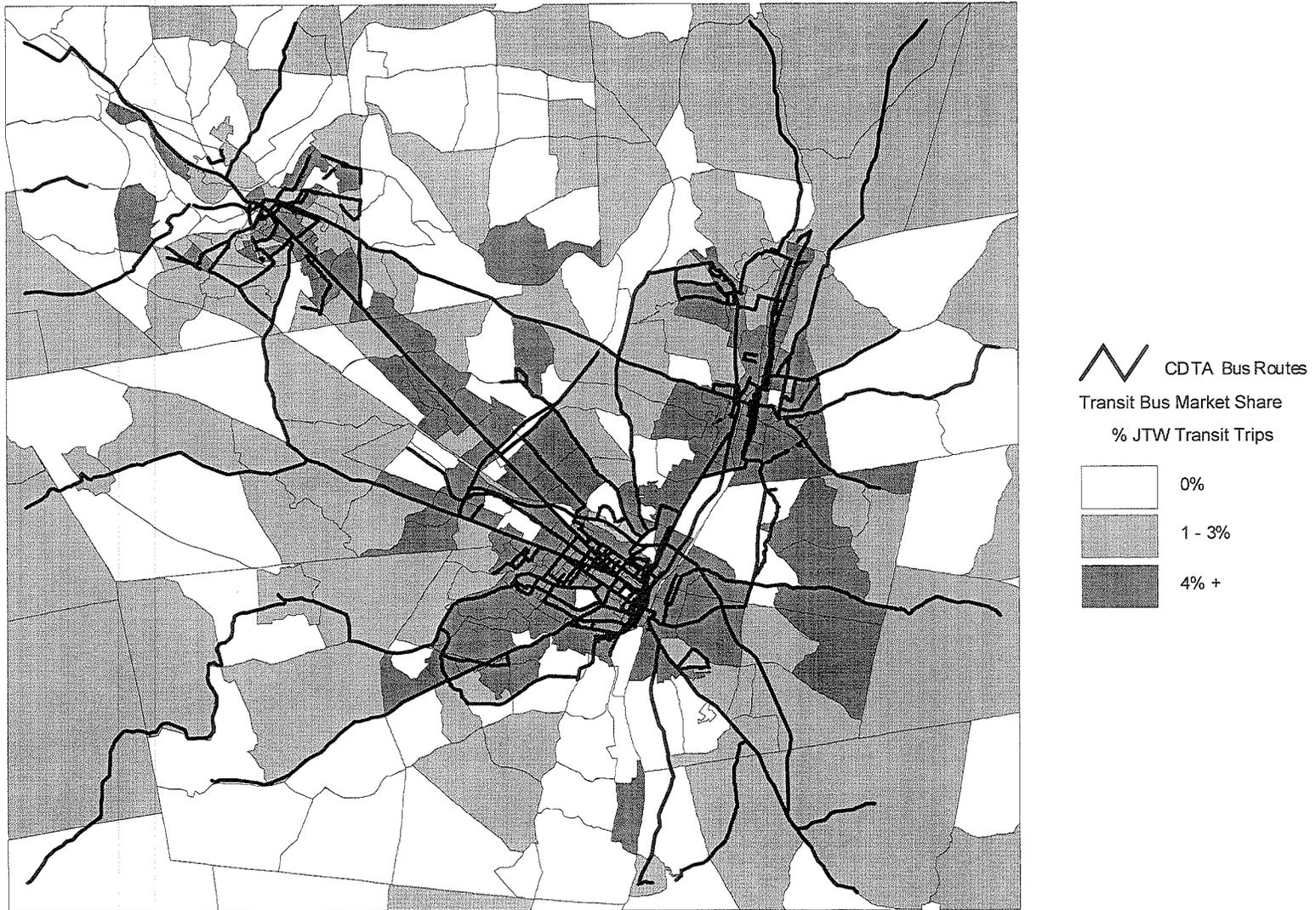


FIGURE 4 1990 CDTA market area transit market share (source: 1990 CTPP, STF3).

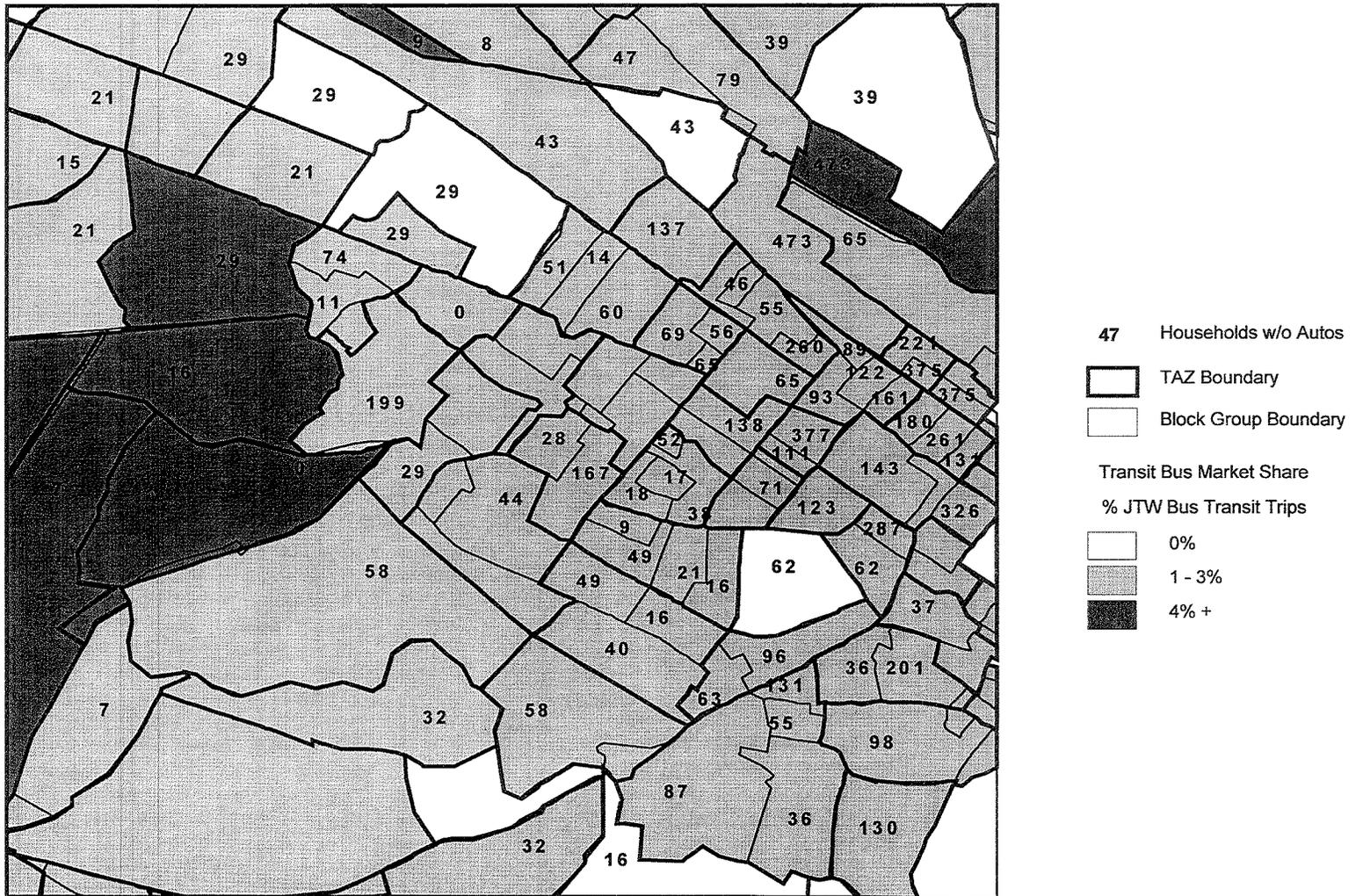


FIGURE 5 1990 CDTA market area households without automobiles by TAZ block group (source: 1990 CTPP, STF3).

- The graphic on page 1 of the *Census Mapbook for Transportation Planning (11)* illustrates a multidimensional presentation of JTW data. This is a very powerful presentation and is not easily performed by most GIS software. A project to explore the presentation of information in more graphically innovative ways and work with vendors and universities to identify new software display techniques should be undertaken by FHWA, BTS, and the Census Bureau.

- Presentation graphic packages and spreadsheets often provide data analysis and display capabilities more powerful than those in a GIS. FHWA, BTS, and the Census Bureau should work with GISs, simulation modeling, and other software vendors to develop standard formats and coverage translation procedures.

- BTS and FHWA should lead in developing examples of census and travel data buffered within a project corridor.

In 2000, computers will have advanced significantly in power and capability. The GIS should be viewed as the analyst's window on data, a tool that is essential to show information. The selection and presentation of census and transportation information drive data collection, delivery format, and analysis software. Focusing on how the data are used is essential to better address what information is required and what presentation tools are necessary.

- New graphical analysis and data management software should be examined to look at areawide data as a surface foil. For example, traffic can be viewed as a 24-hr surface along a route. Population at the block group and block level can be observed in a similar way along with any other variables.

- Examination of spatial data in three-dimensional space by changing the perspective of the surface foil enables a new perspective on census and travel data that has never been examined. Information that remains hidden in tables is now visible in this manner.

- Examining basic demographic variables such as population, households, and automobile availability by using a topographical format, time of day, and the ability to create holographic images is the goal for future data analysis techniques.

Despite the difficulties encountered in applying this technology, it is very powerful. The coupling of GIS and census data provides an advanced set of analytical tools previously unavailable for use with census data. The GIS clearly enables the user to portray various spatial interrelationships, location of service corridors, and factors influencing the transportation dynamic. Census 2000 will benefit greatly from the advances in this technology.

## SUMMARY

Census and transportation data are invaluable for transportation planning. None of the three applications discussed could have been accomplished if these data were not available. Having these data allows analysts to develop a better understanding of the underlying elements shaping travel. Better information clearly leads to improved decision making. The three applications and the provider-user approach applied by PDAG serve to bridge the gap between data and information. Key issues and concerns encountered are summarized below:

- FHWA and the Census Bureau should explore improvements in documentation, terminology, definitions, products, and software for all end-user CD-ROM data products.

- FHWA and the Census Bureau should create an inventory of practitioner-based examples, application-oriented documentation, frequently asked questions, and experiences of others.

- Census Bureau software needs to be more robust to address how data will actually be used. Currently, it just provides access to singular data items within consistent geographical areas. Data requests are driven by area profiles, trend analyses, and future forecasts to support cross-sectional or cross-temporal views of sociodemographic data.

- Historical census and transportation data products should be made available on CD-ROM.

- Software products should have consistent output file formats, printing capability, and access methods.

- An end-user committee should be established to review and examine software and census data products before and after distribution.

- Census geographical referencing should remain available even when data are aggregated to TAZ. The Census Bureau should ensure that a consistent referencing system and linkage are maintained across all census data files and all geography.

- TIGER File coverage should be provided with CTPP data.

- New initiatives concerning the graphical analysis and presentation of data should be explored.

- The development of sociodemographic data estimates beyond population forecasts should be considered.

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