What Has Happened to Carpooling: Trends in North Carolina, 1980 to 1990

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County-level trends in mode to work, particularly carpooling, for all of North Carolina's counties from 1980 to 1990 are explored. Using 1990 census information, statistics are computed on the extent and relative levels of carpooling. These data are related to changes in demographics, geography, and accessibility. It was found that as a share of work travel, and in absolute numbers, carpooling has declined precipitously in the vast majority of North Carolina's 100 counties in the last 10 years. Overall, carpooling dropped by 122,608 workers—more than 32 percent—whereas total commuting increased 24.4 percent. Of all the counties, only one registered a slight increase in carpooling during the decade. Carpooling was found to be highest—more than 25 percent—in counties that are rural and isolated but within long-distance commutes of major metropolitan areas, including areas outside of the state. Carpooling was found to be lowest in major metropolitan counties and their immediate surrounding suburban counties. Per capita income levels and average travel time were found to be the highest correlates of carpooling: carpooling was found to have declined most rapidly in first-tier suburban counties that have increased greatly in accessibility and in per capita income in the last decade. Declines in carpooling have shown up as single-occupant automobile drivers rather than in public transit or other modes. It is concluded that present programs to encourage carpooling are misdirected, focusing on urban and suburban markets where carpooling is relatively low and ignoring longer-distance rural isolated markets where carpooling is much higher. A restructuring of carpooling programs to better fit the underlying needs of carpoolers, which are driven not by commuting costs but by long-distance job economics, is recommended.

It should come as no surprise to the casual observer of transportation and travel patterns in the United States that automobile travel is increasing and overall average occupancy is declining. Between 1980 and 1990, travel in the United States increased from 1.527 trillion vehicle miles to 2.148 trillion vehicle miles, or about 40.7 percent. This compares with a 9.7 percent increase in population, a 14.4 percent increase in households, and a 17.4 percent increase in vehicles. The preliminary tabulations of the 1990 National Personal Transportation Study (*1*) show that overall automobile occupancies have declined from approximately 1.9 to 1.6 in 13 years. During the 1980s, many states and local governments established urban area carpool programs to encourage commuters to use carpooling for work travel. A considerable amount of federal and state funding, perhaps $150 million in urban areas, has been spent in the last decade to establish these programs and encourage them. As we cross the threshold of the decade, it is useful to review facts about carpooling trends. It is the purpose of this paper to identify and review detailed county-level trends in carpooling in North Carolina, to determine the probable effect of comparable programs on these trends, and to suggest further actions, if any, that might be appropriate to increase the incidence of carpooling and make better use of vehicle availability.

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LITERATURE REVIEW

Carpooling was (until recently) a significant share of travel, generally between 17 and 22 percent of most metropolitan work trips. The 1980 census, for instance, showed that most metropolitan areas had about 3 times as much carpooling as transit usage. Most of this carpooling, of course, is privately generated, in the sense that it is not related to local matching programs. U.S. carpooling percentages have been in the 20 percent range since the 1960s. The 1980 census (*2*) reports about 22.4 percent of commuters in 2+ person carpools for the top 34 U.S. cities. Pisarski (*3*) put carpool use at 19.7 percent of commuters nationwide in 1980; the "all metro" number was 19.0 percent, implying that rural carpooling was higher than 20 percent. Using the 1990 National Personal Transportation Study, Hu and Young (*1*) reported an average house-to-work vehicle occupancy of 1.1, implying a carpool rate of 20 percent (employed residents minus jobs). This implies a carpool market of about 22 million. However, Pisarski's review (unpublished data, 1992) put the total at 15.39 million, about 13.4 percent of commuters.

Organized carpool programs, now common in major cities, have not been particularly successful. Ferguson (*4*) and Oppenheim (*5*) note that most such programs produce much less than a 1 percent reduction in regional vehicle miles traveled (VMT). Hartgen and Brunso (*6*) compared employer-end and residence-end carpool matching and found them to be equally effective, but insignificant overall in producing area VMT reductions. In reviews of carpooling "behavioral sensitivity," Pratt (*7*) and Dupree and Pratt (*8*) report that the effect of park-and-ride lots will be modest but observable: typically about 20 to 30 cars per "fringe" lot but upwards of 1,000 cars for close-in "peripheral" lots served by buses.

More successful, but also narrowly targeted, are employee-sponsored services including vanpools. Wegman (*9*) reports average carpool use of 16.7 percent and B/C rates of 2.2 to 21.2 in a review of 160 employer-sponsored services nationwide. Ferguson (*4*) also found substantially more effective performance when the organization is committed to the program, and Beraldo (*10*) reports an average of a 23 percent "placement rate" for inquiring employees within employer-sponsored programs. Spence (*11*) reports growing interest in

these services nationally, more than 586 nationwide, often called transportation management associations. Southern California's Regulation XV has also resulted in small, but statistically significant, increases in the average vehicle ratio (employees per vehicle) from 1.21 to 1.25, about 2.7 percent (*12*).

High-occupancy vehicle lanes (HOVs) that are open to carpoolers, as most are, can show substantial use within the service corridor. Fuhs (*13*) reports growth in HOV lanes from 15 mi nationwide in 1970 to 300 mi in 1989, across 20 cities. Turnbull and Hanks (*14*) report 332 mi nationwide in 1990; in lanes with full data available, they report that 19.6 percent of commuters are in carpools. The cost of these systems has been about $1.5 billion so far; if planned facilities are built, the total will be 800 mi costing an additional $3.0 billion by 2000.

In a recent review, Wegman (*9*) evaluated the incidence and extent of employer-sponsored carpool programs in U.S. cities and found that a significant number of cities around the country had established employer-sponsored carpool matching services. In North Carolina, for instance, at least 138 lots are now operated by carpool agencies in the four largest metropolitan regions. Not counting additional informal unpaved lots in surrounding counties, approximately 6,800 spaces are available for carpool users. According to the latest estimates (Table 1), more than 13,112 individuals are registered with carpool matching services in North Carolina's largest cities.

Despite these very considerable government efforts, surprisingly few comparative studies have been done to determine the overall effectiveness of carpool programs on reduction in VMT or related statistics. Most programs do not keep track of breakups in carpools and therefore have no handle on the overall effectiveness of the programs. In one study (*6*), statistical analysis of carpool data against background statistics showed that the effects were far less than originally believed. The overall cost of forming a carpool was found to be between 14 and 21 hr of effort per carpooler attracted.

Carpooling now seems to be dropping rapidly. In preliminary reviews of 1990 census data, Pisarski (unpublished data, 1992) notes radical across-the-board drops in carpooling in virtually all U.S. cities. Nationwide, carpooling fell 32 percent, from 19.09 million to 15.4 million, in just 10 years. Not only have the shares dropped, but absolute numbers have dropped as well. Pisarski notes that other modes (walk, bus) have also declined.

METHOD

The method used in this study is a straightforward comparison of 1980 and 1990 county-level mode-to-work statistics for the state of North Carolina. National data for all states, as reported by Pisarski (unpublished data, 1992) suggest that the trends observed in North Carolina are also occurring nationwide. The methodology is as follows:

1. Overview of aggregate trends for North Carolina's mode-to-work statistics and automobile ownership data;
2. County-by-county comparison of changes in carpooling, automobile ownership, solo occupant commuting, and transit usage;
3. Analysis of correlations between carpooling and changes in carpooling and other behavioral and economic statistics at the county level; and
4. Analysis of the magnitude of organized carpooling using public agency information for major North Carolina cities.

Very little modeling or analytical structure-seeking work is undertaken in this study. The intention is to identify major

TABLE 1 Park/Ride Lots and Vanpool Figures: North Carolina Urbanized Areas

City	# park/ride lots	vanpools	carpooling database	Estimated* lot spaces	Estimated daily use of all lots	Estimated vanpool use
Charlotte (Mecklenburg Co.)	34 in county 12 not served by CHLT transit City owns 2 lots=171 spaces 38% utilized	16 15-seater vans	4500 names	1,700	646	240
Raleigh (Wake Co.)	10 lots 2 in Cary 2-3% utilized	18 15-seaters 4 7-seater 100% utilized	6000 names	600	NA	298
Greensboro (Guilford Co.)	40 in Co. church lots, etc.	14 15-seaters 7 7-8-seaters	NA	2,000	NA	266
Winston-Salem (Forsyth Co.)	approx. 50 lots	31 15-seaters	2612 names	2,500	NA	465
Total	134		13,112	6,800	NA	1,269

*To average 50 spaces/lot

directions of trends and to suggest underlying causes, not to quantify the specific magnitude of relationships; that is left for a later time.

FINDINGS

The following describes the primary findings of our review. Data and supporting materials are shown in the accompanying tables, maps, and figures. Figure 1 shows the overall pattern of the state's major cities and Interstate road system.

Trends by Mode

In the aggregate, commuting travel behavior in North Carolina has changed radically in the last decade. These changes are related to changes in family activities, automobile ownership, economics, and accessibility.

Household automobile ownership has also increased in North Carolina in the last decade (Table 2). In 1980 there were 2.043 million households in North Carolina, of which 219,000 or about 10.8 percent owned no cars. By 1990 the number of households had grown to 2.517 million, whereas the per-

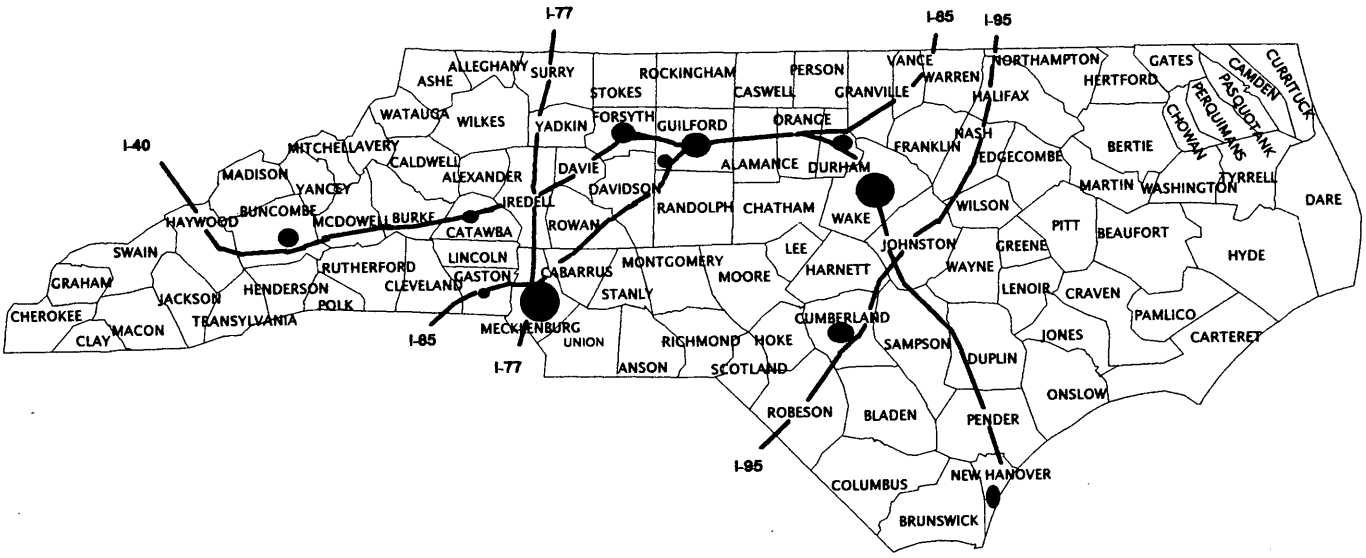

FIGURE 1 North Carolina counties, largest cities, and Interstates.

TABLE 2 Travel-Related Statistical Trends in North Carolina

	1980	(%)	1990	(%)	Percent Change	USA % Change
Total daily person trips	12,938,000		15,246,000		+17.8	
Population	5,881,166		6,628,637		+12.7	+9.7
Workers 16+	2,652,593		3,300,481		+24.4	+19.1
Drove alone	1,756,417	66.2	2,528,168	76.6	+43.9	+35.4
Carpool	653,985	24.7	531,377	16.1	-18.7	-19.3
Public transit	40,100	1.5	33,005	1.0	-17.7	-1.9
Other modes	34,468	1.3	39,606	1.2	+14.9	-5.6
Walk/home work	167,623	6.3	168,325	5.1	+ 4.1	+4.4
Mean travel time, min.	19.1		19.8		+ 3.7	+3.2
Household auto ownership						
TOTAL	2,043,291		2,517,026			
0	219,700	10.8	241,711	9.6	+10.0	+2.0
1	657,989	32.2	786,080	31.2	+19.5	+8.7
2	745,112	36.5	959,128	38.1	+28.7	+25.6
3+	420,490	20.6	530,107	21.1	+26.1	+13.2
HH owned total vehicles	3,409,683		4,294,657		+26.0	+17.4
Vehicles/household	1.67		1.71		+2.3	+3.1
Total vehicles registered	3,871,840		4,919,592		+27.1	

centage of households owning no cars had fallen to 9.6 percent. In 1990 over twice as many households (530,107, or 21.2 percent) owned three or more vehicles as owned no vehicles. Vehicle ownership is not uniform across North Carolina but rather varies substantially by income. Generally, counties with the highest income levels also have the highest rates of car ownership.

The number of workers commuting in North Carolina increased about 24.4 percent in the last decade, compared with an increase in the population of about 12.7 percent (Table 2). The increase has been in the "drove alone" category, which increased from 66.2 percent of commuters in 1980 to 76.6 percent of commuters in 1990. In fact, the increase in drive-alone commuting (771,751) is much greater than the reduction in other modes (123,868). Of the total change, 13.8 percent comes out of other modes, and 76.2 percent was directly solo driver. Perhaps surprisingly, the percentage of workers in carpools dropped 18.7 percent, from 24.7 percent to 16.1 percent of commuters. In absolute terms, carpooling dropped by 122,608. Public transit also dropped by about 17.7 percent, from 1.5 percent to 1.0 percent (7,095 in absolute terms). The percentage who walked to work or worked at home has also dropped relatively. Thus, the most dramatic changes in commuting patterns are reductions in carpooling, coupled with substantial increases in solo driving.

Solo driving commuting is not generally thought of as closely associated with large metropolitan areas; it is often believed that such areas have a higher percentage of carpooling and public transit use than rural, more isolated areas. In fact, just the opposite is the case in North Carolina. Figure 2 shows that solo driving commuting is highest in North Carolina's larger metropolitan areas. Wilmington, Charlotte, Raleigh, Asheville, and Greensboro have high drive-alone rates. These areas also have generally higher-than-average income levels, which are translated into generally higher levels of automobile ownership. On the other hand, changes in commuting alone (Figure 3) have been most rapid in suburban and rural counties, often adjacent to larger metropolitan counties. A few

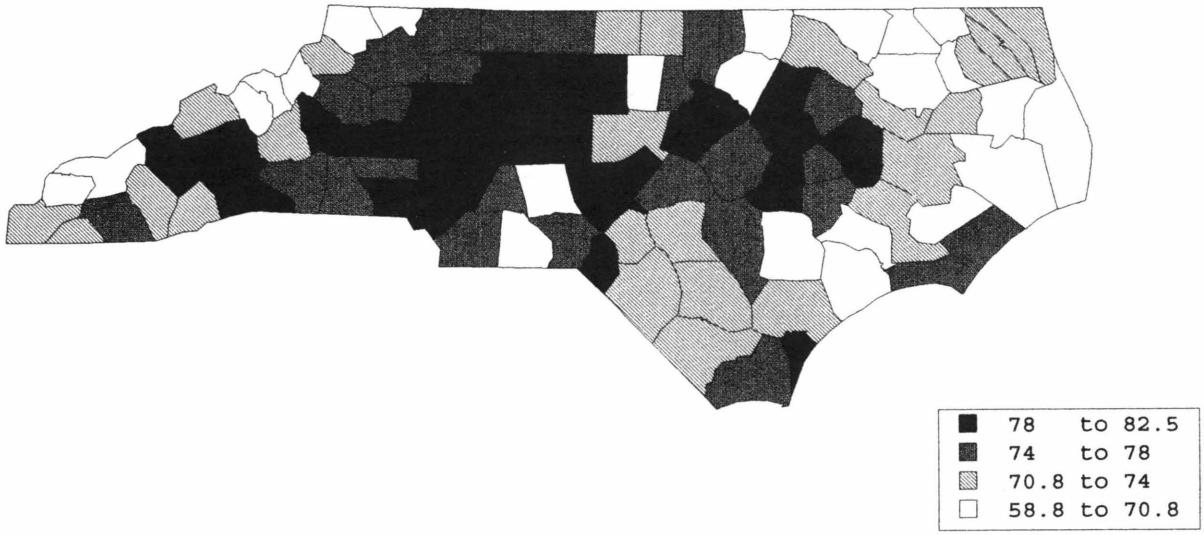

FIGURE 2 Percentage commuting alone, North Carolina counties, 1990 (source: U.S. census).

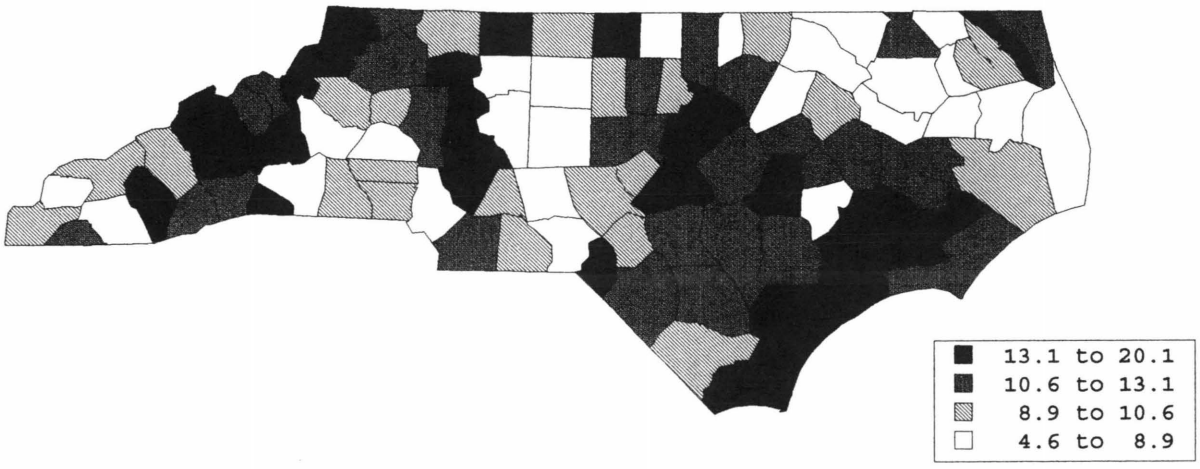

FIGURE 3 Change in percentage commuting alone, North Carolina counties, 1980 to 1990 (source: U.S. census).

counties show both high present solo driver rates and also a very substantial increase in percentage commuting alone; these are counties that have rapidly changed from more rural economies to integrated urban economies in the last decade.

Carpooling is often associated with metropolitan commutes from suburban counties, but in fact carpooling is greatest in North Carolina in rural counties (Figure 4), which have generally lower incomes. It is more accurately associated with the inability to purchase vehicles than it is with long travel times or travel distances. Although the overall percentage of carpoolers has dropped from 24.7 to 16.1 percent between 1980 and 1990, at least 75 of North Carolina's 100 counties have carpool rates greater than 16.1 percent. Two of North Carolina's counties have incidences of carpooling higher than 34 percent. Compared with overall national averages of about 13.4 percent, these are extremely high rates indeed.

Only one county showed an increase in carpooling during the last decade, from 32.3 to 34.5 percent (Figure 5). The decline in carpooling (122,608) has been over 31 times greater than the total use of publicly sponsored carpool or vanpool services.

Public transit commuting has also generally declined, from 1.5 to about 1.0 percent of commuters between 1980 and 1990 (Figure 6). In North Carolina, only the counties containing

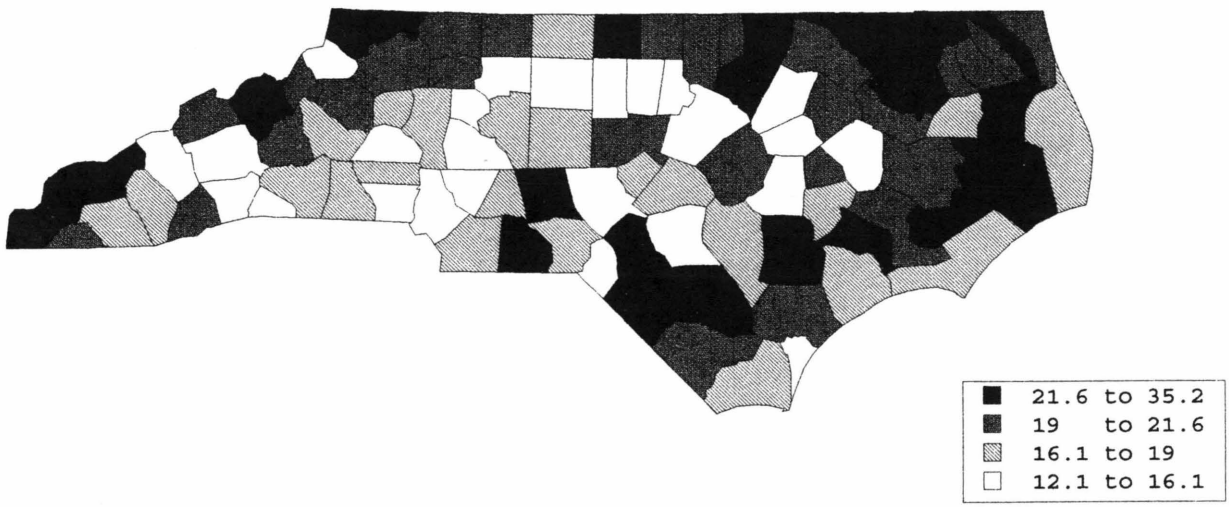

FIGURE 4 Percentage carpooling, North Carolina counties, 1990 (source: U.S. census).

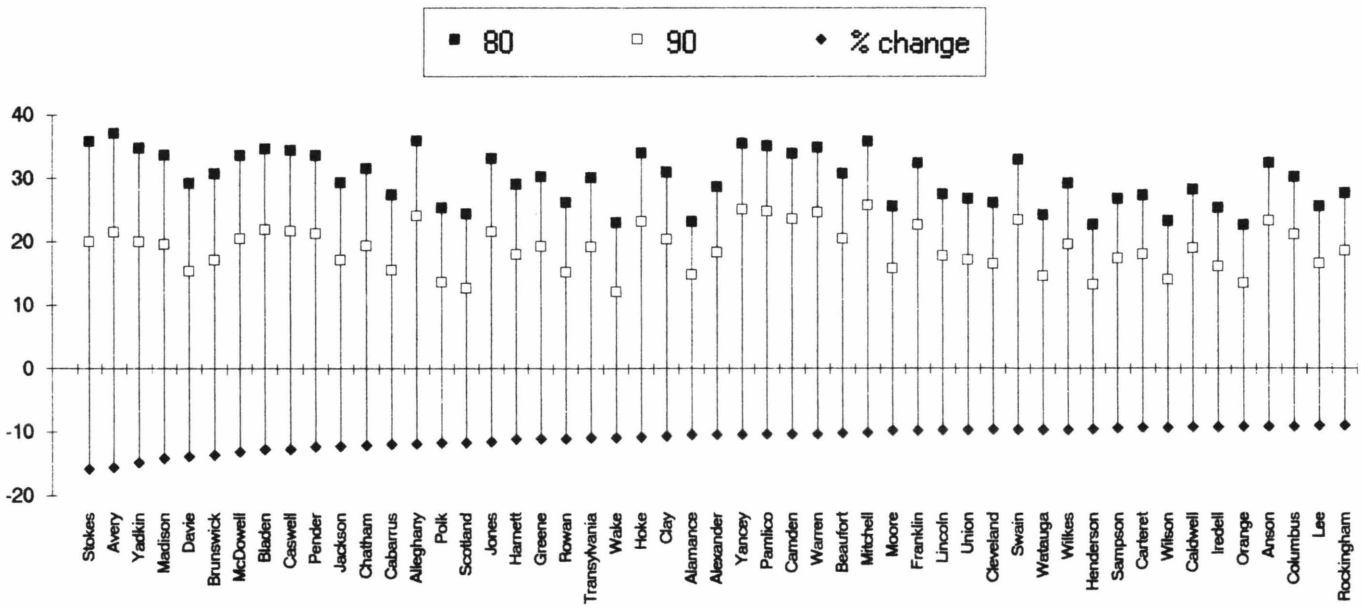

FIGURE 5 Change in percentage carpooling, 1980 to 1990. (*continued on next page*)

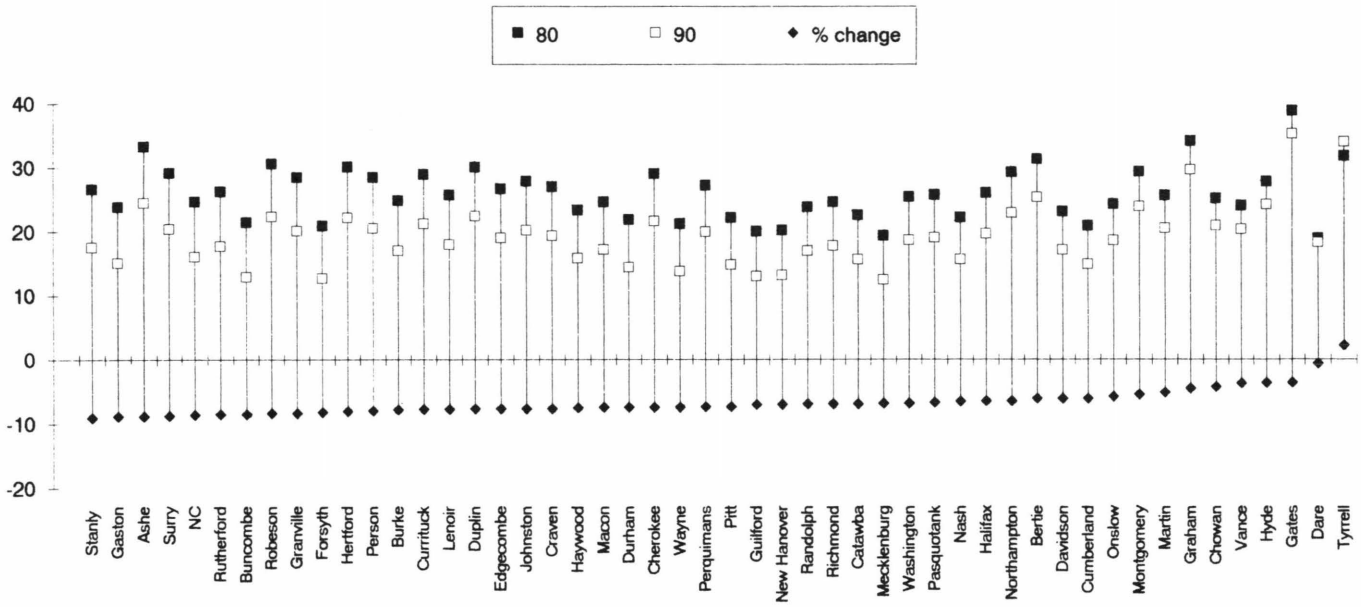

FIGURE 5 *(continued)*

FIGURE 6 Percentage using public transportation, North Carolina counties, 1990 (source: U.S. census).

the four largest cities show transit use greater than 2 percent for commuting.

However, a number of other counties show between 1 and 2 percent transit use, and in no sense can all of these counties be considered urban in character. Whereas several counties have shown increases in transit use in the last decade, the trend in North Carolina is generally down (Figure 7). The greatest declines have generally been in metropolitan areas where the transit share is the highest and in counties suburban to those areas. In both of these cases, rising average incomes have had the effect of increasing ownership more rapidly than availability of transit has had the effect of encouraging the people to use the system. In general, increases in transit use have been in low-income counties with small communities (Figure 7).

Whereas there have been considerable shifts in commuting by mode, the overall effect on trip lengths has been surprisingly small. The average travel time to work in North Carolina has risen only slightly, from 19.1 min in 1980 to 19.8 min in 1990. Commute times are generally longest in suburban counties adjacent to large metropolitan regions (Figures 3, 8, and 9). The 25 counties with the longest commute times in North Carolina range from 22.3 to 33.4 min. These counties commute primarily to Virginia Beach and Newport News, Virginia. Short commute times are associated with both isolated rural economies in which most commuting is highly local and a few large urban areas. The two counties with the lowest overall average travel time to work are, not surprisingly, relatively isolated and self-contained economies.

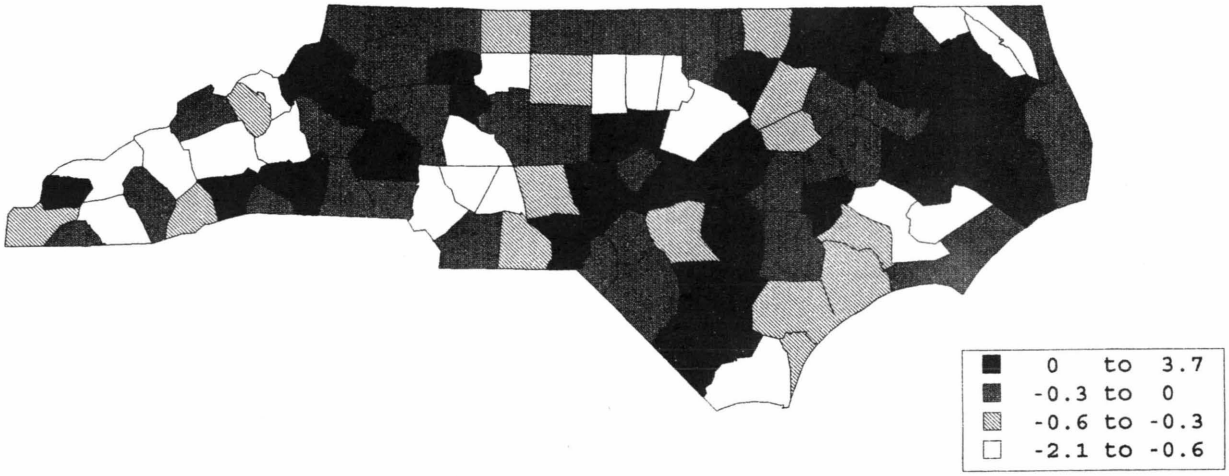

FIGURE 7 Change in percentage using public transportation, North Carolina counties, 1980 to 1990 (source: U.S. census).

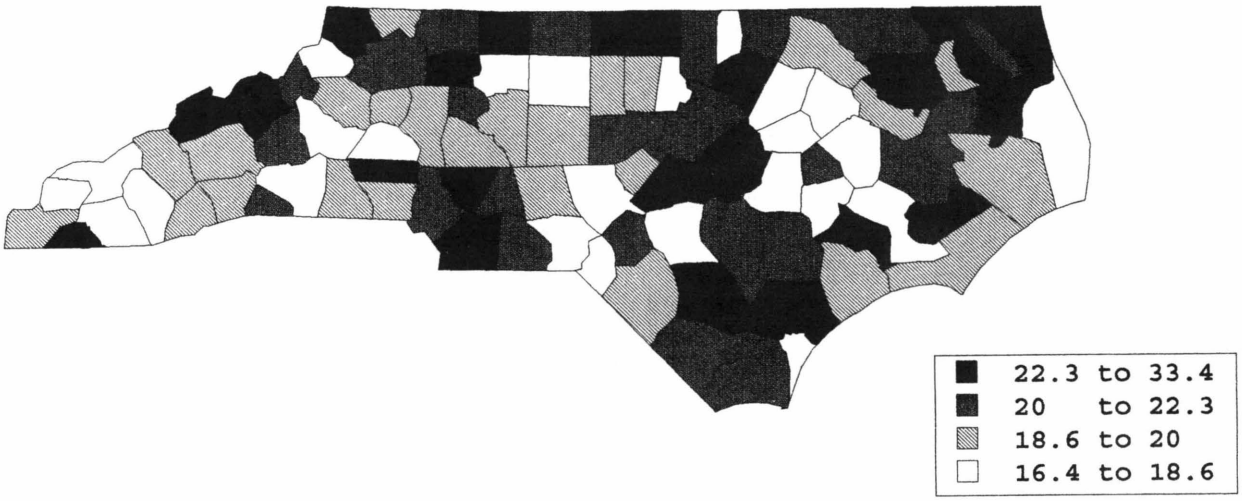

FIGURE 8 Mean travel time to work (min), North Carolina counties, 1990 (source: U.S. census).

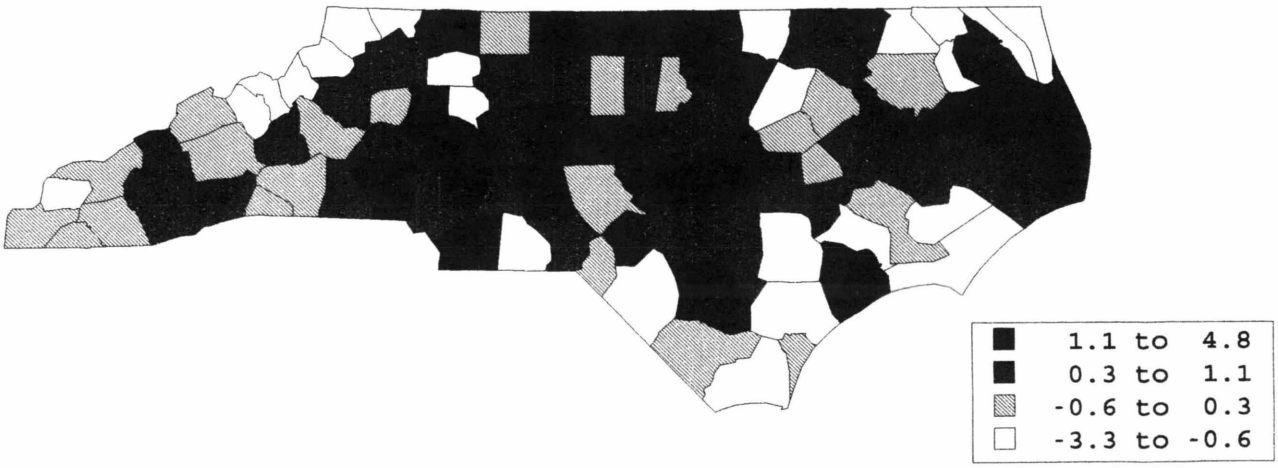

FIGURE 9 Change in mean travel time to work, North Carolina counties, 1980 to 1990 (source: U.S. census).

Carpooling Analysis

Although virtually all counties decreased in carpooling, the magnitude of the reductions has not been uniform by county. County changes in carpooling have ranged from −16 to +2.2 percent (Figure 5). Only one county in the state registered an increase in carpooling during the last decade, from a surprisingly high 32.3 percent in 1980 to 34.5 percent in 1990. As Figure 5 also shows, generally the greatest reductions in carpooling were for counties that were modestly high in carpooling in 1980; perhaps surprisingly, some of the lowest reductions in carpooling during the 1980s were also for counties that ranked high in carpooling in 1980. This apparent anomaly can be explained by the underlying structure of economics encouraging carpooling, which is largely income based.

Reductions in carpooling have been greatest in suburban counties surrounding metropolitan areas and in dense metropolitan counties themselves. Generally, counties that are one-tier around the metropolitan regions show the steepest declines, reflecting both changes in accessibility and rapidly rising per capita incomes. Second- and third-tier counties, that is, two circles and three circles back from metropolitan counties, are considerably more isolated and as a result were less affected by overall rises in per capita income or accessibility. The ingredients for high carpooling are relatively low incomes, a shortage of high-paying jobs, and very long commute distances to locations with high-paying jobs. Figure 10 shows a strong relationship between carpooling and per capita income. Generally, as per capita income rises, carpooling percentages fall substantially. Of the many variables tested in our modeling structure, the relationship with per capita income and mean travel times was among the strongest (Table 3). Table 4 and Figure 11 also illustrate a strong relationship between mean travel time and carpooling: for longer commute distances, carpooling is more probable.

DISCUSSION OF RESULTS

Work travel patterns in a county are closely related to its economic structure and that of its immediate surrounding counties. Basically, higher income levels in metropolitan areas attract workers from surrounding counties, thereby increasing commute times and distances, resulting in significant net in-commuting to these magnets. An important side effect is that incomes resulting from such work go to pay for vehicles in the surrounding counties, thereby reducing carpooling and increasing private car commuting. In North Carolina, six large metropolitan areas account for most of the large in-commuting destinations in the state: Charlotte, Raleigh, Greensboro, Winston-Salem, High Point, and Hickory. In each of these areas, net in-commuting exceeds out-commuting by more than 20,000 commuter workers daily. On the other hand, the greatest net out-commuting is from counties adjacent to these large metropolitan regions, the greatest of which experienced net out-commuting of 17,000 workers daily.

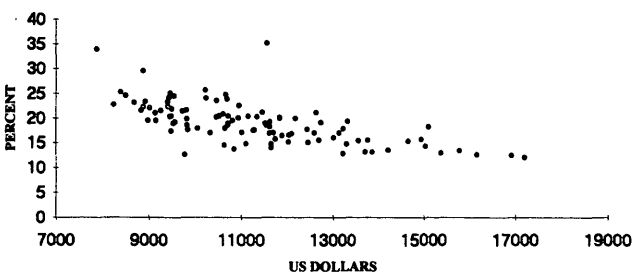

FIGURE 10 Carpooling versus per capita income, 1990.

TABLE 3 Stepwise Regression Model for Percentage Carpooling, 1990

	Value	F
intercept	10.696	7.29
per capita income (000s)	-0.572	6.12
mean travel time '90	0.541	43.17
% 0-car households '90	0.229	4.05
county urban classification	0.301	4.53
population density, '90	-0.00394	2.27

n=100
r squared = 0.67

TABLE 4 Correlations Between Carpooling and Other County Statistics

Percent Carpooling '90		Change In Percent Carpooling 1980-90	
% drove alone '90	-0.86	change in % drove alone '80-90	-0.59
% public transit'90	-0.28	change in % p.t. use '80-90	0.04
% other means '90	0.13	change in % other means	-0.28
% work home '90	0.03	change in % work at home	-0.31
mean travel time '90	0.55	change in mean travel time	0.32
vehicle regist '90	-0.56	percent change in registrations	0.09
Housing units '90	-0.56	change in housing units '80-90	0.06
0-car households '90	-0.54	change in % 0-car HH '80-90	0.08
% households 0-car '90	0.45		
3+ car households '90	-0.58	change in % 3-car HH '80-90	-0.24
% households 3+ cars '90	-0.04		
per capita income	-0.66	per capita income	-0.03
		percent change pop. '80-90	0.05
		1987 employment	0.096
		1987 non-manufacturing employment	0.11
		% manufacturing job change	0.14

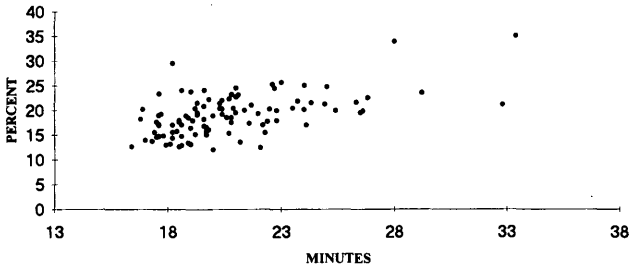

FIGURE 11 Carpooling versus mean travel time, 1990.

Conventional wisdom regarding carpooling—that it is essentially a suburban and urban phenomenon—is incorrect. In fact, carpooling is largely a phenomenon of rural lower-income and isolated regions, not of suburban counties and metropolitan regions (Figures 4, 10, and 11). In suburban and metropolitan counties, carpooling is a lower share of travel than in rural areas. Carpooling is more correctly associated with low income and isolation than it is with traffic congestion and high accessibility.

The reasons for declines in carpooling are many and complex. They are partially attributed to rising incomes, which have put automobiles within the reach of more workers. Perhaps the greatest influence has been increases in labor force participation by women, who have increased both car purchasing and solo driving. Other factors, such as relatively low gasoline prices, slowly declining costs of transportation relative to incomes, and generally increasing accessibility have also contributed to these trends. The energy crisis in 1973–1974 and again in 1979 temporarily lowered overall travel growth but have not substantially changed the basic underlying trend toward increasing private mobility.

It has been long recognized that carpooling, in the aggregate, is the summation of behaviors from different motivations. The traditional carpool markets identified in travel surveys are as follows:

1. Individuals economically driven in commuting environments,
2. Friends and acquaintances who live and work close to each other, and
3. Family members.

The total carpool market from rural counties, though relatively large, is small numerically. Since approximately 30 percent of Americans live in rural environments, it may be useful for studies to begin to review the nature of carpooling from such environments to distant metropolitan regions. People carpool for a variety of reasons, but the greatest proportion of people carpool because of job economics. When jobs are not available and commute distances are long but feasible and income differentials high, carpooling from relatively isolated second- and third-tier counties to metropolitan centers is likely to occur. Ironically, individuals in first-tier counties brought higher incomes home to their suburban counties and bought cars with them. As a result, solo car commuting in those counties increased rapidly.

Travel time's role in carpooling is complex. If travel times are too short and job access is high, the gains from carpool coordination are not worth the hassle. On the other hand, if distances are too great, commute travel will be dampened and carpooling will be low. Moderately long commuting distances, generally in the 40- to 60-min range at the extreme and the 35-min range on the average, appear to be the ideal circumstance for carpooling. Beyond that range, travel times are too great to make the gain in income worth the trip to the city.

The intention of this paper has not been to explain or develop a structure underlying the causality of carpooling, but rather to describe one of the most remarkable shifts in travel behavior ever observed in the United States. We believe that research should turn to the following items:

1. Full documentation, in every state and every county, of the extent of reductions in carpooling;
2. Identification of those few areas in the nation where carpooling has increased, both in real and percentage terms;
3. Thorough behavioral analysis of the structure of carpooling, particularly in rural markets, where it has been virtually unstudied, and particularly in informal family and friend-related markets where our knowledge is extremely weak. Research should cease on how to increase carpooling for those who choose to match their names with other riders and should be accelerated on understanding the behavior of markets perhaps 15 times larger than this one;

Carpooling service organizations need to refocus attention from concern about counting the number of names in data bases to the loss of market share. Serious consideration should be given to reducing or eliminating the present focus of carpooling programs on urban travel. They should be replaced with programs that focus strongly on rural residents who commute long distances to cities. Present employer-focused programs in urban areas should be replaced with residence-based programs in rural areas.

In summary, insistence on the cost-effective expenditure of taxpayer dollars means that all programs, including carpooling programs, should be carefully reviewed. The data presented in this paper suggest that carpooling as a commuting behavior has declined radically in the last 10 years for reasons related to shifts in demographics, accessibility, and income. Government agencies need to understand these trends and assist people in achieving mobility while minimizing energy consumption, air pollution, and congestion. It is clear that present programs to encourage carpooling have not had the desired effect. More cost-effective approaches for achieving the goals rather than concentrating on the means should be explored.

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