Highways and Sprawl in North Carolina

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Contents

Abstract

This study carefully reviews the growth of North Carolina's 1551 Census tracts during the 1990s compared with the location of major road improvements. Tract data on changes in population, demographics, prior density, and location are merged with detailed data on 312 major road projects completed during the 1990s, and the relationships between road investments and growth are determined for each of the 12 commuting regions. The study finds that growth in North Carolina is complex, occurring throughout the State and throughout each region. Local growth patterns depend heavily on prior density. Growth goes where there is room for it, filling in the urban tracts and lower-density edge tracts. About 1/2 of the State's growth went into tracts that had no major road improvements during the 1990s. Nearness to the Interstate system or to city centers had a small positive effect on growth. Road improvements, primarily urban and rural widenings, had a minor effect on growth, increasing tract decade-long growth rates by 50-550 persons per decade per mile of investment, about 2-14 percentage points above the baseline decade growth rate. However, the relationships are weak, generally explaining only about 15-25 percent of the variation in growth, thus indicating that factors other than density or road investment (e.g., schools, taxes, sewer and water, taxes, community receptiveness) influence the location of growth significantly. The study concludes that local governments, not road agencies, should accept their responsibility for growth policies. Road projects are blunt and inefficient instruments for either spurring or slowing growth.

Key words

Population growth, sprawl, roads, induced travel, density, North Carolina, highways.

I. Introduction:

A. Roads, Growth and Sprawl in North Carolina

Population growth is a major policy issue in urban America. There is no doubt that the urban boundaries of US cities are spreading out. This form of growth, often pejoratively called "sprawl", is particularly visible in the suburbs of urban regions where rapid increases in population, housing and commercial activity lead to overcrowded roads and schools. But "sprawl" is not the only form of "growth": within built-up urban regions, population is also changing as single family dwellings are converted to multi–family dwellings and the remaining residential lots are developed. Family sizes are also slowly declining and so the number of housing units may be increasing even as populations stabilize. In many regions the densities (population per square mile) of individual tracts are generally increasing, even as the geographic size of the region increases and the overall density declines. And growth is occurring in some rural areas too, distant from large cities, while in other rural areas the population is declining. So, changes in population are occurring in urban, suburban and rural areas.

Do roads cause "growth" or "sprawl"? This seemingly easy-to-answer question has been the subject of a great deal of study over the past several decades, and defies a simple response. The problem is that although the correlates of growth, those circumstances that seem to go along with it, are quite visible, the specific causes and their sequence are very difficult to determine for particular cases and impossible for general cases. Among the many factors often associated with growth (or the lack of it) are a region's economic health and location advantages, prior growth and available land, site suitability, geographic location, zoning, sewer and water provision, other utilities, highways and roads, income, tax rates, crime, schools, housing policies, and race and other demographics, just to mention a few. In particular, the impact of road investments on growth is often mentioned since the public frequently sees development follow major road investment. However, road investment often follows growth, addressing capacity or other needs. A recent review of growth in Ohio's cities[1] found that almost 70 % of the growth occurred in tracts that had NO recent major road improvements, and that the key factor in directing growth was prior population density: as tracts fill up, growth goes to other tracts that have room for it. Perhaps that might be expected, since in most states the State is responsible for major road improvements, but local governments are responsible for zoning land and providing other infrastructure[2]

North Carolina's recent population growth has been stronger and more dispersed than Ohio's, and its economy more robust. Growth has occurred throughout the State, not just in the suburbs of large cities. Of North Carolina's 100 counties, 97 increased in population during the 1990s. And some of the most rapid growth was in recreation, retirement, mountain and coastal counties, far from urban centers and Interstate highways. Some of this growth has been initiated from afar by rising disposable incomes in the Mid-Atlantic States. Clearly, the circumstances of population growth in North

Carolina over the past decade cannot be described simply as "urban", "suburban" or "near major roads".

That said, there is also some expectation that roads might encourage growth in North Carolina, perhaps more so than in other States. In 1989 the NC Legislature passed the Infrastructure Act[3], which designated 3800 miles of 2-lane rural roads to be widened to 4 lanes or new loops to be built. The stated goal of this Act, initially estimated to cost about $13B, was to bring 90 percent of the State's population within 10 miles of a 4-lane road. Given the focus on improved accessibility, one might expect that one effect of the program would be to increase inter-county access and perhaps spur rural development. During the 1990s particular attention was placed on those routes initially on the Infrastructure Program: our data shows that, of the 1559 miles of major projects completed in the 1990s, about 711 miles, 46 percent, were on the designated Infrastructure System including urban loops.

To clarify this complex issue, the John Locke Foundation requested a careful assessment of the nature of population growth in North Carolina over the past decade and its relationship to road improvements. This study reviews population growth patterns throughout North Carolina over the last decade, and relates that growth to road investment and other factors. **Specifically, the goal of the study is to quantify the magnitude and spatial location of population growth, compare it with the locations of major road investments and other factors, and determine the extent to which population growth preceded or followed the road investment.** The relevant questions asked are:

- **Where and how has population growth occurred** in different regions of the State during the 1990s?
- **How is this growth related to the major road improvements**, both prior and during the 1990s? Did the growth warrant the road improvements, or did the road improvements spur the growth?
- What **other factors** seem to influence growth?
- What **policy implications** for growth and road-building can be drawn from this assessment?

This issue is important because public policy related to growth and to road investment should be based on factual information concerning the causes of growth, not on opinions or impressions. Particularly, the role of road investment in growth policy must be understood, so that road investment can be used positively to alleviate congestion and improve safety and access, rather than negatively as a tool to shape or prevent sprawl.

B. Methodology

The approach used in this study is based on straightforward analysis of numerous information sources for North Carolina. The method uses TransCAD[4], a computerized geographic mapping system called a "geographic information system" (GIS), to organize and locate the information. Specifically, the major steps in the study are:

1. **Describe the population growth in the State's 100 counties and 17 largest urbanized areas,** and relate it to overall changes in traffic (measured as

average daily traffic, **ADT**[a]) and travel (measured as vehicle-miles of travel, **VMT**). Key sources of information are the 1990 and 2000 Censuses, and annual summaries of travel in urbanized areas.

2. **Group the 100 counties of North Carolina into commuting regions** based on commuting patterns. The key source of information here are the 2000 Journey-to-Work data from the 2000 Census.
3. **Determine the magnitude of population growth in each of the State's 1551 census tracts.** The primary sources of information used here are the 1990 and 2000 Censuses.
4. **Quantify the major demographic and spatial factors that might influence the growth of tract population.** These include prior growth, prior density, household income and other population characteristics, distance to Interstates and other major roads, distances to city centers, distances to coastlines, mountains and parks, and other factors. The primary sources of information here are demographic data contained in the Census and spatial data available in TransCAD.
5. **Identify and locate all major road projects completed in the 1990s**. Major road improvements are defined as projects that would be significant enough to cause population growth or shift growth from other areas. They include new major arterials, new freeways, new exits on existing freeways, major new bridges, and major widenings of arterials and freeways. The primary sources of this information are the biennial Transportation Improvement Programs of the North Carolina Department of Transportation and the major road widening records of the State's municipalities. Our review found 312 such projects throughout the State.
6. **Relate the locations of major road improvements to tract population growth,** using several statistical methods (tree-building classification procedures, correlation and regression, and spatial correlations.) The primary sources of this information are statistical routines and computerized maps available in TransCAD.
7. **Draw conclusions and make recommendations.** Include policy implications for North Carolina's transportation and growth programs.

More detailed information on the study's methodology is available in the Appendix

It is important to understand what this study does not cover. It does not review NON-residential growth, such as retail growth at major interchanges or increases in employment within urban areas. While an important and visible form of growth, such change is more complex and difficult to study and is highly dependent on very local factors such as parcel prices, sewer and water, site suitability, and regional advantages. Several recent studies (e.g. Cervero, 2003[5], and Hartgen and Kim, 1998[6]) have studied this form of growth. Second, (with just a few exceptions) the study does not include major road improvements completed or still underway after 2000, such as portions of outer belts in Charlotte, Greensboro and Raleigh. While it might be argued that these projects are pulling their regions outward and causing sprawl in advance of construction,

[a] Transportation planners distinguish between **average daily traffic, ADT**, the average count of vehicles passing a point, and **vehicle-miles-of-travel, VMT**, the total miles driven by all the vehicles in a region or on a section of road in a given time. Most studies of increased traffic use VMT, which accounts for both increased traffic and trip length. See the Appendix for a short Glossary.

their inclusion would create other questions (how far ahead to look, what projects to include, how "big" is "big"). Some portions of these very large projects completed in the 1990s are included in our study, as are other large projects such as the completion of I-40 from Raleigh to Wilmington. Third, the study does not look at the longer-term (20-30 year) impact of major roads built earlier on recent growth. Such a study while useful is beyond the scope of the research and introduces even greater uncertainty as to the causes of growth. Fourth, the study does not look at the full range of factors affecting local population growth. These include educational, racial and housing data, crime statistics, school performance, tax rates, parcel prices and suitability, sewer and water service and plans, localized demographics, competition between communities and community attitudes, political support or opposition, or economic health. While interesting and important, such factors are far beyond the current study's scope. While these limitations may reduce the overall comprehensiveness of the study, they do not detract from its findings or its general applicability. We believe that this study, even with its limitations, is one of the most comprehensive and detailed assessments of population growth in North Carolina recently undertaken.

C. Literature Review

1. Economic impacts of roads

Studies of the impacts of road improvements on economic growth and sprawl are extensive in the transportation and planning literature, and a full review is not possible here. Brown[7] provides a recent annotated bibliography covering the economic development impacts of highways in rural areas and industry sector impacts over time. We focus here on the most recent studies of economic impacts, sprawl and induced travel.

Although the public typically associates development directly with the road itself, transportation economists generally view development along improved roads as a second-order impact that is another way of expressing the increase in traffic. In this view, traffic is attracted to the new or improved facility because road users benefit from savings in travel time, reduced operating costs and improved safety. Benefits are typically evaluated at _ the wage rate for time savings[8], about $3M per life for reduced fatalities and $0.50 per mile for reduced operating costs. These benefits are compared with the amortized cost of the improvement to determine its "benefit-cost ratio". To determine negative impacts, the additional VMT is translated into energy[9] or air pollution[10] estimates based on travel speeds[11]. Development occurs along the facility if the additional traffic makes those sites more attractive relative to other undeveloped sites. This implies that the development is 'diverted' from other locations that would have otherwise grown.

There is a very large literature on transportation's impact on economic development, and only the most recent will be reviewed here. Many studies have noted that road investments often lead to increases in economic activity, particularly in rural areas. For instance, Hooker and Potter[12] found (perhaps not surprisingly) that the completion of I-80 across Wyoming from 1955-1975 resulted in additional economic activity totaling more than twice its initial $103 M construction cost. The fundamental question, does a new highway spur economic development, has been generally answered "yes" by local politicians, but the hard evidence is less convincing. A primary issue is whether the development is 'new' or was just diverted from other locations. This problem

occurs in both rural and urban settings. Forkenbrock[13] suggests strict criteria to judge whether road-generated development is truly new or merely diverted from other sometimes distant locations, creating losers elsewhere. If strictly applied, these criteria would eliminate most such benefits[14].

Another set of problems relates to causality. Few if any of the studies succeed in isolating the effect of the road improvement from other factors influencing growth. In their 1990 assessment of the impacts of I-40's completion from Raleigh to Wilmington NC, Hartgen et al[15,16] hypothesized that I-40 would spur development near the major cities (Raleigh and Wilmington) and at exits within easy commuting distance, but that intermediate development along the 120-mile corridor would be limited unless communities worked cooperatively to organize enterprise zones and other incentives. Thirteen years later that muted forecast has generally turned out to be the case. Rephann and Isserman[17] supported this finding in a quasi-experimental study of counties with Interstate highways and those without. The winners were counties near urban areas that received Interstates, while rural counties with Interstates and those without Interstates benefited little.

MacDonald and Peters[18] found that the commuting patterns of rural women living in four eastern Iowa counties on the metropolitan periphery were more dependent on carpooling, but most continued to drive alone to the suburbs of cities. Henry and Johnson[19] found that Interstates generally encouraged re-distributed development that would have gone elsewhere, so that the local impact was found to be positive but the regional impact was zero. Forelle and Brown[20] found that Florida's most rapid growth occurred on the coast during the period 1960-1990, coincidentally with the development of the Florida Limited Access Highway network, but that more recently growth is occurring in rural areas away from the coast where land is cheaper, growth management constraints are less stringent, and where the road network was developed previously.

The Road Information Program[21] found that Louisiana's road system is a key element of sustained economic growth, but that the state's road system is among the worst in the nation. Forkenbrock[22] reviewed the role of transportation investment in Iowa's economic future, concluding that rural road investment alone was insufficient to spur development: joint investment and pricing decisions are needed that affect roads, waterways and rail services. Turnbull[23] reached a similar conclusion for rural Texas.

Hartgen and Kim[24] found that the key factors influencing commercial growth at rural Interstate exits were the size of the nearby community, distance to the Interstate (affecting the community's ability to provide sewer and water to the exit), closeness to major metropolitan regions, and cross-street traffic. They concluded that economic development along Interstates or other major rural expressways is primarily an extension of the local community's business structure rather than the volume of tourists or Interstate traffic. The use of geographic information systems to describe and analyze the relationships is becoming more common[25].

The consensus of these studies, still controversial, is that roads are a necessary but not sufficient condition for development, operating as a gate that permits development to occur but only if a host of other factors are favorable. Reviews of the impact of major road networks in other nations[26] have reached similar conclusions. Whether the new development is good or not is of course open to debate. Weiss[27] argues that perhaps too much negativity has been associated with road improvements, which generally do have

positive impacts on economic activity, and remain a key rural development tool in many states in spite of their less-than-spectacular impacts.

2. Sprawl and Induced Travel

In urban areas, major new roads also seem to impact the direction of local growth, creating increased residential and commercial development sometimes termed "sprawl". The deceptively simple step of defining "sprawl" as an impact of road improvements is not trivial. How is "sprawl" different from "growth"? Burchell[28], working from Ewing, defines sprawl as "skipped over haphazard, auto-oriented development at the edges of regions", to differentiate it from in-fill and other forms of development. Garb[29] argues that the economic growth of Prague has contributed to the spread of suburban "hyper-markets", leading to a decrease in transit use. But the 1990's "in-fill" areas were the 1960's "sprawl", leading to circularity in the definition. Similarly, Epstein[30] used the buffer areas around road GIS lines to define the limits of suburban growth. In the author's review of the impacts of beltways[31], the definition of sprawl was avoided by simply referring to the Census data on the geographic area and population of urbanized areas.

Many studies argue that major transportation actions encourage sprawl by permitting activity to spread out and increasing average trip length. The result is hypothesized to be an increase in travel ("induced travel") that would have otherwise not occurred. The concept of induced travel is controversial and open to considerable disagreement. When a new road is opened or an existing road improved, traffic is attracted because travelers save travel time. But whether the traffic so created is 'new' or just shifted in time, mode, or location is problematical. In the short run, changes in travel include changes in:

- Route choice (diverting from the prior path to take advantage of the new road),
- Mode choice (dropping use of transit or carpooling),
- Time of day choice (diverting back into a peak hour from a travel time earlier or later than the peak),
- Destination choice (selecting different destinations that are now more accessible), and
- Trip frequency (making more trips).

These behaviors are sometimes manifested in the clogging of new roads immediately upon opening, a phenomenon that frustrates drivers and traffic planners alike. In addition to these initial changes, longer term changes may include:

- Work site change (workers changing to jobs farther away from residences),
- Home site change (consumers changing to residences farther from work),
- Increased auto ownership, and
- Increased development along the facility, as developers take advantage of the additional accessibility of sites near the facility. It is this change that people frequently observe and pejoratively refer to as "sprawl".

The impact of induced travel depends on which of these many forms of induced travel are included in the particular assessment[32]. No studies have been able to sort out these many forms and isolate their separate impacts. Some observers note that these effects are precisely what new roads are *intended* to do, and that the negative perceptions of the impacts stem from a failure of traffic planners to articulate clearly the purpose of

new facility. Nevertheless, these generally negative perceptions of induced travel are sometimes used to argue that increasing highway capacity is pointless because the induced travel fills up the added capacity[33]. Cervero[34] argues that the concept of induced travel, so apparent yet difficult to quantify, has been responsible for delay and cancellation of numerous transportation projects during the last decade.

Estimates of the magnitude of induced travel vary widely and are highly dependent on methodology. Most aggregate studies (those that look at trend statistics for urbanized areas or counties) show modest correlation between highway capacity (e.g., lane-miles) and traffic (e.g., VMT), and elasticities[35] ranging from 0.3 to 0.7. The earlier studies typically showed larger correlations and higher elasticities. For instance, reviewing the evidence for induced traffic in the US and UK, Noland and Lem[36] found that new transportation capacity increases travel in both the short run through diversion, and long run through development. Hansen and Haung[37] found elasticity of 0.9 between increases in capacity (lane-miles) and travel (VMT) in 14 California urbanized areas over 18 years. Using aggregate data on VMT and lane-miles of capacity for counties in 3 Mid-Atlantic States, Fulton et al[38] confirmed the ranges of elasticity found in earlier studies. However, later assessments found that the effects were overstated when subjected to more careful controls. In a study of changes in aggregate travel in 34 California counties over 22 years, Cervero and Hansen[39] found that increases in lane-miles and increases in VMT each affected each other, with lane-miles influencing VMT slightly more than the reverse. And looking at the 65 largest urbanized areas over 7 years, Hartgen and Curley[40] found that urbanized areas with no or partial belts actually grew in population and geographic area more rapidly than cities with complete or mostly complete belts, suggesting that belts actually followed earlier development that increased the need for circumferential roads. In a review of studies, Heanue[41] found that the impact of induced travel from new road capacity was relatively small compared to other factors influencing travel. Far more important in creating travel were population, employment, personal income and auto ownership. Studies using the traditional 4-step urban modeling process with feedback loops to account for some of these changes have found similar results, but show less value for major road improvements such as building new freeways[42].

Studies based on individual travel behavior or on case studies of specific road improvements also report mixed results. For instance, using National Personal Travel Survey data on individual travel behavior Barr[43] estimated that about 30-50% of the time saved by a road improvement would be re-spent in induced travel, but this study did not actually compare travel before and after new roads were opened. On the other hand Dowling[44] found the impacts of new roads on induced traffic to be quite small, in the range of 3-5 percent. Looking at individual road projects Goodwin[45] reviewed the results of 100+ road improvements in England and found that savings in travel time were just balanced by the increases in traffic. But in the US, studying the impact of the Loma Prieta earthquake on the use of I-880 in Oakland Dahlgren[46] concluded that the increased travel on the reopened freeway 10 years later would be primarily caused by economic and population growth, not by induced travel. Mokhtarian and others[47], carefully comparing traffic growth trends for 23 specific California freeways that had been widened, found that the traffic growth on widened roads was the same as the growth on parallel un-widened roads, suggesting elasticity near zero. Studying the impacts of major road investments on the cities of Ohio, Hartgen[48] found that most of the population growth in

Ohio's urbanized areas took place in tracts that had no major road improvements, and that the typical impact of a 1-mile road widening on increased traffic was about the same as a mid-sized McDonald's. Summarizing the state-of-the-practice in travel demand modeling, DeCorla-Souza and Cohen[49] found that induced travel was the greatest when the congestion prior to improvement was high[50], and devised a straightforward spreadsheet modeling system to analyze these effects for a proposed road expansion. Virtually all of these studies deal with increasing highway capacity; in the reverse direction, that is closing roads, one study in England[51] found upwards of 25% reduction in traffic when roads were closed. Kulash[52] hypothesizes that not building major roads would lead to reducing-travel adjustments in driver behavior over time.

In the middle ground, Cervero's review of the empirical evidence for induced travel[53] found that aggregate studies tended to point to a significant effect, while the more detailed micro-scale studies from individual sites suggested more modest effects. His follow-up study of 24 specific California freeway projects over 15 years[54] found that the elasticity of additional capacity on induced traffic was lower than reported in earlier studies, and that the effect went both ways: increased capacity attracts commercial development but traffic increases also cause subsequent road investments. In spite of the conflicting evidence researchers agree that better knowledge of travel behavior, retrospective studies, before-and-after studies, and simplified procedures are needed to account for the effect[55].

3. Reducing Congestion

If increasing road capacity just increases traffic, then what should be done about congestion? Some researchers, for instance Habig[56], argue that increasing transit options, improved roads, and enhanced technology will help communities deal with congestion, and that cooperation and smart-growth "sensible land use policies" are the key to long term progress. Ewing[57] argues that building more roads and abandoning our cities to the auto culture ignores the social impact of this choice and abandons progress made so far in better transportation planning. But he also notes with some alarm the rush to private-car mobility[58] occurring in eastern European nations and other societies as freedom increases and democracy spreads. On the other hand, the evidence that such actions actually help reduce congestion is limited. Cox[59] argues that so-called anti-sprawl measures such as smart growth are actually counterproductive, increasing traffic as density rises because the increase in activity more than offsets the diversion to transit, walking or reduced travel. He also cites the European experiences[60] that cities there are rapidly spreading out and people are increasing their use of the private car. Reviewing the actual VMT per job in the DC area, Mann and Jani[61] found that the inner and outer portions of the city have about 8 VMT per job, suggesting that relocating jobs to the inner city would not reduce VMT. Reviewing the travel data from the 2000 Census Pisarski[62] sees no reversal of the "democratization of mobility" that has been underway for 50 years. And Dunn[63] argues that the auto is preferred in all societies because of the freedom and convenience it provides and that its positive impacts on mobility far outweigh its negative impacts. He seriously doubts that government exhortations or actions to reduce its use will be heeded.

Of course, studies that relate road improvements to sprawl and pollution can have highly charged political overtones and be foils for larger agendas to reduce car use and make cities denser. Perhaps hoping that rational assessments will win out over screeds,

Hansen[64] recognizes the inherent political sensitivity of the issue and calls for better monitoring of impacts so that such issues as induced traffic can be clarified. But others are not so conciliatory. For example, a periodic report by Smart Growth America[65] rates cities according to levels of air pollution, increased fatality rates, and traffic. On the other side Cox[66] and others[67] have published a variety of analyses showing how European cities are also spreading out, and that their generally higher densities actually lead to more congestion than less dense US cities. Dunphy[68] strikes a somber note, arguing that additional capacity *ought* to be slightly greater than demand to allow for growth, and that short of adding capacity there is virtually no other effective way of dealing with congestion. As the reauthorization of TEA-21 is considered during 2003, one might expect such studies to become more frequent as various views of the federal road program are expressed.

4. Summary

In summary, our review of the literature on sprawl, induced traffic, and road investments notes several key weaknesses:

- Studies of the impact of major roads on rural economic development indicate that they are a necessary but not sufficient prerequisite for growth. The 'growth' so created is often merely redistributed growth from other areas that does not substantially affect rural economies beyond the commute range of major metropolitan areas.
- Growth at rural exits of Interstate-like facilities is highly dependent on the characteristics of the local market rather than on the volume of thru traffic.
- The literature does not carefully define "sprawl" or "induced travel" or "increased capacity"; the studies contain a variety of definitions, which increases the uncertainty of the overall findings.
- With the exception of one study, the literature does not link road improvements directly to sprawl (urban spreading); instead it focuses on the link between road improvements and increased traffic.
- The studies show a very wide range of sensitivity, from 3-5 percent on the low end to about 90 percent on the high end. This means that the effect of increased road capacity on increased traffic can range from essentially zero to a one-to-one correspondence.
- No studies specifically link rural road improvements to either improved rural access, increased rural development or to urban or suburban growth.
- With just two exceptions, the studies do not look at whether traffic increases influence later capacity additions. They generally presume that capacity improvements influence traffic. The more likely possibility that road capacity is increased to address prior congestion is essentially ignored.
- Most of the studies are highly aggregate in nature, focusing on big-picture, area-wide trends between VMT and lane-miles of capacity. Only recently have more focused studies of specific road improvements been conducted, and these show much lower impacts.
- Most studies contain significant methodological problems, particularly the failure to include other influencers of increased traffic, or "control" groups to

isolate the main effects. Those that include control groups show much lower effects.

- Many studies seem to have a political tone to them, suggesting advocate-driven agendas that are intended to support preconceived views rather than careful objective assessments of complex relationships.
- The best, most careful, and most objective of the studies suggest weak-at-best relationships between road investments, induced traffic and sprawl.

On balance, therefore, the literature suggests significant weaknesses in present knowledge, particularly in the causal connections between road investments and either sprawl or traffic increases. Further, the range of findings reported in the literature is so large as to be essentially useless for policy analysis.

II. State and County Growth Trends

This section provides an overview of the growth of North Carolina during the 1990's, with focus on state-level trends and major county-level trends. The purpose of the discussion is to set the stage for more detailed analysis of traffic growth in urbanized areas, discussed in Section III, and in the geographic sub-regions of the state, discussed in Section IV.

A. State Trends

North Carolina's growth during the 1990's can only be described as strong. Overall, the State grew more rapidly than the US on several key indicators:

Table II.1: North Carolina Demographic Trends, 1990-2000

Statistic	1990	2000	Change	**Percent Change**	US Percent Change
Population	6.629	8.049	1.421	**21.4**	13.2
Households	2.517	3.132	0.615	**24.4**	14.7
Employment	3.929	4.943	1.013	**25.8**	16.7
Per-Capita Income (99 vs. 89 infl	$17,266[a]	$20,307	$3041	**17.6**	15.2

[a] $12,885, the 1989 average, inflated by 1.34 to 1999.

North Carolina gained substantially relative to the US on all four measures of growth.

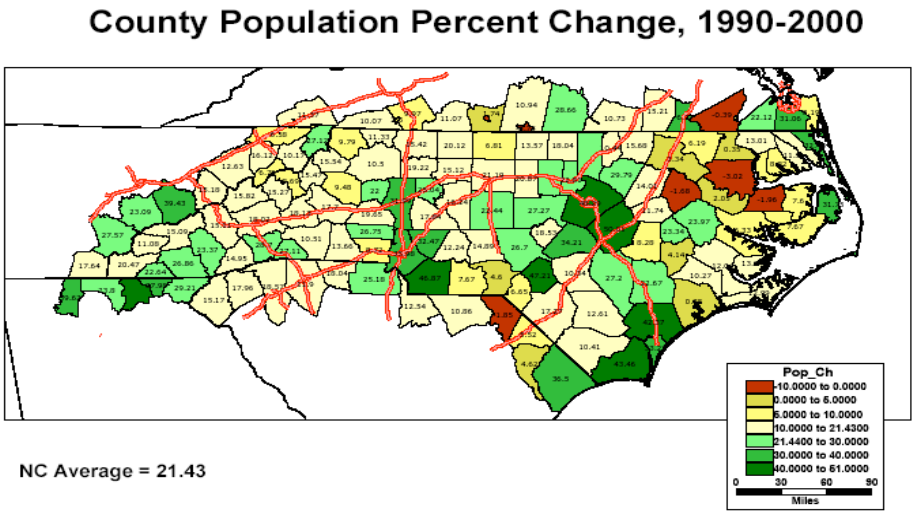
Although the State made impressive gains overall during the 1990s, its economy has cooled considerably since then, and economic problems have increased as the State's 'big three' industries (tobacco, furniture, and textiles) have all suffered slumps. Nevertheless the population of the State continues to grow.

B. Population

The population of North Carolina grew at a strong pace of 21.4 percent between 1990 and 2000, reaching 8,049,313. This rate of growth compares favorably to the U.S. average growth of 13.1 percent. In fact, North Carolina was the ninth fastest growing state in the U.S. during the 1990's.

Figure II.1 shows the geographic pattern of this growth by county, along with the growth in nearby-NC counties in VA, TN, GA, and SC. Population growth was widely distributed across the state, with 97 of the state's 100 counties increasing in population.

Figure II.1



In absolute terms growth was largest in the urban centers of Charlotte, Raleigh-Durham and Wilmington. However, the fastest relative growth was in a combination of suburban, urban core and rural counties. The 10 fastest growing counties are listed below in Table II.2. Three relatively small rural counties— Hoke, Pender and Harnett— also experienced rapid growth. While not officially considered part of the Raleigh-Durham MSA, Harnett County is increasingly a part of the Triangle region. The relative growth in these smaller counties is impressive but is dwarfed by the absolute number of new residents moving to the Charlotte and Raleigh-Durham regions. In 1990, the population of the Charlotte and Raleigh-Durham regions constituted 28 percent of the entire state of NC, and by 2000 that percentage increased to 31 percent. Over 44 percent of all the population growth in NC during the 1990's occurred in these regions.

Suburban development on the edges of large urban regions makes up some of the State's growth in the 1990s.

Rural mountain development distant from cities

Table II.2: Fastest Growing Counties in North Carolina: 1990-2000

County	2000 Population	Type	Metro Area	Percent Change
Johnston	121,965	Suburban	Raleigh-Durham	**50.0**
Wake	627,846	Urban core	Raleigh-Durham	**48.2**
Hoke	33,646	Rural	-	**47.2**
Union	123,677	Suburban	Charlotte	**46.9**
Brunswick	73,143	Suburban	Wilmington	**43.5**
Pender	41,082	Suburban	-	**42.4**
Mecklenburg	695,454	Urban core	Charlotte	**36.0**
Harnett	91,025	Rural	-	**34.2**

New Hanover	160,307	Urban core	Wilmington	**33.3**
Cabarrus	131,063	Suburban	Charlotte	**32.5**

Source: 2000 U.S. Census, SF3

Relatively high population growth are also found in the southwestern counties of Henderson (+28.7%) and Polk (+27.1) near the Asheville MSA along the I-26 corridor, in other southwestern counties (Clay, Macon, Transylvania), in suburban counties in the Charlotte, Raleigh-Durham, and Wilmington areas, and on the far northeastern coastal shore. Only three NC counties (Bertie, Edgecombe, and Washington) experienced population decline during the last decade and all are located in northeast NC, but are not on the coast.

Inner-city in-fill housing combined with shopping (Charlotte)

Table II.3: Population Change by City, 1990-2000

City	2000	1990	Overall Pct Change	Percent Ch in Hispanic Origin Population
Asheville	68,952	61,654	**+11.8**	+414
Rocky Mount	56,244	49,165	**+14.4**	+413
Greensboro	223,229	183,521	**+21.6**	+630
High Point	85,949	69,394	**+23.9**	+876
Winston-Salem	185,480	143,485	**+29.3**	+1444
Raleigh	276,579	207,951	**+33.0**	+696
Greenville	60385	44927	**+34.3**	+513
Wilmington	75,542	55,530	**+36.0**	+395
Charlotte	542,131	396,003	**+36.9**	+660
Durham	187,183	136,594	**+37.0**	+829
Cary	94,530	43,858	**+115.5**	+476

In terms of city population, North Carolina's major cities grew at rates faster than the state average (Table II.3). Cary has seen its population double since 1990. It is an affluent town (median household income exceeds $75,000) that is now bigger than Wilmington or Asheville. These cities also saw unprecedented gains in Hispanic population since 1990. In absolute terms, the largest agglomeration of Hispanics is found in Charlotte (over 40,000); Raleigh, Durham and Winston-Salem have Hispanic populations in excess of 15,000 each.

Table II.4 ranks counties on a proxy measure of residential mobility, ranked by the largest percentage of residents living in a different house in 2000 compared to 1995. Onslow County, with its strong military economy, had a large percent of residents living in a different house from 1995 and relocating from outside North Carolina since 1995 (36.1%). The counties and their circumstances vary geographically across the state, but Craven, Dare, Onslow, New Hanover, and Pitt are all in eastern NC near coastal communities. The influx of 'newcomers' is low in Pitt and Watauga. Orange, Wake, Mecklenburg, Durham and Cumberland show large increases from those living outside the US in 1995, perhaps related to their significant increases in Hispanic populations.

Table II.4: Population Trends: Change in Residence 1995 to 2000

County	Population 5 years and over: Total	Economic Base	Percent living in different house in 1995	Percent Outside NC in 1995	% Outside US in 1995
Orange	112444	Educ	**54.2%**	17.8%	4.6%
Wake	582978	Urban	**53.8%**	18.0%	4.4%
Pitt	125238	Urb-ed	**53.8%**	9.8%	1.5%
New Hanover	151073	Urb-rec	**53.0%**	15.2%	1.5%
Mecklenburg	645187	Urban	**52.3%**	19.6%	4.2%
Watauga	41021	Recr-ed	**51.8%**	13.4%	1.6%
Durham	207994	Urb-ed	**50.4%**	16.1%	5.3%
Cumberland	278459	Military	**49.8%**	23.0%	4.6%
Craven	84793	Rec-mil	**49.5%**	21.8%	2.0%
Dare	28425	Recr	**48.7%**	20.1%	1.5%
Onslow	137170	Military	**64.2%**	36.1%	3.3%

C. Households

The growth in the number of households between 1990 and 2000 generally mirrors but is slightly faster than population growth. The overall rate of household growth for NC as a whole was 24.4 percent, reflecting both population growth and slowly declining family size. North Carolina's household growth rate was considerably faster than the overall US household growth rate of 14.7 percent.

Figure II.2 shows the geographic pattern of household growth, and shows a similar pattern to Figure II.1. Hoke County, the site of Pinehurst, experienced the greatest household growth at 54.5 percent, followed by Brunswick County, near Wilmington, (51.5), Union (47.6), Johnston (47.8), Wake (46.0), Pender (44.7), New Hanover (42.1), and Mecklenburg (36.6). (See Table II.4). The coastal counties of Dare (+35.0) and Currituck (+37.0) also grew rapidly. On the other hand, the lowest rates of growth in the number of households were also in several northeastern counties back from the coast.

Counties in the Triangle area experienced moderate to strong growth (Table II.5). Growth in households was also strong in the Charlotte region with the exception of Gaston County. The entire southwestern portion of NC saw moderate to strong rates of growth in the number of households (especially Cherokee, Clay, Macon, Jackson, Henderson and Polk). Many of the counties in north central and northwestern NC (Surrey, Allegheny, Yadkin, Wilkes, Ashe, Forsythe, Caldwell) grew at below average rates, as did counties in the northeastern corner of the state. Only one county (Edgecombe) lost households during the 1990's.

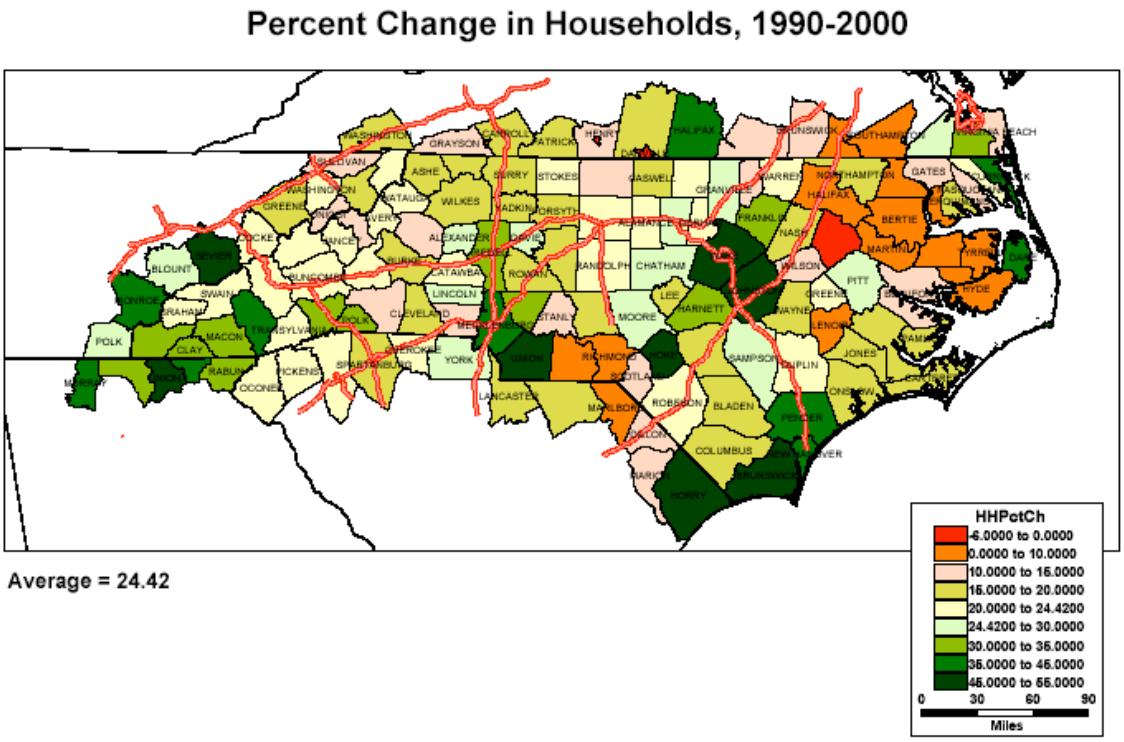
Table II.5: Growth in Housing Units and Households: 1990-2000

County	Housing Units			Households
	2000	1990	Percent	Percent

			Change	Change
Brunswick	51431	37114	38.6%	**51.5**
Union	45695	30760	48.6%	**47.6**
Wake	258953	177146	46.2%	**46.0**
Pender	20798	15437	34.7%	**44.7**
New Hanover	79616	57076	39.5%	**42.1**
Currituck	10687	7367	45.1%	**37.0**
Mecklenburg	292780	216416	35.3%	**36.6**
Jackson	19291	14052	37.3%	**35.2**
Harnett	38605	27896	38.4%	**34.2**
Franklin	20364	14957	36.2%	**33.0**
Pitt	58408	43070	35.6%	**29.9**

Percent changes in housing units correlates strongly with changes in households. Small-population counties like Hoke, Currituck, Jackson, Franklin, and Pender had impressive gains in the relative number of new housing units and households. In absolute terms, though, Wake and Mecklenburg were the most impacted in terms of household growth. Wake added 81,807 housing units and Mecklenburg added 76,364 housing units during the 1990's.

Figure II.2



D. Jobs

Since jobs support people, the overall change in employment (both full-time and part-time) is similar to the change in population. Overall, North Carolina's job growth during the 1990's was a strong 25.8 percent, considerably faster than the US average of 16.7 percent.

During the 1990's the strongest economic engines were Mecklenburg County (Charlotte) and Wake County (Raleigh) (Table II.6.) Combined, these two counties produced 341,986 new jobs, 27.2% of the state's job growth. The other major urban counties (Guilford, Durham, Cumberland, New Hanover, Forsyth and Buncombe) in total created more than 235,410 jobs during the decade. The ten leading counties in terms of job growth accounted for roughly 63 percent of all the new jobs created in NC during the 1990's.

Table II.6: Employment Changes: 1990-2000

County	Job Growth, Percent	Jobs Created	Pct of Jobs Created
Mecklenburg	40.6	**177,371**	14.1
Wake	51.9	**164,615**	13.1
Guilford	19.3	**54,149**	4.3
Durham	35.8	**52,554**	4.2
Cumberland	24.3	**35,590**	2.8
New Hanover	43.1	**33,145**	2.6
Forsyth	16.6	**31,828**	2.5
Buncombe	25.6	**28,144**	2.2
Cabarrus	48.3	**24,623**	2.0
Orange	38.9	**21,891**	1.7
Iredell	34.1	**18,100**	1.4
Top 10 Total	**34.4**	**642,010**	**63.2**
North Carolina	**25.8**	**1,015,697**	**100.0**

Table II.7 examines the shift in industry during the last decade by Metropolitan statistical Area (MSA). Throughout the state, job growth in each sector was moderate to strong, with the exception of manufacturing (-8.5% for NC). Growth in service sector jobs was particularly strong across the board, 60 percent.

However, growth varied considerably by region. Wilmington grew at the fastest rate (47%) with strong gains in the construction (77%) and finance-insurance-real-estate (FIRE) (83%) sectors. Raleigh in particular experienced high rates of growth in the service sector, but it also experienced robust gains in all sectors. It was the only MSA that experienced an increase in manufacturing employment (13%). Charlotte experienced rapid growth in services and Finance-Insurance-Real-Estate (65%), reflecting the impact of the finance and banking industry in the Charlotte MSA. Asheville showed a very large increase in the wholesale sector, albeit from a small base of jobs. Growth in jobs was generally slower in smaller communities like Hickory, Goldsboro and Rocky Mount. Average rates of growth occurred in Asheville, Fayetteville, Greensboro-Winston-Salem, and Jacksonville. However in each area individual sectors scored impressive gains.

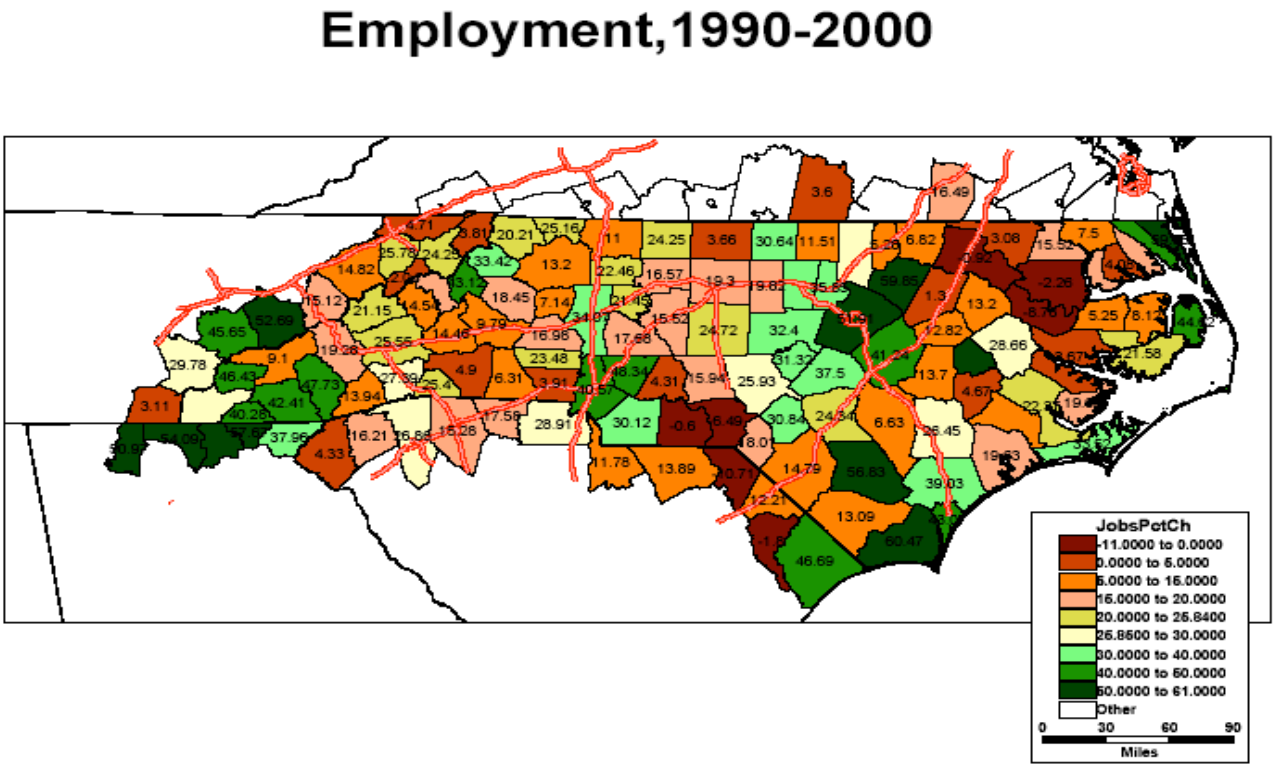
Table II.7: MSA Job Growth (Percent) by Sector: 1990-2000

MSA	Constr	MFG	Trans PU	Wholes	Retail	FIRE	Service	Govt	Total
Wilmington	**76.7**	-4.3	ND	7.5	46.1	**82.7**	ND	33.5	**47.0**
RalDurCH	**61.8**	**13.0**	45.0	39.5	44.5	27.5	**74.2**	26.4	**46.5**
Charlotte	44.6	-11.9	13.3	26.1	32.1	**65.5**	67.3	33.7	**33.3**
Greenville	34.3	0.5	55.3	6.8	21.8	14.5	**86.1**	18.4	**30.1**
Asheville	**61.2**	-15.0	13.7	**226.3**	25.5	38.8	54.9	13.9	**26.6**
Fayetteville	**51.1**	-7.4	**57.7**	19.4	26.4	28.6	58.8	14.4	**24.5**
Jacksonville	67.2	-15.4	26.5	30.9	28.9	27.7	57.9	9.3	**19.9**
GreensWS	18.3	-8.5	27.4	10.1	17.2	31.6	46.4	15.0	**18.8**
HickryMor	28.5	-2.2	28.9	24.3	20.5	7.9	50.8	21.6	**15.7**
Goldsboro	30.3	-18.1	ND	3.5	12.0	42.8	39.0	7.9	**13.9**
RkyMount	37.0	-22.9	ND	66.4	-4.9	-100.0	45.0	22.7	**6.4**
NC Tot	**41.4**	**-8.5**	**25.0**	**20.8**	**25.2**	**43.3**	**60.4**	**20.8**	**26.7**

Source: Bureau of Labor Statistics: REIS database

The variation in job growth is greater than that of population growth. Figure II.3 shows the geographic distribution of job growth in North Carolina's 100 counties during the 1990s.

Figure II.3



The greatest increases in terms of absolute number of jobs created occurred in the Charlotte region, the Raleigh-Durham region, and the Wilmington region. However, the leading counties in terms of percent change in employment between 1990 and 2000 were not leading population centers. Instead several quite rural counties (Brunswick, 60.5%; Franklin, 59.8%; Currituck, 59.5%; Bladen, 56.8%; and Greene, 52.5%) saw the greatest relative increases in employment. In each area these gains were fueled by large increases in one or more sectors. The 28,328 jobs created in these counties in absolute terms compose less than 1 percent of the number of jobs created in NC during the 1990's. Within and near the large metro regions, relative job growth is often greatest in the suburban counties.

E. Income

Given the economic growth of the 1990's, gains in per capita income (PCI) are expected. Overall, North Carolina's nominal per capita income increased 57.7 percent during the 1990's. Adjusted for inflation the change was 17.6 percent.

Table II.8 and Figure II.4 show the geographic pattern of per-capita income change. Perhaps surprisingly, the rates of growth in PCI were especially strong in small, rural counties. Clay, Northampton, Jones, Camden, Hertford, Warren, Allegheny, and Yancey counties, for example, all experienced real PCI growth exceeding 28 percent. As Table II.8 shows this is largely due to the initially low median PCIs of these counties in 1989. Chatham County's growth in PCI is attributable to the influx of higher income residents associated with the Research Triangle.

Table II.8: Leading Counties: Rate of Per Capita Income Increase, 1989-99

County	Per capita income in 1999	Per capita income in 1989	Inflated* per capita income in 1989	Percent Increase: 1989-99
Clay	18,221	9,456	12,671	**43.8**
Northampton	15,413	8,244	11,047	**39.5**
Jones	15,916	8,832	11,835	**34.5**
Camden	18,681	10,465	14,023	**33.2**
Madison	16,076	9,149	12,260	**31.1**
Chatham	23,355	13,321	17,850	**30.8**
Hertford	15,641	9,016	12,081	**29.5**
Warren	14,716	8,502	11,393	**29.2**
Alleghany	17,691	10,237	13,718	**29.0**
Yancey	16,335	9,462	12,679	**28.8**

*Inflated by 1.34 from 1989 to 1999.

PCI grew at a strong pace in southwest North Carolina and at moderate rates in more urbanized areas. Slower rates of growth are scattered throughout the state. Catawba, Polk, Rutherford, and Cleveland counties experienced minimal increases in PCI. Davidson, Forsyth, and Davie Counties also lagged, with PCI growing by 11 percent, 6 percent and 9 percent respectively. Onslow (3 percent), Wilson (10 percent), Hyde (4 percent), Gates (3 percent), Pasquotank (3 percent) and Chowan (5 percent) saw minimal increases in PCI, but no counties declined in real per-capita income.

Figure II.4

Percent Change in Real Per Capita Income, 1989-2000

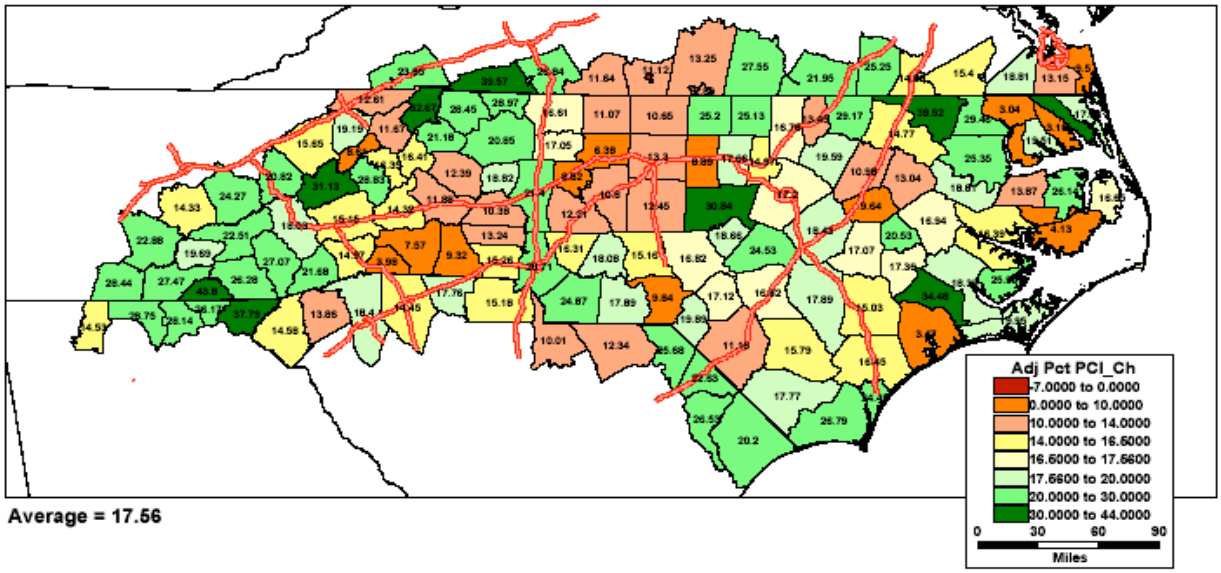


Table II.9: Highest Per Capita Income: 1999

County	Per capita income in 1999	Per capita income in 1989	Inflated* per capita income in 1989	Percent Increase: 1989-99
Mecklenburg	**27,352**	16,910	22,659	20.7
Wake	**27,004**	17,195	23,041	17.2
Orange	**24,873**	15,776	21,140	17.7
Dare	**23,614**	15,107	20,243	16.7
Moore	**23,377**	14,934	20,012	16.8
Chatham	**23,355**	13,321	17,850	30.8
Guilford	**23,340**	15,373	20,600	13.3
Durham	**23,156**	15,030	20,140	15.0
New Hanover	**23,123**	13,863	18,576	24.5
Forsyth	**23,023**	16,151	21,642	6.4

*An inflation rate of 1.34 was used to convert 1989 dollars to 1999 dollars

The highest levels of PCI are generally found in larger, urbanized counties. As Table II.9 shows, Mecklenburg, Wake, Orange, Chatham, Guilford, Durham, Forsyth and New Hanover have relatively high PCI's, even though their percent increase since 1989 was not as high. Most of these counties have larger economies with higher paying jobs than those found in the smaller counties. This factor is significant in inter-county commuting, discussed below.

F. Travel Time

The mean travel time to work in North Carolina in 2000 was 24.0 minutes, approximately the same for the US as a whole.

Figure II.5 shows the geographic distribution of mean travel times. Perhaps surprisingly, average travel time to work correlates most highly with the variable "worked outside county of residence." As such, relatively isolated rural counties typically have longer commutes. The leading counties in this category are shown below in Table II.10. Counties with longer commutes tend to be rural or ex-urban. The key factors influencing long commuting are relatively low local incomes, a not-too-distant urban center with higher average wages, and highway access.

Figure II.5

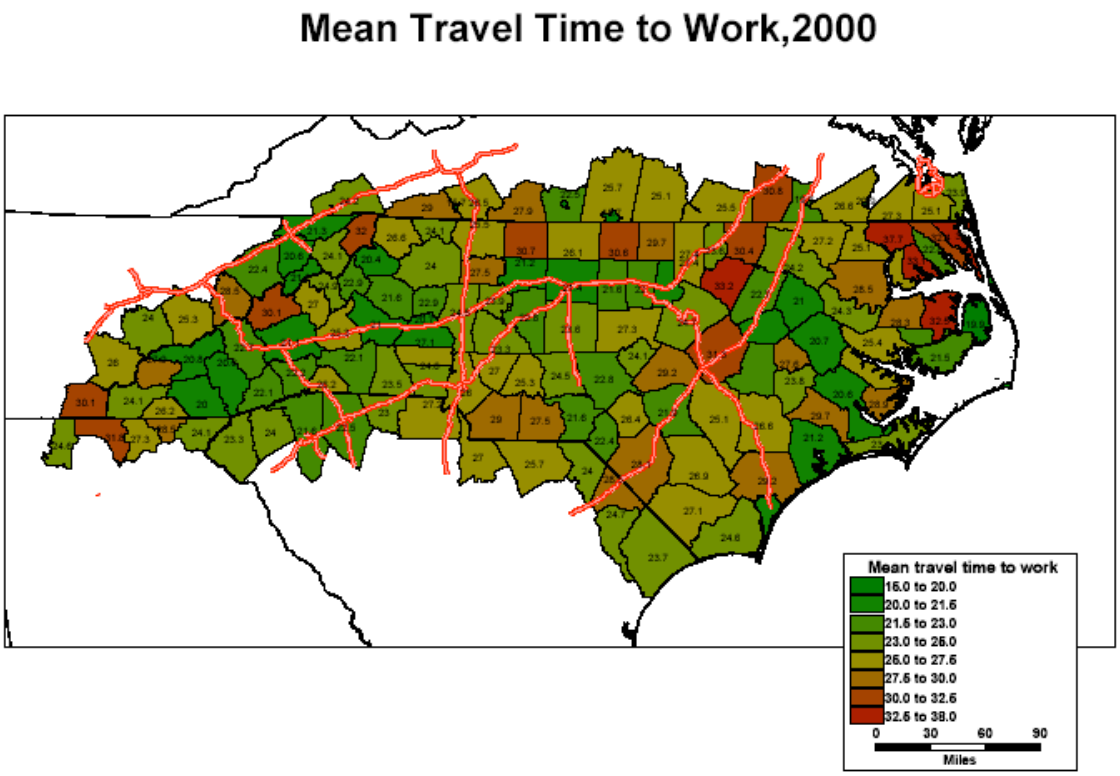


Table II.10: Counties with Highest Travel Time to Work

	Mean Travel Time to Work:	Percent Worked Outside County of Residence:	Percent Worked Outside County of Residence: 1990

		2000	
Gates	**37.7**	65.3	62.1
Currituck	**35.0**	66.5	61.0
Franklin	**33.2**	65.1	58.8
Perquimans	**33.1**	62.2	58.2
Tyrrell	**32.5**	39.8	46.3
Camden	**32.4**	76.3	82.0
Johnston	**31.3**	54.0	42.3
Stokes	**30.7**	70.8	70.2
Caswell	**30.6**	72.8	68.8
Warren	**30.4**	55.1	42.8

Many of the counties experiencing high average commute times are located near the Virginia border in northeast NC. Some of these workers commute north to the Norfolk-Newport News area. In contrast, almost all of the counties west of Interstate 77 (Madison and Monroe being the biggest exceptions) have average to below-average travel times to work. In the major urban areas, mean travel time to work rarely exceeds 30 minutes. However, mean travel times have been increasing over time.

G. Commuting

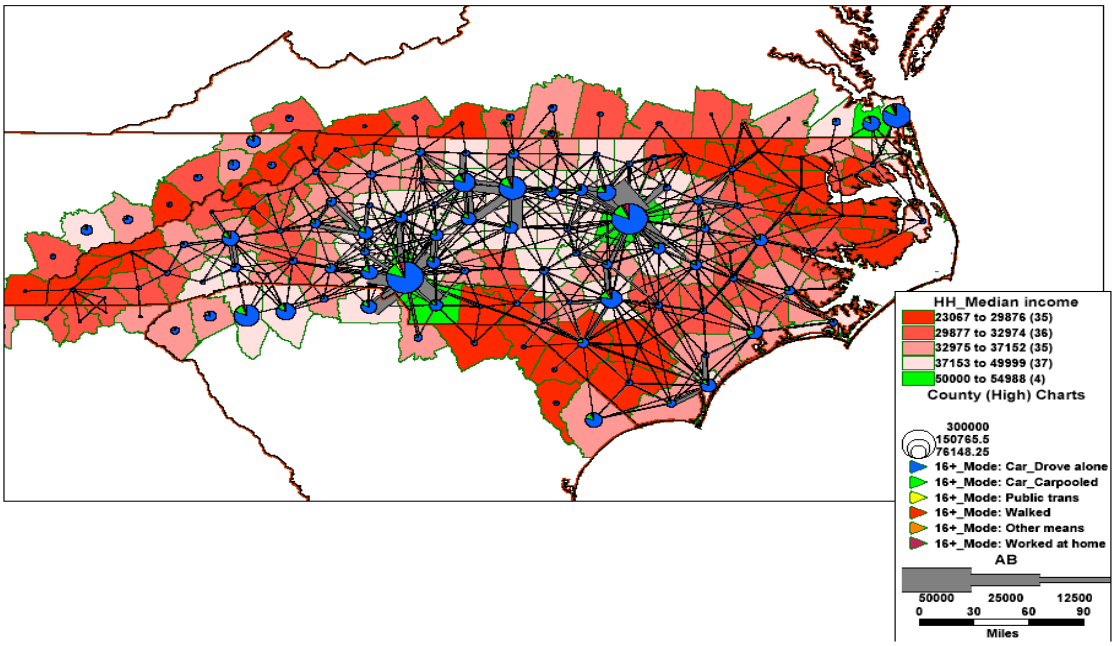
North Carolina workers do not work just locally, but often commute over long distances for higher-paying jobs in distant urban areas. Figure II.6 shows the extent of this "out-commuting", showing county-to-county commuting against mean household incomes. Inspection of the county-to-county commuting flows shows clearly that the key factor inducing inter-county commuting is the wage differential between counties. Suburban counties near larger metropolitan counties, and nearby urban counties, have relatively greater inter-county commuting. In North Carolina, the largest inter-county commuting is from Wake County to Durham County, about 48,000 daily commuters, followed by Cabarrus-Mecklenburg, Gaston-Mecklenburg, York (SC)-Mecklenburg, and Union-Mecklenburg, all about 22,000 commuters. Several county-to-county flows in the Triad area are also near or over 20,000 daily commuters. Inter-county commuting in North Carolina is a complex blend of travel time, distance, job availability, income differentials, and local economic health.

H. Recent Trends Since 2000

Like most other states, North Carolina has seen its economy struggle from 2000 to 2003. The burst of the 'dot-com' bubble, the softening of manufacturing and retail activity, and of course the events of September 11 have all taken their toll. North Carolina's unemployment rate reached 6.6 percent in June 2003, about 0.2 percent higher than the US average[69]. Although about 18,000 jobs have been created in North Carolina from July 2002 through July 2003 (Employment Security Commission), since 2000, North Carolina has lost over 50,000 jobs. (Recent announcements, such as Pillowtex closing, are not included)

Figure II.6

County to County Commuting Flows, Income and Mode Shares



The consequences of economic restructuring have hit North Carolina's rural counties the hardest. Thousands of jobs in textiles and furniture have been lost over the last two years. As Table II.11 shows, Burke, Gaston and Guilford have each lost more than 4,000 jobs since 2000. Wake County has lost 3,247 jobs, but this is a small fraction of its total job base. In the smaller counties, the job losses are particularly devastating. The loss of jobs translates into lost tax revenues in a climate of general revenue shortfalls.

Table II.11: Recent Trends in Employment

County	2001	2000	Lost Jobs	Percent Decrease
Burke	43815	48289	-4474	-9.3%
Robeson	48977	51977	-3000	-5.8%
Stanly	26598	28149	-1551	-5.5%
Rowan	55320	58157	-2837	-4.9%
Gaston	95658	100060	-4402	-4.4%
Johnston	49467	51720	-2253	-4.4%
Randolph	61831	64614	-2783	-4.3%
Lenoir	35385	36607	-1222	-3.3%
Catawba	111468	115058	-3590	-3.1%
Cleveland	45915	47262	-1347	-2.9%
Davidson	72763	74423	-1660	-2.2%
Iredell	69653	71072	-1419	-2.0%

Orange	74919	76303	-1384	-1.8%
Alamance	80967	82241	-1274	-1.5%
Cumberland	179530	181983	-2453	-1.3%
Guilford	330515	334671	-4156	-1.2%
Wake	472500	475747	-3247	-0.7%
NC	**4901707**	**4952549**	**-50842**	**-1.0%**

Not all counties are experiencing employment loss. In fact, some counties have managed to generate a substantial number of jobs since 2000. Mecklenburg leads all counties in the number of jobs created—almost 5000 during 2001. But some small rural counties like Watauga, Jackson and Franklin also showed robust percentage increases in the numbers of jobs created in 2001.

Table II.12: NC Counties with Recent Job Gains

	2001	2000	New Jobs	Percent Increase
Watauga	29913	28401	1512	**5.3%**
Jackson	19673	18709	964	**5.2%**
Brunswick	34434	33099	1335	**4.0%**
Franklin	18059	17455	604	**3.5%**
Dare	25331	24668	663	**2.7%**
Durham	204163	200353	3810	**1.9%**
Union	59906	58774	1132	**1.9%**
New Hanover	112039	110066	1973	**1.8%**
Henderson	45768	45136	632	**1.4%**
Mecklenburg	620420	615443	4977	**0.8%**
Onslow	89127	88391	736	**0.8%**

The continued demise of the textile and furniture industries is the major factor associated with North Carolina's economic decline. The recent closing of Pillowtex is the most recent example of the eroding textile industry, and the furniture industry is under increasing pressure from foreign competitors. Restructuring in the financial industry via mergers has also had an impact on service sector employment. However, the majority of the job losses in depository institutions took place in 2002, and the industry has stabilized in 2003.

In summary, while the 1990s showed impressive gains and the last three years some weakening, North Carolina's job losses have slowed, but not stalled, its overall economic growth.

III: Urbanized Area Trends

Urbanized areas are census geographies defined by urban character, density, and commuting, rather than jurisdictions boundaries such as counties or cities. On maps, they might be thought of as the "line around the subdivisions" at the outer edges of urban regions. Unlike counties, whose boundaries rarely change, or cities, whose boundaries change frequently as areas are annexed, urbanized area boundaries change infrequently. But over a decade, the geographies of most urbanized areas show considerable growth since they are not restricted to political actions. Typically, the data for urbanized areas show more rapid change than the data for cities or for counties, since they are growing both through "capture" of nearby development as well as internal growth and in-migration.

A. Population, Area and Density

Neo-traditional neighborhoods at the edges of regions are spreading out urban areas

The populations, geographic areas, and densities of North Carolina's urbanized areas have exhibited considerable change over the past decade. Generally, North Carolina's larger urbanized areas are growing in extent more rapidly than population, and hence their average densities are declining. However, the populations of the smaller urbanized areas are increasing faster than their geographies, and hence their densities are increasing.

Overall, the State's population growth was about 21.4 percent. However, Table III.1 indicates that the population of the 17 largest urbanized areas grew 50.7 percent over the 1990's, from 2.511 million to 3.785 million persons. The fastest population growth was in Hickory, at 168 percent, followed by Asheville at 100.6 percent. On the other hand, several areas (Jacksonville, Goldsboro) reported population declines. These are both military-based economies that have been affected by US military downsizing, but they also had their geographies redefined.

Overall, the state's 17 urbanized areas increased about 61.4 percent in area during the 1990's. The most rapidly spreading urbanized area was Hickory, increasing 210.9 percent in geographic area during the 1990s. Asheville's geographic area increased 118.5 percent, Winston-Salem 108.2 percent. On the other hand, two areas (Jacksonville and Goldsboro) both had their geographies redefined as smaller areas.

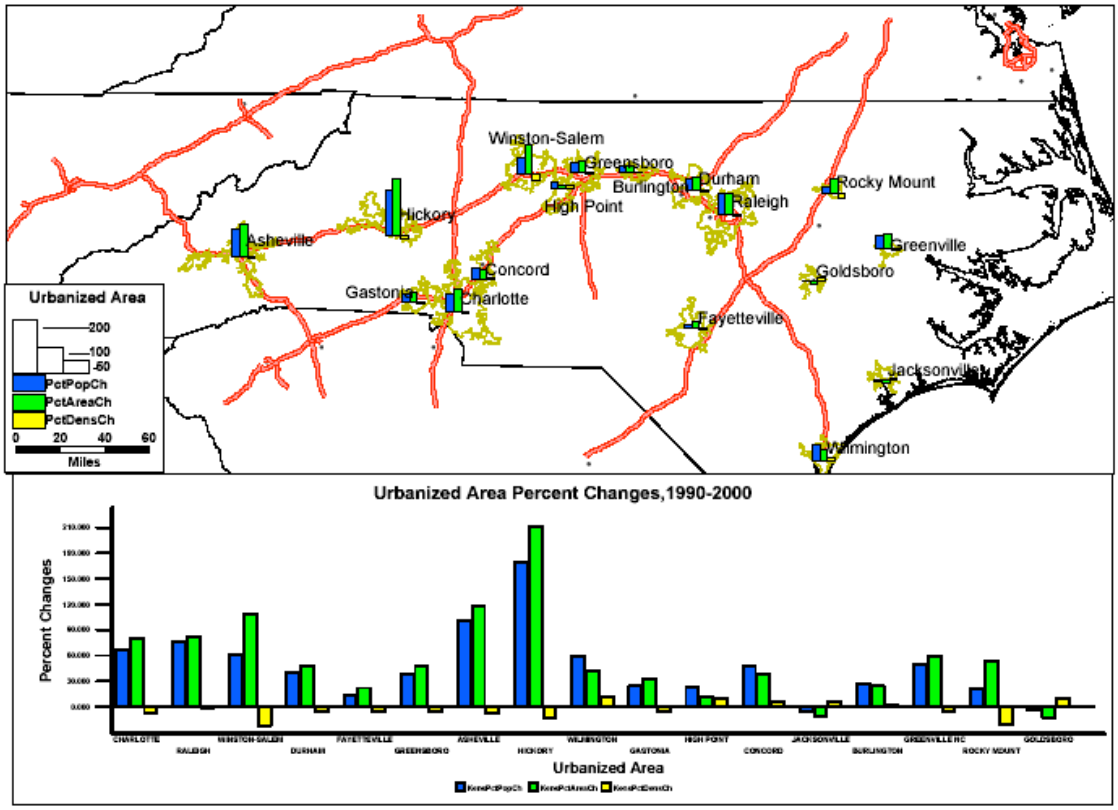
Figure III.1 shows, perhaps surprisingly, that the greatest relative increase in urbanized area population and size was several western and west-central urbanized areas (Asheville, Hickory and Winston Salem), while growth in the Piedmont was less in relative terms and growth in the Fayetteville-Jacksonville-Goldsboro areas east of I-95 was the slowest. This means that **the most rapidly sprawling urbanized areas of North Carolina are not the largest urbanized area in the Piedmont, but several smaller regions.**

Table III.1

	Characteristics of North Carolina Urbanized Areas, 1990-2000								
		Population			**Area**			**Pop Density**	
Urbanized Area	**1990**	**2000**	**Pct Chng**	**1990**	**2000**	**Pct Chng**	**1990**	**2000**	**Pct Chng**
Charlotte	453597	**758927**	67.30%	241.7	434.9	79.93%	1877	1745	-7.00%
Raleigh	305925	**541527**	77.00%	176	319.6	81.59%	1738	1694	-2.50%
Winston-Salem	185184	**299290**	61.60%	120.7	251.4	108.25%	1534	1191	-22.40%
Durham	205355	**287796**	40.10%	105.8	156.8	48.17%	1941	1836	-5.40%
Fayetteville	241763	**276368**	14.30%	137	167.1	21.98%	1765	1654	-6.30%
Greensboro	194508	**267884**	37.70%	92.2	135.5	46.92%	2110	1978	-6.30%
Asheville	110429	**221570**	100.60%	94.6	206.8	118.55%	1167	1072	-8.20%
Hickory	69914	**187808**	168.60%	67.8	210.8	210.89%	1031	891	-13.60%
Wilmington	101357	**161149**	59.00%	83.6	118.9	42.24%	1212	1355	11.80%
Gastonia	113637	**141407**	24.40%	89.5	118.8	32.77%	1270	1190	-6.30%
High Point	108686	**132844**	22.20%	84.4	94.1	11.43%	1288	1412	9.70%
Concord-Kannapolis	78177	**115057**	47.20%	66	91.2	38.17%	1185	1262	6.50%
Jacksonville	101297	**95514**	-5.70%	72.1	64.1	-11.10%	1405	1490	6.10%
Burlington	74053	**94248**	27.30%	51.9	64.8	24.76%	1427	1456	2.00%
Greenville	55884	**84059**	50.40%	28.3	44.9	58.73%	1975	1871	-5.20%
Rocky Mount	50870	**61657**	21.20%	26.6	40.8	53.34%	1912	1512	21.00%
Goldsboro	60230	**57915**	-3.80%	50	43.7	-12.52%	1205	1324	9.90%
Sum	**2510866**	**3787020**	**50.70%**	**1588.2**	**4564.06**	**61.44%**	**26041**	**26932**	**-4.30%**

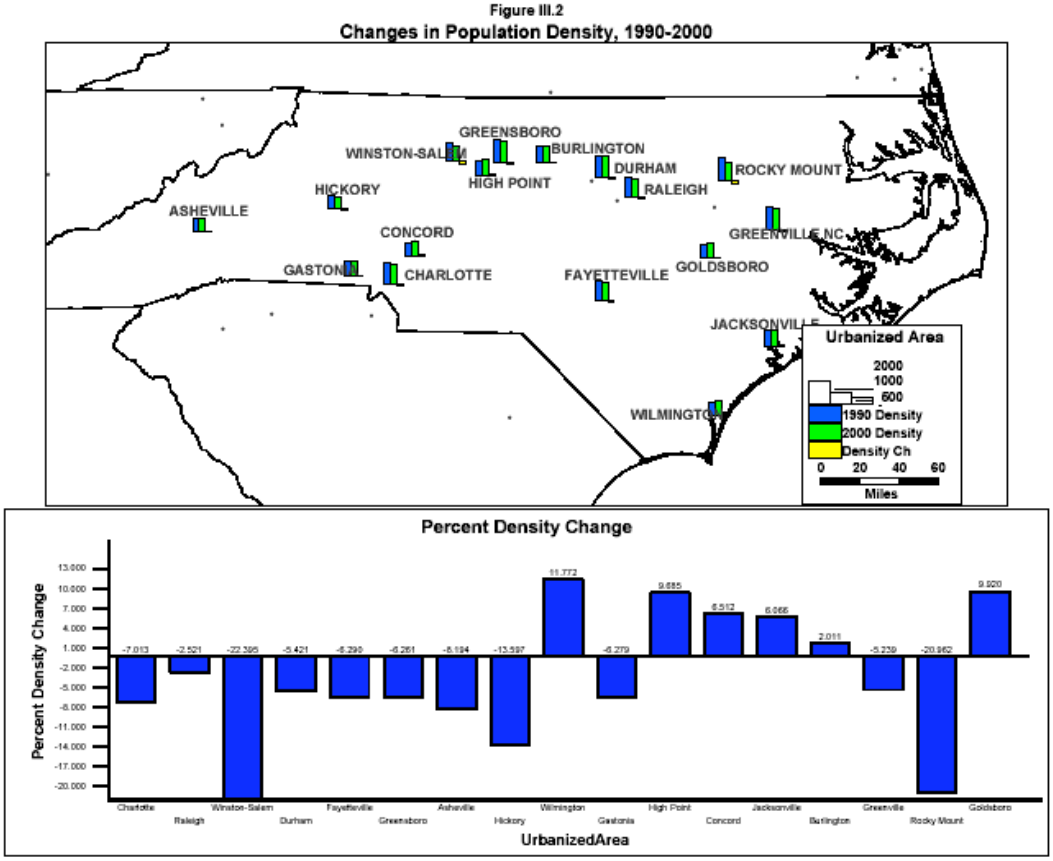
Figure III.1

Percent Population, Area, Density Change, 1990-2000



As a result of faster geographic expansion relative to population increases, the densities of the 8 largest urbanized areas fell during the 1990s. Figure III.2 indicates that Charlotte's density fell about 7.0 percent during the decade, Raleigh's fell 2.5 percent, and Hickory's fell 13.6 percent. However (with the exception of Gastonia and Rocky Mount) the densities of the smaller regions actually rose during the 1990's. Wilmington's density increased 11.8 percent, High Point's rose 9.7 percent, Concord's rose 6.5 percent, and Jacksonville's rose 6.1 percent. So, North Carolina's urbanized area growth patterns are quite different from conventional wisdom. The larger regions are growing slowly out and declining in density, while the smaller regions are growing rapidly and increasing in density.

Figure III.2
Changes in Population Density, 1990-2000



B. Traffic and Freeway Congestion

Transportation planners use "vehicle-miles of travel" (VMT) to describe the amount of traffic in regions. A vehicle-mile is defined as one vehicle traveling one mile, so the VMT of a region would be the total miles traveled by all vehicles on the region's streets. This measure is sensitive to the amount of traffic on each section of road (the so-called "average daily traffic") as well as the changing length and frequency of household trips and the changing amount of tourist and commercial traffic not reported in household travel surveys.

Overall, travel in North Carolina has risen substantially during the past decade. Table III.2 indicates that North Carolina's VMT (that is, all the miles traveled on all the

state's roads) increased 42.7 percent during the 1990's, 2.5 times faster than its population growth and considerably faster than US travel (28.1 percent). Urban interstate traffic grew most rapidly, 154 percent, but substantial gains were also made in rural arterial and urban local traffic. Many of the major traffic routes in the state – I 85, I 40, I 95 – saw traffic increases of 30-70 percent. The traffic growth was caused by several factors: increasing population, increasing auto use and increasing national connectivity and travel on the Interstate system by tourists and commercial vehicles.

It is commonly believed that urban travel has been increasing most rapidly, and on balance this data confirms that. However, rural travel has grown considerably more rapidly than rural population. Table III.2 shows that the population growth of North Carolina's 17 urbanized areas (50.7 percent) was roughly in line with the VMT growth (56.8 percent). However, the rural population grew just 3.5 percent, while the rural VMT grew 30.7 percent. In rural areas, travel is increasing not because of rural population growth but because of increasing national connectivity and wealth, reflected in increasing truck traffic, tourism, and long distance commuting. **So, relative to population growth, rural areas of North Carolina have experiences greater recent increases in traffic and congestion than urban areas.**

Within urbanized areas, some regions are showing more rapid growth of travel than others. Table III.4 shows that in the 17 largest urbanized areas daily VMT increased about 56.7 percent over the 11 years from 1990 to 2001. However, freeway travel increased considerably faster, 129.2 percent, more than doubling in an 11 year period. Generally, freeway VMT has increased about twice as fast as non-freeway VMT (Figure III.3.) One city – Concord – saw its freeway VMT increase 483 percent, and Burlington saw its freeway VMT increase 280 percent. Both are cases of greatly increased Interstate traffic through a relatively small region.

		Table III.2			
		North Carolina Travel s, 1990-2000			
		Annual Vehicle-Miles of Travel, Millions			
System	**Functional Class**	**1990**	**2000**		**Pct Change**
Rural	Interstate	6403	8230		28.5
	Other Principal Arterial	5751	9439		64.1
	Minor Arterial	3327	6875		106.6
	Major Collector	11166	10691		-4.3
	Minor Collector	3773	4108		8.9
	Local	3358	4797		42.9
	Total rural	**33778**	**44140**		**30.7**
Urban	Interstate	3708	9417		154.0
	Other Freeway Expy	2313	3582		54.9
	Other Principal Arterial	9036	9601		6.3
	Minor Arterial	5561	8026		44.3
	Collector	1194	2409		101.8
	Local	7117	12339		73.4
	Total urban	**28929**	**45364**		**56.8**
Total NC VMT		**62707**	**89504**		**42.7**
NC Pop		**6,620**	**8,040**		**21.4**

Table III.3: North Carolina Urbanized Area Population Growth

Statistic	1990 (% of NC)	2000 (% of NC)	Percent Change
Population in 17 largest urbanized areas	2.511 (37.9)	3.785 (47.0)	50.7
Population in Rest of the State	4.118 (62.1)	4.264 (53.0)	3.5
Total Population	**6.629 (100.0)**	**8.049 (100.0)**	**21.4**
Urban VMT	28929 (46.1)	45364 (50.6)	56.8
Rural VMT	33778 (53.9)	44140 (49.4)	30.7
Total VMT	**62707 (100.0)**	**89504 (100.0)**	**42.7**

Table III.4

Traffic Trends 1990-2001

an Area	DVMT 90	DVMT 01	Percent Change	Freeway VMT 90	Freeway VMT 01	Percent Change	Freeway Lane Mi 90	Freeway Lane Mi 01	Percent Change	Freeway ADT 01	Percent Change	ADT per Lane 90	ADT per Lane 01	Pct Chng
Charlotte	10146	19559	92.78	2508	7815	211.6	178	483	171.35	84671	21.54	14089	16166	14.74
Raleigh	8210	15815	92.63	2101	4925	134.4	185	362	95.68	79336	54.82	11956	13593	13.69
Winston-Salem	8072	7549	-6.48	1707	3101	81.7	156	264	69.23	53763	22.83	10942	11755	7.43
Durham	4814	8229	70.94	1363	2788	104.5	139	208	49.64	58057	44.82	9805	13419	36.86
Fayetteville	4134	6732	62.84	292	484	65.8	56	66	17.86	29918	43.44	5214	7323	40.45
Greensboro	5095	7687	50.87	1707	3206	87.8	144	259	79.86	58763	13.60	11854	12370	4.35
Asheville	3773	6033	59.90	1430	2577	80.2	184	224	21.74	46467	49.48	7771	11528	48.35
Hickory	3524	3867	9.73	628	1002	59.6	76	90	18.42	44786	35.50	8263	11196	35.50
Wilmington	2295	3501	52.55	0	265	100.0	12	28	133.33	38407	7.69	8916	9602	7.69
Gastonia	3077	4689	52.39	788	1536	94.9	62	103	66.13	81077	54.34	12709	14960	17.71
High Point	2960	4717	59.36	626	1212	93.6	128	181	41.41	33380	38.64	4890	6687	36.75
ord-Kannapolis	1770	3684	108.14	181	1056	483.4	28	57	103.57	74596	188.49	6464	18649	188.51
Jacksonville	1403	1546	10.19	0	0	0.0	0	0	0.00	0	0.00	0	0	0.00
Burlington	1959	3533	80.35	380	1444	280.0	32	129	303.13	89554	88.53	11875	11194	-5.73
Greenville	1200	1479	23.25	0	0	0.0	0	0	0.00	0	0.00	0	0	0.00
Rocky Mount	1150	1311	14.00	0	232	100.0	0	37	0.00	29113	0.00	0	6329	0.00
Goldsboro	1320	1765	33.71	195	226	15.9	24	24	0.00	38765	39.16	6964	9691	39.16
Sum	64902	101696	**56.69**	13906	31869	**129.2**	1404	2515	**79.13**			9905	12672	**27.94**
Average	3818	5982	56.69	818	1875	129.2	83	148	79.13			7748	10262	32.46
US Averages		**10842**			**3794**			**262**					**14478**	

However, the 17 urbanized areas also increased the *capacity* of their freeways to carry traffic. Over the 11 years from 1990 to 2001, freeway lane-miles (that is, the total mileage of freeways times their number of through lanes) increased about 79.1 percent, from 1404 lane-miles to 2516 lane miles. This increase in capacity was primarily responsible for only modest growth in congestion. During the same period, the average

freeway traffic *per lane* increased about 27.9 percent, considerably slower than the growth in freeway VMT (129.2 percent). Indeed, one urbanized area (Burlington) actually saw its traffic per lane decline by 5.7 percent as I-85 was widened. Freeway congestion (traffic per lane) was generally lower in the smaller urbanized areas.

Figure III.4 indicates that growth of freeway traffic per lane was actually quite modest during the 1990's. The growth rates of traffic per lane in the largest areas (Charlotte, Raleigh and Winston-Salem) was about 1 percent per year while the growth in traffic per lane was considerably higher in the smaller urbanized areas. Durham, Fayetteville, Asheville, Hickory, and High Point all saw increases of over 30 percent, or about 3 percent per year. However these regions has only modest freeway expansion programs with little or no freeway widening. The Concord area is the extreme case. Concord has only one freeway, I-85 on the northeast suburban edge of the Charlotte region. I-85 through Cabarrus County is one of the few remaining 4-lane sections, and this section of I-85 saw its average daily freeway traffic per lane increase from 6946 to 18649, the highest in the state. Only a few large cities nationwide have average traffic per lane greater than 18000, putting Concord in dubious company. **As of 2001, only three urbanized areas in North Carolina (Concord, 18649; Charlotte, 16166; Gastonia, 14960) had freeway traffic per lane greater than the national average (14479[70]).** So, while the growth of freeway traffic congestion has certainly been significant over the recent past, North Carolina still has relatively less freeway traffic congestion that the US generally.

Residential development near Concord Mills has contributed to traffic growth on I-85

Figure III.3
Changes in Freeway and Non Freeway VMT in Urbanized Areas,1990-2001

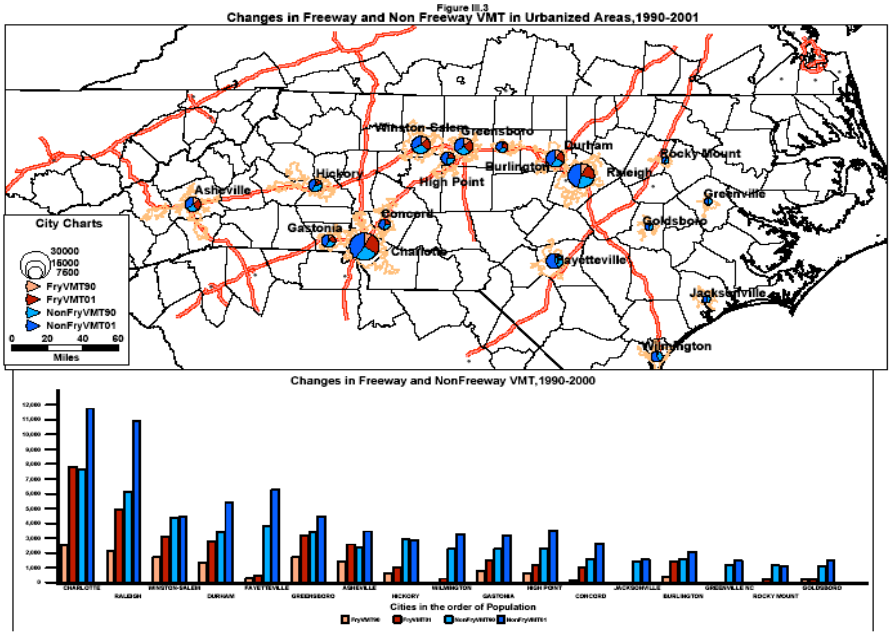
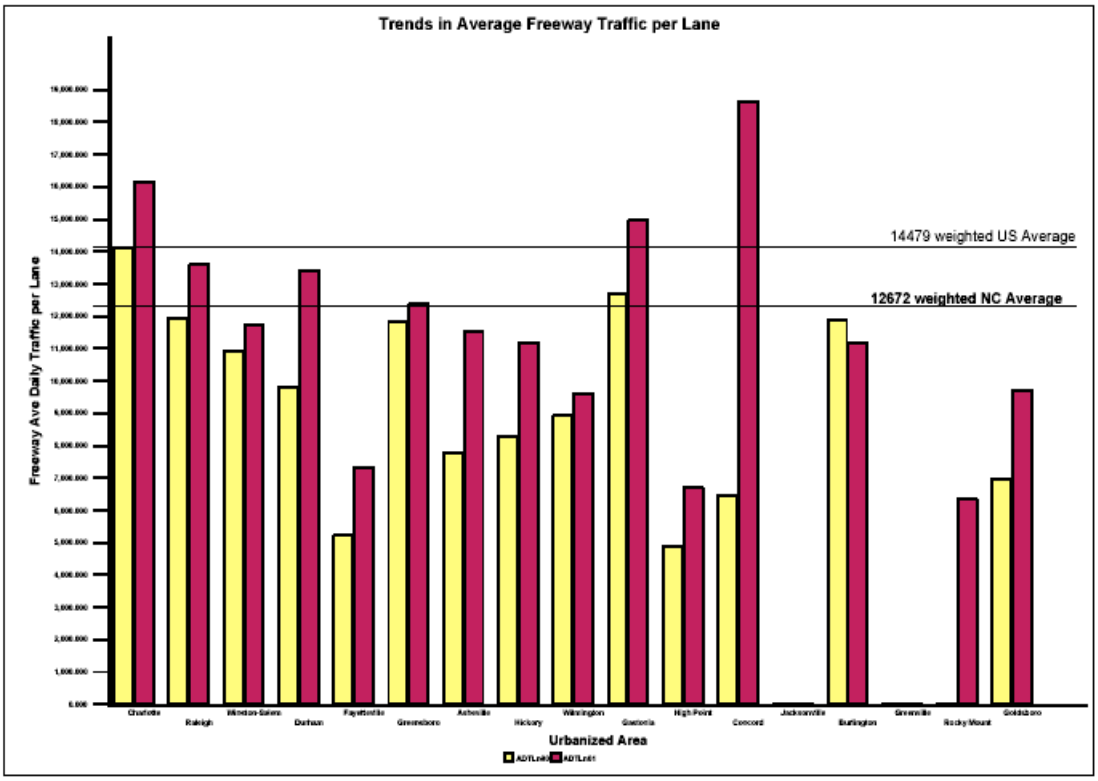


Figure III.4


Trends in Average Freeway Traffic per Lane
Freeway Ave Daily Traffic per Lane
14479 weighted US Average
12672 weighted NC Average
Urbanized Area

IV: Population Growth in Regions

A. Overview

In this section we analyze the population growth within each region of the State and relate it to prior and concurrent investment in major road system improvements and other factors. The **goal** of the analysis is to **determine, for each region, the extent to which major road investments influence the location and magnitude of population growth**, versus other factors that might cause growth.

The procedure used in this analysis is straightforward. First, all major road projects completed during the 1990s are identified and located exactly, along with detailed information on the type of improvement, length and number of lanes added, when the work was done, traffic before and after the work, cost of construction, and other items. These road improvements, along with data on the pre-existing road system, are then consolidated into tract data, so that the amount of road improvement in each tract can be determined. Next, the State is divided into 12 groups of counties that form "commuting regions", based on a careful assessment of the county-to-county commuting patterns from the 2000 Census. Finally, for each commuting region, the road improvements and prior road investments are related to the population growth and other location and demographic factors using correlation and other statistical methods.

B. Major Road Improvements

To link growth with major road improvements, it is necessary to identify the exact location and characteristics of these roads. Numerous road improvements are undertaken annually in North Carolina by a variety of governments and others, but most of these are minor actions that would not likely affect growth patterns. The primary organizations that make these improvements[71] are:

- The **North Carolina Department of Transportation (NCDOT)**, which is responsible for most highways outside of municipalities and many major roads within municipalities. These include the Interstate system, US numbered highways and state-numbered highways. Unlike most states, North Carolina does not have a county-owned road system. With few exceptions, most roads outside of municipalities are state-owned. At 78,000 miles, the NC road system is the largest state-owned system in the nation[72].
- **Municipalities**, which own city and town streets including some major thoroughfares.
- **Private developers,** which often build subdivision roads and sometimes fund the construction of major state-owned or municipal roads. These roads are typically transferred to the State or to municipalities upon completion.
- **Other governments.** Universities, park agencies, other local and state agencies and the federal government sometimes manage relatively small road systems. However, an example deserving special mention is the Blue Ridge Parkway.

The NCDOT and municipalities are responsible for most major road improvements with few exceptions. A key source of information for these improvements is the biennial

Transportation Improvement Program (TIP)[73] prepared by the NCDOT which lists all road projects for which federal funds are expended and many other projects as well. However, the TIP does not contain some major roads built entirely by local governments. For those, direct contact with major municipalities is required.

Not all road improvements are "major", that is, large enough to likely affect development patterns. For purposes of this study, "major road improvements" are the following:

1. **New 4+ lane freeways;**
2. **New exits** on existing freeways;
3. **New 4+ lane arterials**, in urban or rural areas;
4. **New major 2-lane roads** that open up major areas or provide connectivity for later expansion to 4 lanes;
5. **New major bridges**.

A portion of I-485, a new 6-lane freeway in the Charlotte area (Project R-211)

Major new roads typically have the effect of opening up new areas for growth by significantly reducing travel times, thus bringing residences significantly closer in time to work and shopping. As such they can influence both commercial and residential growth.

In addition, some widening projects may also be extensive enough to impact growth in certain circumstances. They include:

6. **Widening of 2-lane rural arterials** to 4+ lanes;
7. **Widening of 2-lane urban arterials** to 4+ lanes;
8. **Widening of 4-lane freeways or arterials to 6 lanes;**
9. **Widening of 4/6 lane freeways to 8+ lan**es;
10. **One-way pairs**, generally in urban city centers;
11. **Climbing lanes** in mountainous areas, for example 2-to-3 lanes, with the extra lane in one direction only.

A 6-lane widened urban arterial serves commercial development (Wilmington)

Widening projects typically increase capacity by adding lanes. These projects are typically undertaken to relieve congestion in urban areas, or to improve safety and connectivity in rural areas. These projects are undertaken within the context of an existing network that already provides access.

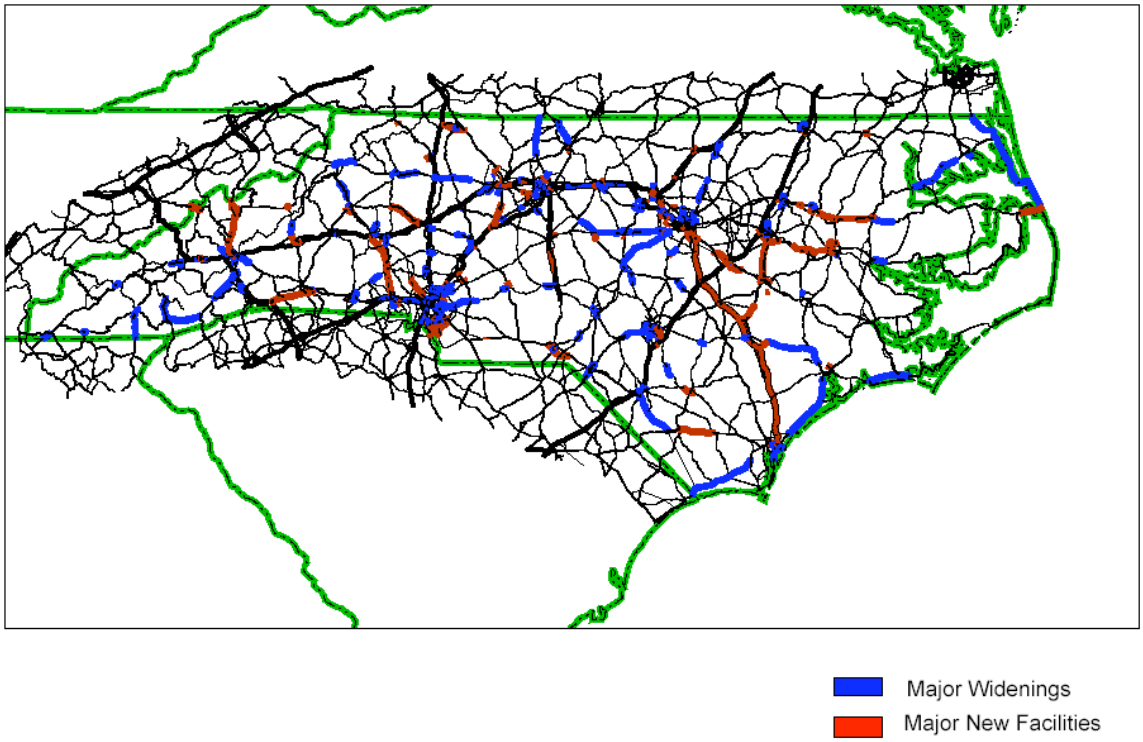
In addition to these major road improvements, other improvements also include many projects that generally do not influence growth. These include increased lane widths, intersection treatments, pavement and bridge repairs, signing and signals, and subdivision streets. These projects are generally less costly than major widenings or major new roads, and they actually make up the majority of projects in most urban areas and smaller communities.[74] While such projects are important locally for traffic flow, safety and congestion, these projects were not included in our assessment.

To compile a complete list of major projects, we worked carefully through the 1990-1997 and 1996-2003 Transportation Improvement Programs for North Carolina, identifying all major projects completed during the 1990s, including a few completed since 2000 that had a major local effect. This list, about 290 projects, was then supplemented in the major urban areas by additional local projects undertaken by

municipalities. MPO staff and city officials were contacted to obtain this information. Once identified, these projects were then located exactly in the computerized mapping system (GIS) TransCAD, so that further analysis can be conducted. Figure IV.1 shows the locations of the major projects.

Figure IV.1

Major Road Improvements, 1990-2000



The final list contains 312 major projects; see the Appendix for a complete list. Table IV.1 summarizes the projects by type. The majority of the projects, by count and mileage, were widenings.

Table IV.1: Summary of Major Road Improvements, 1990-2000

Improvement Type	Number of Projects	Miles	Added Lane-Miles	Total Cost, $M	Cost per Added Lane-Mile $M
1.New 4+lane Freeways	34	405.31	1577.29	2283.36	1.45
2.New Freeway Exits	16	17.84[c]	21.49	99.87	6.24[b]
3.New 4/5-lane Arterials	38	133.72	487.58	563.67	1.16
4.New Major 2-lane Roads	23	58.87	119.09	136.01	1.14
5.New Major Bridges	-	-	-	-	-
6.Widen Urban Arterial, 2- to 4+lane	138	387.83	863.97	1031.96	1.19
7.Widen Rural Arterial, 2-	45	395.77	804.85	1209.18	1.50

to 4+lane					
8.Widen Freeway or Arterial from 4 to 6 lanes	9	57.47	114.94	340.02	2.96
9.Widen Freeway, from 4/6 to 8 lanes	5	61.57	246.30	533.42	2.17
10.Widen urban streets, 1-way pair	1	2.39	4.77	4.20	0.88
11.Widen rural arterial, Climbing lanes	3	37.01[a]	37.01	9.9	0.26[a]
Total	**312**	**1557.78**	**4277.29**	**$6211.59**	**1.45**

[a] Only portions of these sections were widened. [b] Average cost per exit. [c] Assumes 1 mile of roadwork per exit.

All total, these **312 projects** represent work completed on **1558 miles** of road, adding **4277 lane-miles of capacity** at a cost of $**6.21 B**. A complete list of projects is in the Appendix to this report. While this list may not be absolutely complete, we believe that it contains the vast majority of major projects and is an accurate representation of all projects in the State that would have been large enough to impact growth.

On average, North Carolina's program for major improvements has cost about $1.45 million per lane mile of added capacity. New exits average about $6.24 M. Freeway widenings average about $2-3 M per lane-mile, since they require significant traffic control and some reconstruction activities. Widenings of rural and urban arterials, new arterials and freeways cost $1.2-1.5 million per added lane-mile of capacity. Widening projects constitute about 64 percent of the projects but about 50 percent of the expenditures. The majority of widening projects were from 2 to 4+ lanes.

Projects were completed quite uniformly throughout the 1990s. Table 4.2 summarizes the data by year of completion. Included in the table are a few projects completed after 2000. As noted, these were included in the listing because of their major local significance.

Table IV.2: Major Projects by Year of Completion

Year Completed	Number of Projects	Total Miles	Total Cost $M
1990	3	119.4	298.86
1991	21	90.43	147.77
1992	23	68.61	181.79
1993	24	108.89	508.04
1994	29	114.43	499.32
1995	25	110.49	438.12
1996	16	80.79	380.25
1997	28	152.27	831.90
1998	38	113.97	669.20
1999	42	195.32	800.48
2000	37	220.06	645.94
2001	21	129.32	760.30
2002	3	23.98	92.3
2003	2	12.77	132.72

Total	**312**	**1541.73[a]**	**$6186.99[a]**

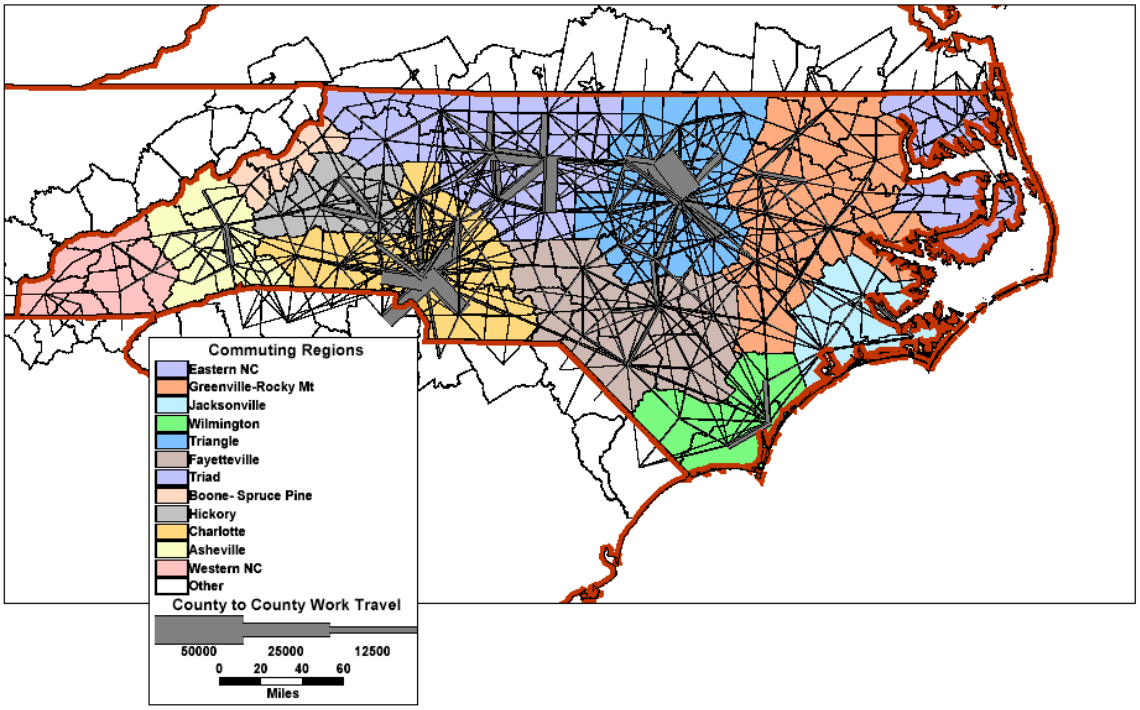
[a] Summaries from the GIS differ slightly from project listings in the TIP, due to slight length and cost differences.

C. Commuting Regions

North Carolinians do not just work locally within their resident counties. According to the 2000 Census, about 25 percent commute across county lines, accounting for almost 2/3 of work VMT[75]. These workers use the major road system to commute to jobs in the central county from residences in adjacent (first-tier) and more distant (2nd tier) counties. The key factors influencing cross-county commuting are wage differences between counties, distances between counties, and the availability of jobs. Inter-county commuting is greatest from suburban and rural counties adjacent to larger metropolitan regions, within about 30-40 miles of the metro county, and when differences in average household incomes are greater than about $10,000[76]. These factors lead to interlocking economic interdependence between groups of counties that form "**commuting regions**", and greater likelihood of population growth along the commuting corridors connecting these counties. The nature of the mutual interdependence is that the central county depends on the surrounding counties for workers, and the surrounding counties depend on the central county for jobs.

Careful inspection of the State's county-to-county commuting patterns reveals that North Carolina can be described by 12 "commuting regions", as indicated in Figure IV.2.

Figure IV.2
North Carolina Commuting Regions, 2000



These regions are groups of counties that have different economic bases but form cohesive economic units. These commuting regions are defined along economic and geographic lines. A brief description of these regions, from most urban to rural, is:

Large Urban Center:

1. **Charlotte**: 11 counties focused on Mecklenburg County, including Anson on the east, Iredell on the north and Rutherford on the west.
2. **Triangle:** 12 counties in and near the Raleigh-Durham-Chapel Hill area; One county, Harnett, also sends many workers south to Fayetteville but is increasingly in the Triangle economic orbit.
3. **Triad:** 14 counties focusing on the Greensboro-Winston-Salem-High Point region, including several mountain counties. The border between the Triad commuting region and the Charlotte commuting region is generally the Pee Dee River.

Medium-Sized Urban Center:

4. **Asheville**: 6 counties focused on the Asheville region, including Henderson and Transylvania Counties.
5. **Wilmington:** 4 counties on and near the southeast NC coast centered on Wilmington.
6. **Fayetteville:** 9 counties focusing on Fayetteville in Cumberland County, but including several on the eastern edge of the Charlotte region.

Smaller Urban Center:

7. **Jacksonville:** 5 counties focused on Jacksonville and New Bern.
8. **Hickory-Morganton**: 5 counties in the western Piedmont, generally along I-40.
9. **Greenville-Rocky Mount:** 14 counties covering a wide area between the eastern shore and the Raleigh area, with several mid-sized cities serving as regional trace and employment centers.

Rural:

10. **Boone-Spruce Pine**: 4 mountain counties west of the eastern continental divide.
11. **Western NC**: 6 counties in far western North Carolina.
12. **Eastern NC**: 10 counties in NC's northeastern corner, bordering on Albemarle and Pamlico Sounds, characterized by relatively long travel times, relatively low household incomes and high percent carpooling.

These regions differ substantially in demographic characteristics, income, area and density. Table IV.3 summarizes some of the key regional differences.

Table IV.3: Key Statistics: North Carolina Commuting Regions (Regions in Order: Urban to Rural)

Variable	Char-Meck	Ral-Dur-CH	Triad (WS-Gr-HP)	Ashe-ville	Wilm-ingtn	Fayette-ville	Jack-son-ville	Green-Ville-Rocky Mount	Hickory Morgan-ton	Boone-Spruce Pine	Eastn NC
Area	5318	6069	6892	2660	2897	5844	2827	7764	2112	1095	3295
Pop 2000	1699	1475	1538	416	329	736	324	784	384	93	131
Pop 1990	1340	1083	1310	347	237	639	261	706	328	81	90

Pop Change	359	391	228	69	92	97	63	78	56	12	41
% Pop Ch	26.8	36.1	17.4	19.8	38.8	15.3	23.8	11.0	17.0	14.8	45.6
Density 2000	320	243	222	156	114	126	115	101	182	85	40
Density 1990	252	178	190	136	82	109	92	91	155	74	27
Pct Non-White	25.4	31.9	23.5	8.2	23.1	45.1	25.3	44.3	12.2	3.2	32.5
HH 2000	655	568	614	175	137	269	117	302	151	37	51
Ave HH size	2.67	2.59	2.50	2.38	2.40	2.73	2.76	2.60	2.54	2.51	2.57
Fam PCI 2000	22188	22749	20424	20100	20118	16556	17272	15944	18623	17147	18292
Fam PCI 1990	14008	14465	13798	12936	11709	10626	11378	10273	12233	10476	11409
%Ch PCI	57.9	57.1	48.0	55.4	71.8	55.8	51.8	55.2	62.9	63.6	59.6
Workers 16+	841	743	751	190	150	320	158	335	192	43	56
Drive Alone %	80.9	91.9	79.6	91.9	81.3	77.5	71.9	78.8	81.2	72.5	75.3
Carpool %	12.9	13.4	13.5	12.6	12.2	15.6	16.4	15.2	14.9	17.1	16.5
Mean Travel time	25.0	24.5	22.5	21.9	23.3	23.7	22.2	23.1	21.2	23.4	28.8
# Tracts	**327**	**259**	**323**	**87**	**61**	**126**	**55**	**157**	**77**	**22**	**27**

Economic growth within each commuting region is dependent on good road access. Since the major highway systems within these regions form the backbone of the commuting flows between counties, improvements to these major highways are a key factor in allowing each region's population to commute across county lines. This grouping of counties is a more convenient way of assessing the link between population growth and road investment than other, perhaps more common groupings.

Cross-county commuting has increased in recent years in North Carolina. According to the 1990 and 2000 Censuses, the percentage of workers commuting across county lines has increased substantially, from 20.3 to 24.9 percent in the last decade (Table IV.4). The share of inter-county workers' travel (vehicle-miles) has increased from 57.0 percent to 62.1 percent in just one decade. Thus, almost 2/3 of North Carolina workers' vehicle-miles of travel is across county lines.

Table IV.4: Commuting in North Carolina, 1990-2000

Statistic	**1990**	**2000**	**Percent Change**
NC Population	6.628 m	8.049 m	21.3
Resident Workers	3.240 m	3.762 m	16.4
Pct intra-county	79.7	75.1	-5.8
Pct inter-county	**20.3**	**24.9**	**22.6**
Worker VMT	18.3 b	23.7 b	29.3
Pct intra-county	43.0	37.9	-11.9
Pct inter-county	**57.0**	**62.1**	**8.9**
Average Trip Dist	11.32	12.60	11.4
Intra-co. ave dist	6.10	6.36	4.2
Inter-co. ave dist	31.79	31.47	-1.0

Source: Cervera and Hartgen, Op.Cit.

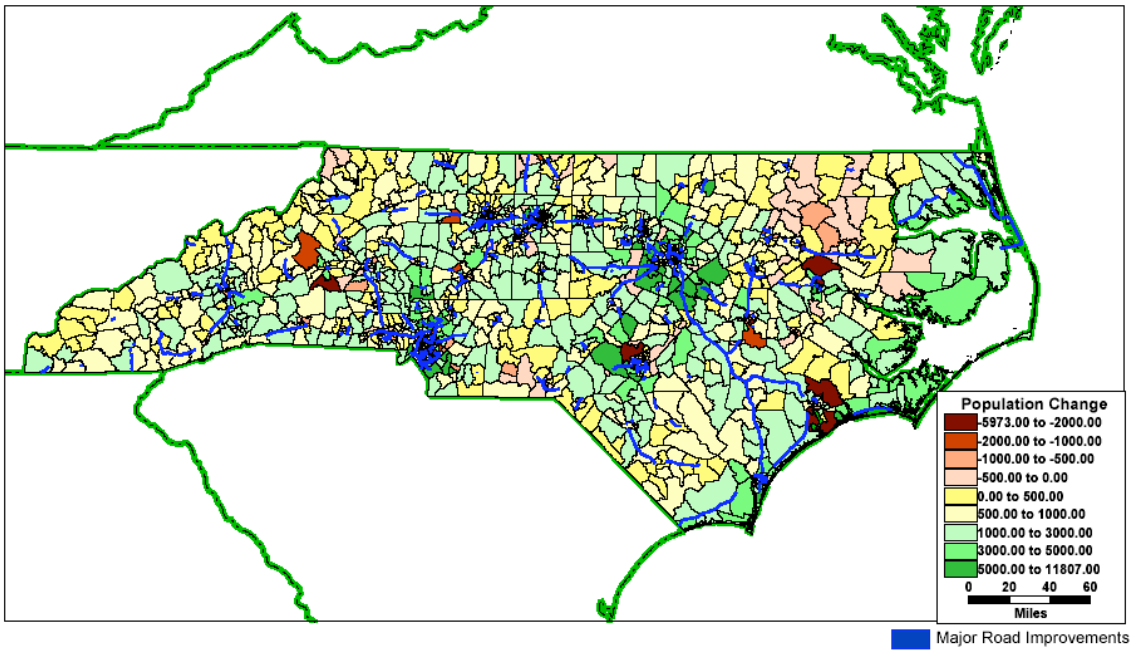
However, while overall trip lengths for NC commuting have increased, most of the change has been in intra-county travel, not in inter-county travel. Trip lengths for intra-county workers have increased slightly, but inter-county trip lengths, while longer, have actually declined slightly. Thus, while a higher share of NC workers are traveling inter-county, they are not traveling longer distances while doing so.

D. Overall Growth Trends by Tract

As noted in Section II.2, North Carolina's population has increased substantially during the past decade, rising about 21 percent. Figure IV.3 shows the growth of the State's 1551 census tracts, along with major road projects. **Most of the tracts in North Carolina grew in population during the 1990s**. Statewide, the overall average tract growth was 971.8 persons per decade.

Figure IV.3

Population Change and Major Road Projects,1990-2000



The greatest growth (increases of 5000+ persons) was typically in tracts surrounding the major metropolitan areas (in particular, the rings of tracts surrounding Charlotte, Raleigh and Wilmington), in some tracts along the coast, and in other tracts quite distant from metropolitan regions. More modest, but still quite rapid growth (1000-5000 person increases) was spread

Dense in-fill in urban cores has increased in-city population and density.

throughout the state, and less modest growth (0-1000 person increases) also occurred throughout the state. Even within metropolitan areas, most tracts grew in population.

Conversion of residential property to office and commercial reflects increasing land values and more jobs.

Slow tract growth, or modest decline in population, is not necessarily a bad thing. Tract growth can slow for many reasons. In most urban cores, tracts are filled up and more population growth is difficult without changes in housing types. In some tracts, land values have increased making land more appropriate for non-residential uses. In others, average household sizes are declining so that tract population is declining even as housing units are increasing. As cities evolve and change, these changes are part of the process of redefinition of land uses that goes on steadily.

The only large area of the state to loose tract population was on the northeast coastal plain. Only three of the State's 100 counties (Edgecombe, Bertie and Washington) lost population during the 1990s. This is associated with slowdowns in tobacco farming and lower per-capita incomes in those counties. Only a few other tracts (those marked in shades of red) showed declines in population. The largest losses are associated with major changes in military forces (Fort Bragg, Camp Lejeune, Cherry Point, Pope AFB, and Seymour Johnson AFB), and a few by tract splitting. So, it is simply not true that North Carolina's growth in the 1990's occurred only in and around metropolitan areas. Growth occurred throughout the State.

E. Factors Affecting Tract Growth: State as a Whole

To understand the relative importance of various factors affecting tract growth, we used two statistical techniques. The first of these is linear regression. This method, well known in the statistical sciences, relates a dependent variable, in this case the change in tract population between 1990 and 2000, to other variables describing the tract. The model takes the form of a linear equation[77]:

$$Y = a + b_1X_1 + b_2X_2 + \ldots + e$$

Where: Y = dependent variable
X_1, X_2 = independent variables
a =constant term
b_1, b_2 = coefficients
e = unexplained variation in Y

In the case here, the 'dependent variable' is population change, 1990-2000, in each of the State's 1551 census tracts. The 'independent' variables include:

- **Demographic data** such as the tract's prior density, 1990 and 2000 per-capita income and racial statistics;
- **Location data** such as the tract's distance to city center, distance to Interstates, and distance to the coast and Blue Ridge Parkway (measures of nearness to recreation);

- **Road investment data** such as the mileage of widened roads, new freeways, and new exits; and speculative and spurring effects (measures of whether the timing of the investment pulled or pushed growth during the decade)[78].

The strength of the regression equation, known as the coefficient of variation (R-square, RSQ) varies between 0 (no correlation) and 1.0 (perfect correlation). Low values of RSQ indicate a weak correlation between the dependent and independent variables. The strength of each individual variable in the equation is measured by its 't-statistic', with a t-value of 2.0 or greater generally being considered significant. The GIS tool TransCAD contains the necessary statistical routines[79].

Table IV.5 shows the resulting best linear regression model for the State as a whole and for each region. For the State as a whole, the linear model is:

Population Change = 891.9
- 0.38 $_{t = -11.3}$ (1990 Density)
+ 0.03 $_{t = 6.7}$ (Per Capita Income)
- 14.0 $_{t= -4.3}$ (Distance to City Center)
+ 123.1 $_{t=1.9}$ (New 4-lane Arterial Miles)
+ 148.9 $_{t=4.1}$ (Widened Urban Arterial Miles)
+ 123.2 $_{t=4.6}$ (Widened Rural Arterial Miles)

RSQ = 0.141 F = 43.53 N = 1551

This model indicates that only a few of the variables tested are correlated with population growth. Overall, the model is quite weak, explaining only about 14 percent of the variation in tract growth. Demographics play a major role in tract growth rates. **The key factor is prior density**: that is, tracts that were more densely developed in 1990 did not experience much growth in the next decade. The effect is substantial. Average growth per tract falls from 972 per decade to just 131 per decade if the prior density was 2000 persons per square mile (a little over 1 house per acre). However, growth increases for higher income tracts (about 300 additional persons per decade, per additional $10,000 per-capita income). In addition, the tract's location in the urban geography plays a role, with tract growth falling by 14 persons per decade for every mile out from the city center. Location is important in growth rates, but not as important as prior density and per capita income.

Table IV.5: Linear Models of Tract Population Growth, 1990-2000
Coefficients (T-Statistics)
(Regions in order: Urban to Rural)

Variable	Char-Meck	Ral-Dur-CH	Triad (WS-Gr-HP)	Ashe ville	Wilm Ingtn	Fayett' Ville	Jacks' ville	Grnv RkMt	Hick Morg	Boone SprPi	Eastn NC	We NC
Constant	1206.0	2717.9	1218.8	1188.7	3072.5	1745.4	3171.8	306.3	1289.9	617.2	1808.0	72
Density 1990	-0.49 (-6.9)	-0.59 (-6.8)	-0.31 (-7.3)	-0.52 (-5.7)	- 0.81 (-4.6)	-0.61 (-3.5)			-0.54 (-2.4)		-0.58 (-2.1)	
Per Cap Income 2000												
Per Cap Income	0.045 (2.9)							0.079 (2.3)				

1990												
Pct Non White Pop								-13.1 (-2.7)				
Distance To Coast							-63.7 (-3.85)				-16.1 (-0.94)	
Distance To Park-Way										-22.0 (-1.50)		-1 (-0.
Interstate Distance			-28.1 (-4.1)	-31.1 (-2.5)					-53.9 (-2.2)			
Dist to City Center	-23.4 (-2.1)	-46.1 (-3.5)			-45.1 (-3.4)	-23.8 (-2.2)						
Dist to Project												
New 2L Arterial												
New 4L Freeway Miles		353.9 (3.1)		86.3 (2.1)								
New 4L Arterial Miles	455.9 (3.1)											
New Exit			4845.7 (4.1)									
Widened Urban Art Miles	525.3 (3.9)		237.4 (2.1)	106.8 (2.1)							143.9 (2.4)	
Widened Rural Art Miles				552.8 (5.2)		206.9 (2.2)	192.6 (1.9)			122.9 (-3.5)	50.6 (0.7)	7 (2
Widen Fy to 6 lanes												
Widen Fy to 8 lanes		-1130 (-2.7)										
1WayPairs												
Climb Lns												
Total Proj Length												
Tot Added Lane Mi												
Tot Cost												
Spur												
Spec												
VMT Change		0.039 (3.3)										
VMC Change												
Ave Change	**1099.6**	**1512.9**	**708.6**	**792.1**	**1502.4**	**772.4**	**1136.8**	**495.1**	**726.3**	**530.1**	**1499.1**	**69**
RSQ	**0.226**	**0.217**	**0.217**	**0.452**	**0.251**	**0.107**	**0.199**	**0.162**	**0.074**	**0.448**	**0.338**	**0.**
Total F	**20.11**	**15.30**	**23.29**	**15.17**	**11.08**	**5.98**	**7.71**	**16.11**	**4.03**	**9.51**	**4.32**	**2**
N	**327**	**259**	**323**	**87**	**61**	**126**	**55**	**157**	**77**	**22**	**27**	

In addition, major road investments have a modest effect on growth. The model contains three terms reflecting road investment in a tract: widening of urban arterials, widening of rural arterials, and new 4-lane arterials. The effects of each are modest: an increase of about 123-149 persons per decade for one mile of each action. Other road-

related terms (e.g. distance to Interstate, mileage of new freeways, new exits, etc) did not enter the equation, indicating that on the State level they are not significant factors – they may be significant in regions.

This model can be used as a policy analysis tool by applying it to the specific data for a given tract. The application can best be illustrated by an example. Consider, for example, a suburban tract with the following characteristics:

Area:	15 square miles
Population:	6000 persons (density 400 persons per square mile)
Distance to city center:	12.5 miles
Family per capita income	$22000

The "baseline" (no new roads) 10-year growth predicted for this tract in the next decade would be:

$$\text{Population Change} = 891.9 - 0.38(400) + 0.030(\$22000) - 14.0(12.5) = 1224.9$$

If a 1-mile section of widened rural arterial were built in the tract, the expected population growth would be:

$$\text{Population Change} = 1224.9 + 123.2(1.0) = 1348.1$$

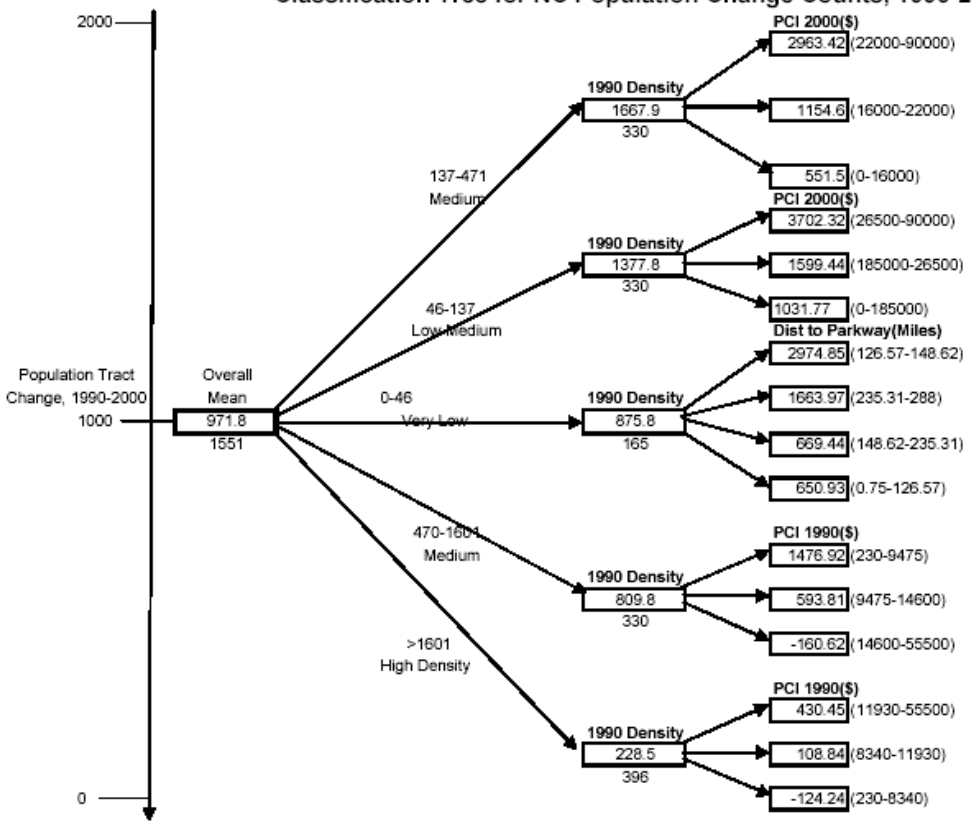
In other words, the tract's demographics and location is such that it might be expected to grow by about 1224.9 persons, or 20.4 percent, in the next decade. However with a widened rural arterial, its growth would be slightly faster, about 22.5 percent. So, for an 'average' tract, the road widening would add about 2.1 percentage points to the decade growth rate. This example shows that tract demographics, particularly prior density and per capita income, along with its location circumstances have the primary impacts on its future growth. The highest growth can be expected in tracts that are presently low density, nearer to city centers, and have high per-capita income. The impacts of additional road investment, although minor, can slow or accelerate this baseline growth by several percentage points, but not dominate it. However, because the overall equation is quite weak, explaining only about 14 percent of the variation in growth rates, local circumstances such as land suitability, price, development quality and a host of other factors are likely to influence the tract's growth more than the factors in the equation.

The importance of density and income in tract growth can also be seen by another statistical method, 'classification analysis.' This tool constructs a "tree" of subgroups of tracts using those variables that most efficiently explain the variation in growth between tracts. The purpose of classification analysis is to reveal relationships in the data that might not be linear (a requirement of linear regression) or be different for different groups of tracts. The particular classification procedure used here is KnowledgeSEEKER[80], which develops a 'tree' diagram showing the most important variables that influence a dependent variable. For our purposes the 'tree' has been converted into a simplified figure.

The results of the classification analysis are shown in Figure IV.4. The figure clearly shows the complex relationship between tract growth and density: at very low

densities (that is, rural tracts) growth rates are modest. Growth rates are highest at

Figure IV.4
Classification Tree for NC Population Change Counts, 1990-2000



medium densities of between 137 and 471 persons per square mile. These correspond to 'suburban' tracts on the edges of regions. Growth rates then fall as density rises. These tracts correspond to generally urban tracts that are already developed. The variables of secondary importance are 1990 and 2000 per-capita incomes. Tracts with higher initial average per-capita incomes attract more growth, a sort of spiraling effect. However, for rural tracts 'Distance to Parkway' is a key influencing variable, with tracts farther from the Parkway growing more rapidly. This can be interpreted as location effect relating to the generally faster growth of Piedmont and coastal tracts. Note that road-related variables are absent from the first two levels of the classification, confirming that they are generally less important in influencing tract growth than demographic (density and income) and location variables. This assessment was confirmed by separate linear regressions for lower-density tracts (less than 136 persons per square mile) and higher-density tracts (367 or more persons per square mile).

We now review these relationships for each commuting region, beginning with the most urban (Charlotte) to the most rural (western NC) regions; this ordering facilitates comparison between similar regions.

F. Charlotte Commuting Region

1. Growth Patterns

The greater Charlotte commuting region stretches almost 125 miles from Anson County on the east to Rutherford County on the west, and 55 miles from Iredell County on the north to York County in South Carolina. The North Carolina portion of the region contains about 1,700,000 persons. Within the past decade the region has extended its commute boundary east and west, as major new sections of US 74 have allowed commuters from as far away as Forest City in Rutherford County and Rockingham in Richmond County to access the edges of the Charlotte employment market.

The heart of the region, Charlotte and Mecklenburg County, has become a job magnet for the immediate surrounding counties (particularly Cabarrus, Iredell, Union, Gaston, and York SC), and more distant counties as well. Inter-county commuting in this inner area increased about 40 % over the past decade, and population growth rates exceeded 30 percent in suburban Union and Cabarrus Counties. Population growth was particularly rapid in the suburban tracts between Charlotte and the nearby cities of Concord, Gastonia, York SC, and Monroe, about 20-25 miles from the Charlotte city center. many other tracts in the region also grew in population. Inside and outside the immediate metropolitan areas, most tracts increased in population.

The Charlotte city center provides jobs and focus for the region's inter-county commuting.

Figure IV.5 shows the overall population growth pattern for the western half of the region. Details for the eastern half including Charlotte, Gastonia and Concord are shown in Figure IV.6.

Figure IV.5
Charlotte Commuting Region (West)
Population Change, Prior Density and Major Road Projects, 1990-2000

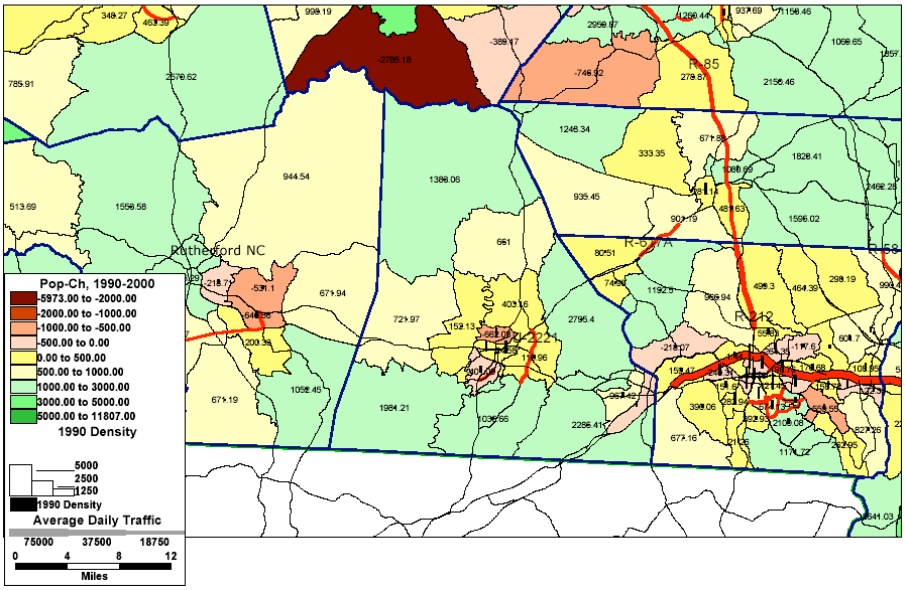
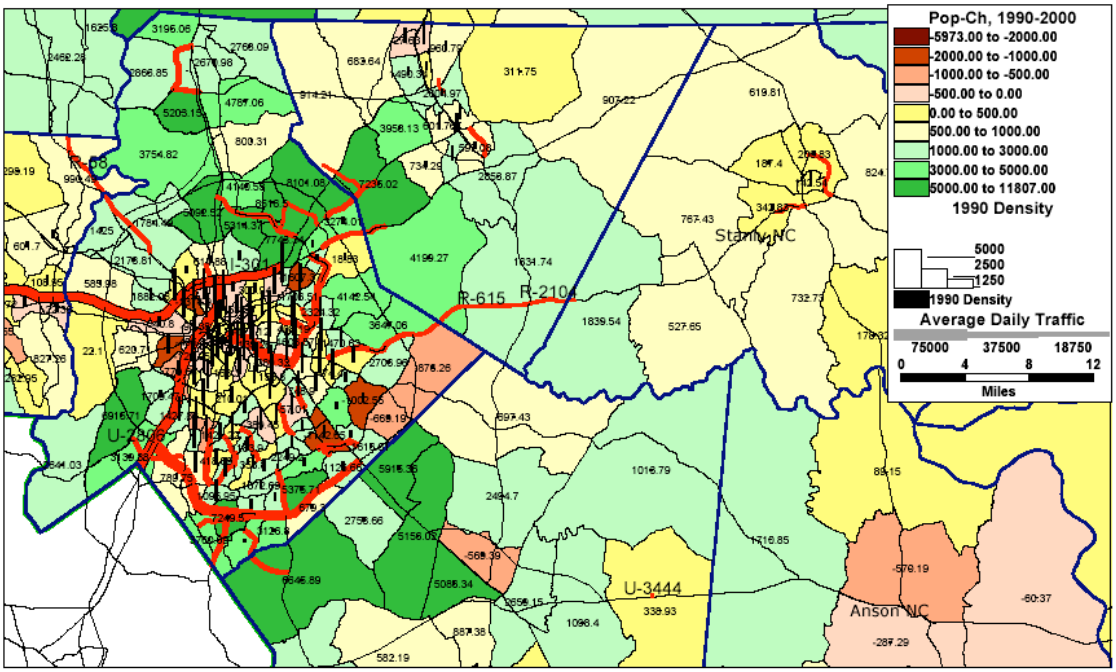


Figure IV.6

Charlotte Commuting Region (East)

Population Change, Prior Density and Major Road Projects, 1990-2000



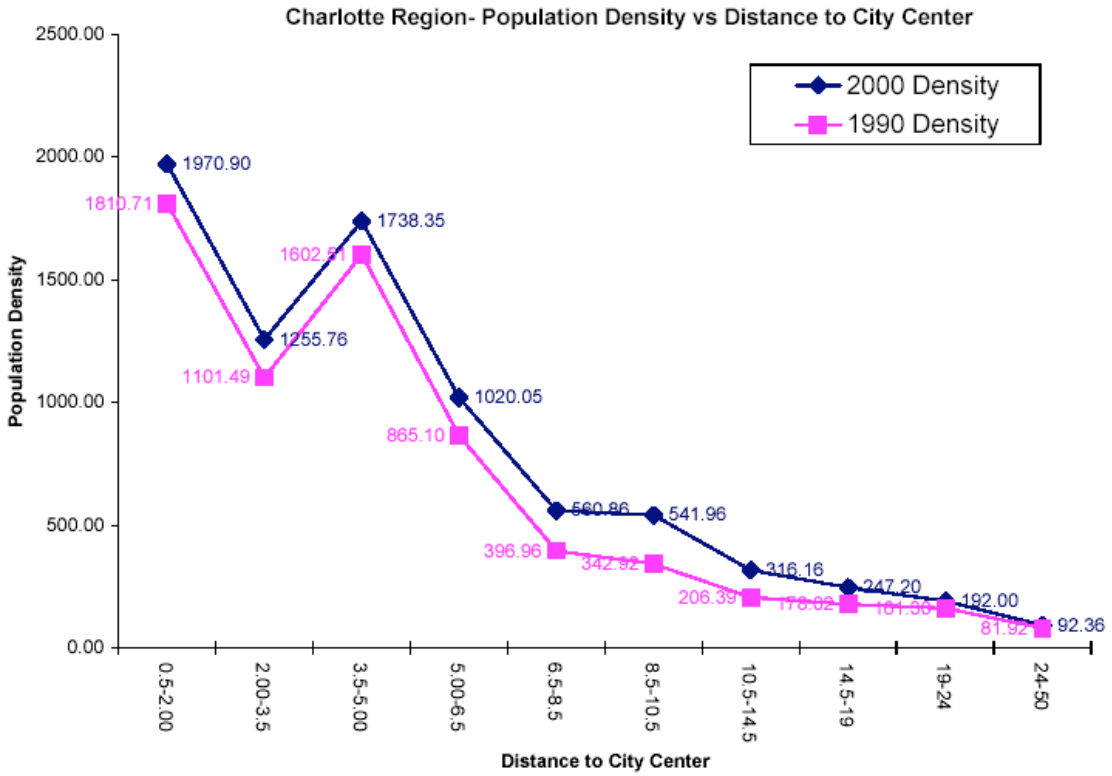
Overall, the average tract growth for the region was about 1099.6 persons per decade, somewhat faster than the State average of 972. The general pattern of growth is that growth was most rapid in suburban tracts. Within each city a few tracts declined in population while most grew at a more modest rate. The smaller cities in the region each experienced their own "sub-regional" growth pattern within their immediate influence area, in which inner-city tracts grew modestly or declined slightly in population while suburban tracts grew more rapidly. Central-city tracts in Charlotte grew modestly (a few declined in population), while in Concord, Kannapolis, Monroe, Gastonia, Shelby and Forest City a few tracts declined in population while most increased.

These figures also show the general relationship between growth, density, and road improvements. Generally urban-area tracts that had room for growth, that is those with lower overall densities, grew the most rapidly while growth was slower in other tracts inside the region's cities or in the rural areas.

New apartments within cities raise densities slowly (Charlotte, Randolph Road)

It is a myth that the inner portions of Charlotte-region cities are loosing population. Figure IV.7 shows clearly that population densities are increasing throughout the greater Charlotte commuting region, even in tracts close to the city centers. For instance, the average density of tracts within 2 miles of city centers increased about 5 percent, from 1811 to 1971, during the 1990s[81]. Densities in suburban tracts, from 6.5 to 8.5 miles from city centers, increased about 41 percent, from 397 to 561. Certainly densities are rising more rapidly in suburban tracts than they are in inner-city tracts or in rural tracts 19-50 miles out, but that is because more land is available and these tracts have lower densities to start with. A

Figure IV.7



few tracts are also declining in population, but as noted above this may be due to declining family size and turnover in land uses in some tracts from residential to other uses.

Within the region inter-county commuting has been increasing. The greatest inter-county flows are from Charlotte's suburban counties (Cabarrus, Union, Gaston, Iredell and York SC) to Mecklenburg County, all about 22,000 daily commuters. There are also strong flows from Rowan to Cabarrus County, from Stanly to Mecklenburg, from Cleveland to Gaston County, Rutherford to Cleveland County, and Lincoln to Catawba and Mecklenburg. The regional commuter map (Figure IV.2) shows a complex economic dependency centered on Mecklenburg County with some inter-regional dependency with Catawba County (Hickory).

2. Major Road Improvements

An extensive road-improvement program in the greater Charlotte region has taken place since 1990. Table IV.6 summarizes these projects by type.

Table IV.6: Charlotte Region: Major Road Improvements 1990-2000

Type of Project	Number	Miles	Cost, $M
1-New 2L Arterial	5	15.88	39.60
2-Widen Urban Arterial	34	73.29	233.39
3-New 4L Freeway	4	66.35	393.70

4-Widen Frwy to 8L	2	19.71	256.80
5-Widen Rural Arterial	4	18.91	57.21
6-Widen Frwy or Arterial to 6 Lanes	4	38.53	213.72
7-New Exit	3	3.50	12.70
11-New 4L Arterial	13	39.16	145.60
Total	**69**	**275.33**	**$1356.72**

More than _ the projects were widenings of urban and rural arterials, and about _ were new arterials. But Interstate mileage was also widened and several new exits were built.

In Mecklenburg County (Charlotte and nearby suburbs), the major projects included 14 projects that were funded entirely by the City of Charlotte, one project funded by a private developer, and a new exit on I-77 at Sam Furr Road. Most of these projects were in the south and northeast suburban areas, particularly in the area south of South Park Mall and around the University area. In addition to these projects, Charlotte also opened the south and southwest portions of its Outer Belt and completed the initial widening and conversion of Independence Boulevard to a freeway. In the Gastonia area, major projects included the widening of I-85, the completion of US 321 connecting Dallas to Hickory, several new urban arterials (in the Hudson Blvd and Hoffman Rd area), and a new exit on I-85 at Lowell (Main St). In the Concord-Kannapolis area, a new exit on I-85 (Dale Earnhart Bvld), a new urban arterial (NC 136 extension) and a private-public road/exit improvement at Speedway Boulevard were the major projects. Elsewhere in the region, US 74 in Rutherford County was connected to I-26; NC 150 was widened; NC 27 widening in Stanley County was begun; in Rowan County, I-85 was widened and Jake Alexander Boulevard was extended, to mention a few.

3. Factors Influencing Growth

These projects partially directed but did not create the growth of the region. Inspection of the figures showing the locations of growth along with major road projects show clearly that imperfect correlation exists between the two. For instance, Figure IV.6 showed that within Charlotte the most rapid growth was in two areas (southeast Charlotte and University). But road improvements were concentrated in areas that had experienced growth in the prior decade: **the road improvements tended to be in areas that had grown up previously.** In this case, the road widening projects generally followed the population growth of prior decades.

The regression equation relating growth to demographics, location and road data shows modest strength. The overall equation is:

Pop Change = 1206.0
- $0.49_{t=-6.9}$ (1990 Density)
+ $0.043_{t=2.9}$ (1990 Per-capita income)
- $23.4_{t=-2.1}$ (Dist to City Center)
+ $525.3_{t=3.9}$ (Widened Urban Arterial Miles)
+ $455.9_{t=3.1}$ (New 4-Lane Arterial Miles)

N= 327, RSQ=0.227, F=20.1

The model explains about 23 percent of the variation in tract growth, leaving about 77 percent for other factors not included. The model constant is close to the region's average growth, 1099.6. As with the statewide model, the key factor is prior density. Growth slows as prior density increases; this means that as tracts fill up the growth goes elsewhere. An additional important factor is 1990 tract per-capita income. The higher the tract's income in 1990, the greater additional tract growth in the 1990s. This can be interpreted in several ways. One view would be that low-income tracts tend to be quite full already and so not have room for more growth. Another interpretation might be that newly locating households have the resources to locate in wealthier tracts. Distance to the city center is also a factor. Tract growth slows by about 23 persons per decade for every mile distant from the city center, suggesting that access to the center of the region's cities is still a factor people consider when choosing a home site. So for example, a tract on the edge of the immediate urban area, with an area of 10 square miles, a population of 5000 (density of 500 persons per square mile), 20 miles from the center and 1990 average per-capita income of $15000 would be expected to grow by about 1563 persons in the next decade, or about 38.1 percent.

In Charlotte widened urban arterial mileage was associated with increased tract growth of about 525 persons per decade.

In addition to these demographic and location factors, tracts in the greater Charlotte region also show considerable sensitivity to road investments as a spur to growth. For each mile of urban arterial widening, tract growth can be expected to increase by about 525 persons per decade. For each mile of new arterial the impact is about 456 persons per decade. These impacts are considerably larger than for the State as a whole, about 125-140 persons per decade. However, since the average tract only received about _ mile of widened arterial, the average impact would be about 131 persons, or about 8 percent of the average growth.

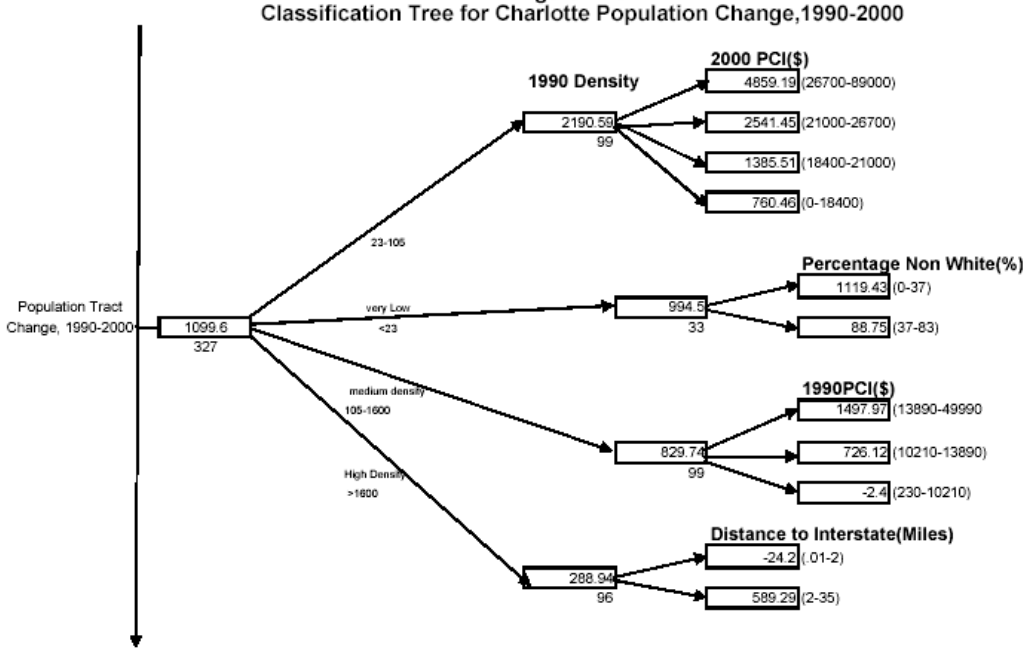
New 4-lane arterials were associated with increased tract growth of about 456 persons per decade.

These findings should not be overstated. Even in tracts with major road improvements the effect of the road improvements would be about 400 persons per decade, or about 150 households. This would generate about 1500 daily trips, less than 10 percent of the increased capacity of an urban road widening, and about the same impact as a single small McDonald's restaurant. So although we find some evidence for modest growth effects of major roads, these effects are quite small relative to the added road capacity. Thus we conclude that the growth of tracts in the greater Charlotte region has been modestly impacted by major roadway investment.

The 'classification analysis' for Charlotte (Figure IV.8) confirms this overall finding. The most rapidly growing tracts are those with 'medium' prior densities, 104-420 persons per square mile. On the other hand rural tracts with lower densities grew less rapidly, as did urban tracts with higher densities. Prior per-capita income increases the growth rate of suburban and urban tracts. In rural tracts the growth rates of high percent non-white population were significantly slower, averaging just 88 additional persons per

decade. Road-related variables were less important than demographic variables in determining growth rates.

Figure IV.8
Classification Tree for Charlotte Population Change,1990-2000



In summary, our analysis of population growth in the Charlotte region shows that growth has been occurring throughout the region, and is determined largely by prior density. Where space is available on the edges of the major cities, growth is occurring most rapidly. Densities are increasing throughout the region, with the increases being relatively greatest in suburban tracts 5-10 miles from city centers. Growth has been strongest in tracts with higher 1990 per-capita income and closer to city centers. New arterials and widened urban arterials can modestly accelerate growth in tracts that have these road improvements. But the overall model of population growth is quite weak, explaining less than _ of the variation in tract growth. This means that numerous factors influence the specifics of growth. Among these factors are availability of space for development, sewer and water infrastructure, competition from other sites, topography and development suitability, zoning, tax rates, local demographics and income, housing stock and quality, schools, community and business attitudes toward growth, longer term business cycles, to name a few.

G. Triangle Commuting Region

1. Growth Patterns

The greater Triangle commuting region is defined by a group of counties centered on the Raleigh-Durham-Chapel Hill area, but extending eastward to include Johnston County, north to include Warren County bordering Virginia, northwest to Person County,

southeast to Chatham County and south to Harnett County. About 1,475,000 people live in the region.

Figure IV.9
Triangle Commuting Region
Population Change, Density and Major Road Projects, 1990-2000

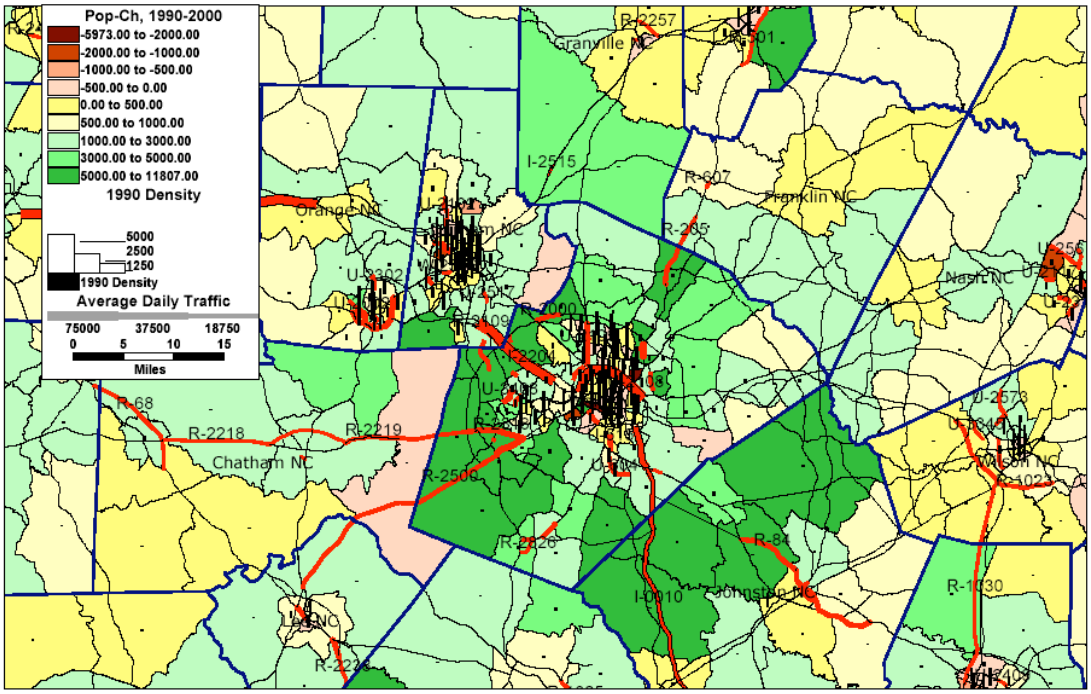
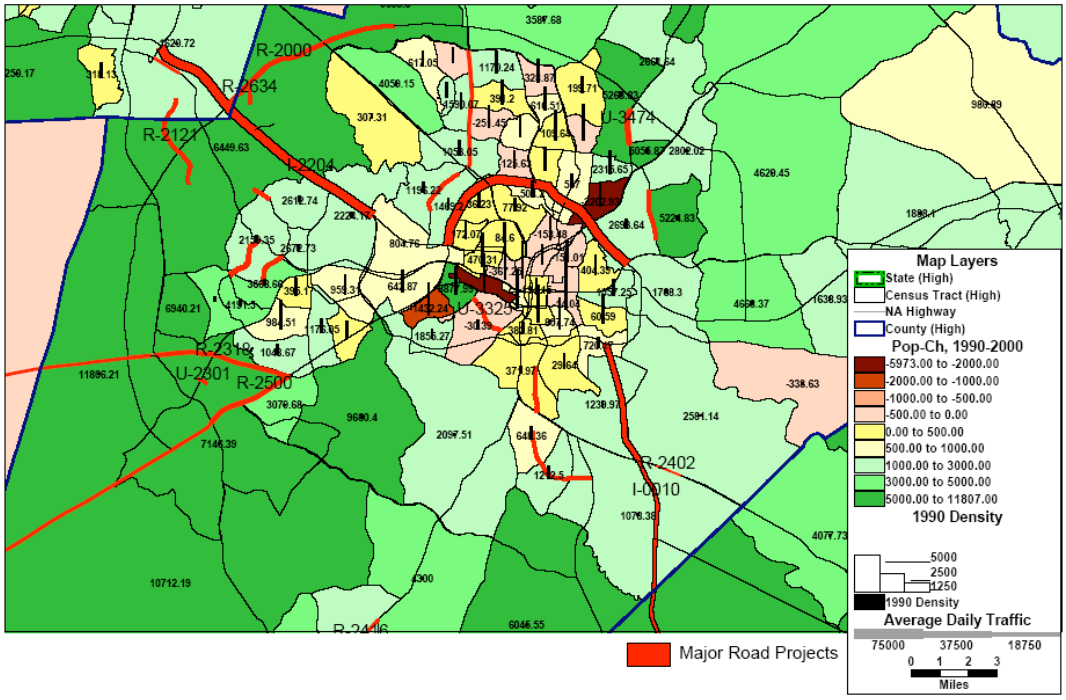


Figure IV.10
Triangle Commuting Region (Inner)
Population Change, Density and Major Road Projects, 1990-2000

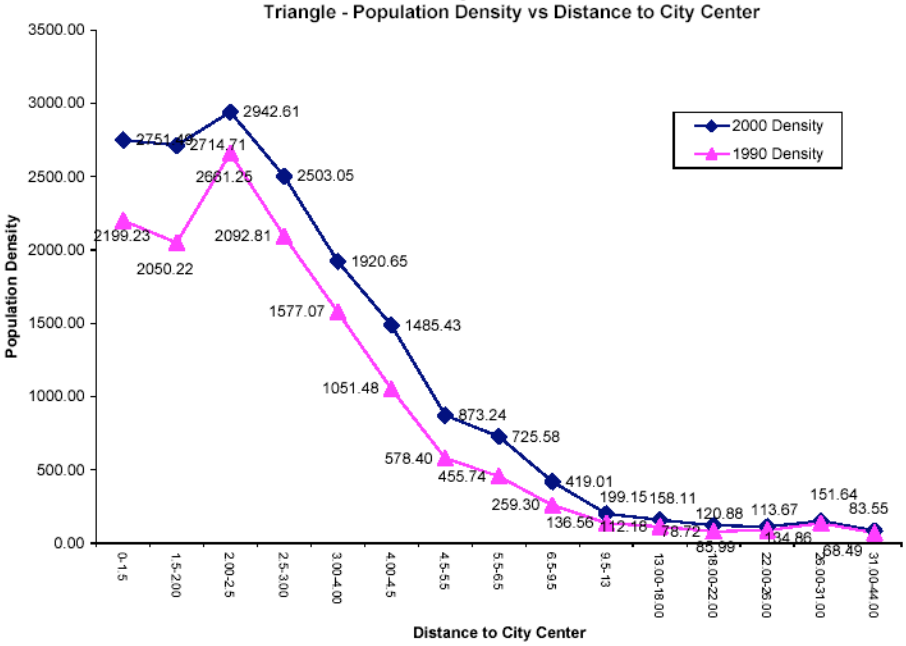


Figures IV.9 and IV.10 provide a graphic overview of population growth in the region. While the growth was centered on Wake County, nearby tracts in Johnston, Granville and Chatham Counties also reported strong growth. Overall the average tract growth for the region was about 1513 persons, about 36 percent, one of the most rapid growth rates in the State. The outer-rim tracts of Wake County (Raleigh) and nearby-county tracts bordering Wake generally reported growth greater that 3000 persons in just one decade. The municipalities of Cary, Garner, Clayton, Smithfield, Wake Forest, Carboro and Apex all reported rapid growth. In the Durham area, growth was most rapid in suburban northeast tracts. In Orange County, growth was fastest north and south of Chapel Hill. Oxford also reported strong growth.

New arterials in the RTP area served both office and residential growth.

Within the urban area, growth in inner rings was generally more modest, and in a few cases population declined. However, densities continued to increase: Figure IV.11 shows that in the inner rings within 2 miles of the center, densities actually rose substantially from 2000-2100 to 2700-2750 persons per square mile. Average densities increased throughout the region at all distances from city centers. On a relative basis, densities in suburban areas increased the most but from lower bases. For instance, in the 5.5-6.5 mile ring, densities increased from an average of 456 to 725 persons per square mile. Farther out, at the edge of the region, densities in the 31-44 mile ring increased less rapidly, from 68 to 85 persons per square mile. This growth pattern (higher density increases in the suburban rings, but smaller increases in the inner rings and outer rings) was also apparent in the Charlotte growth pattern. So rather than loosing population the Triangle region is actually gaining population and density throughout.

Figure IV.11
Triangle - Population Density vs Distance to City Center



Commuting from Wake County to Durham County, at 43,400 daily commuters, is the highest inter-county commuting in the State. Much of this is traffic between Raleigh and the Research Triangle Park area. The 'reverse commute' from Durham to Wake is about 14,000 daily commuters. Commuting between Johnston and Wake County is also substantial, about 24,000 daily commuters. Commuting from Franklin to Wake, Orange to Durham and Harnett to Wake Counties are all over 8,000 daily commuters. Harnett County also sends about 7000 commuters south to the Fayetteville area (Cumberland County), but is increasingly in the Triangle economic orbit.

2. Major Road Improvements

A number of major highway projects were completed in the Triangle region during the 1990s. All total, about 41 major projects were completed. Table IV.7 shows a summary.

Table IV.7: Major Road Improvements, Triangle Area, 1990-2000

Project Type	Number of Projects	Total Miles	Total Cost, $M
1-New 2L Arterial	4	8.51	13.1
2-Widen Urban Art	13	26.35	103.57
3- New 4L Freeway	5	59.43	230.71
4-Widen Frwy to 8L	1	9.57	50.5
5-Widen Rural Art	5	20.41	59.49
6-Widen Freeway or Arterial to 6 Lanes	2	9.91	79.80
7-New Exit	4	3.79	29.20
11-New 4L Arterial	7	28.67	141.53
Total	**41**	**166.64**	**$707.90**

The majority of Triangle-area major road projects were urban arterial widenings and new arterials, but there were also several new freeway sections and freeway widenings. Foremost among these was the opening of initial sections of the Raleigh Outer Loop, the widening of I-40 between Raleigh and Durham, widening of potions of the Raleigh inner loop, and the opening of I-40 to Wilmington early in the decade. New arterials were built in the RTP area, roads around Chapel Hill were widened, and several new exits constructed. Outside the larger urban areas, major improvements included the widening of US 64 into Chatham County, US 1 between Sanford and Raleigh, US 1 from Wake Forest to Henderson, US 70 to Smithfield, the Oxford loop, and a new exit at Butner.

The widening of Creedmoor Road served primarily to increase capacity rather than to create new growth.

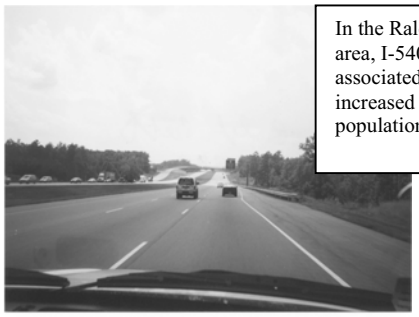
3. Factors Influencing Growth

Given the extensive roadwork in the Triangle commute region, the factors influencing growth in the region show a somewhat different set of variables than that for Charlotte or the state as a whole. The growth model is:

Population Change = 2717.9
- 0.59 $_{t=-6.8}$ (1990 Density)
- 46.1 $_{t=-3.5}$ (Dist to City Center)
+ 353.9 $_{t=3.1}$ (New 4L Freeway Miles)
- 1130.5 $_{t=-2.7}$ (Miles of Widened Freeway to 8 Lanes)
+ 0.039 $_{t=3.3}$ (VMT Change)

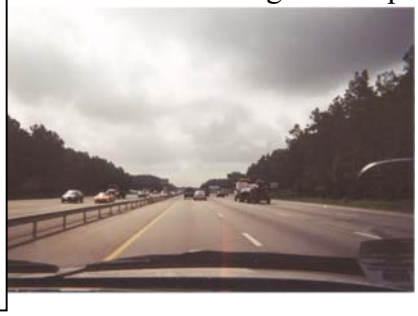
N = 259, RSQ = 0.217, F=15.30

The overall model is also quite weak, explaining only about 22 percent of the variation in tract population growth. This indicates that many other factors not in the model influence tract growth, as we found in looking at other regions and the State as a whole. Within the region, the primary factor influencing growth is prior population density, indicating again that as tracts fill up their growth slows. Distance to the city center is also an important factor. So for example, a suburban tract with average population density of 1500 and 11 miles from the city center would grow by about 1324 persons per decade, or about 31.7 percent.



In the Raleigh area, I-540 was associated with increased tract population.

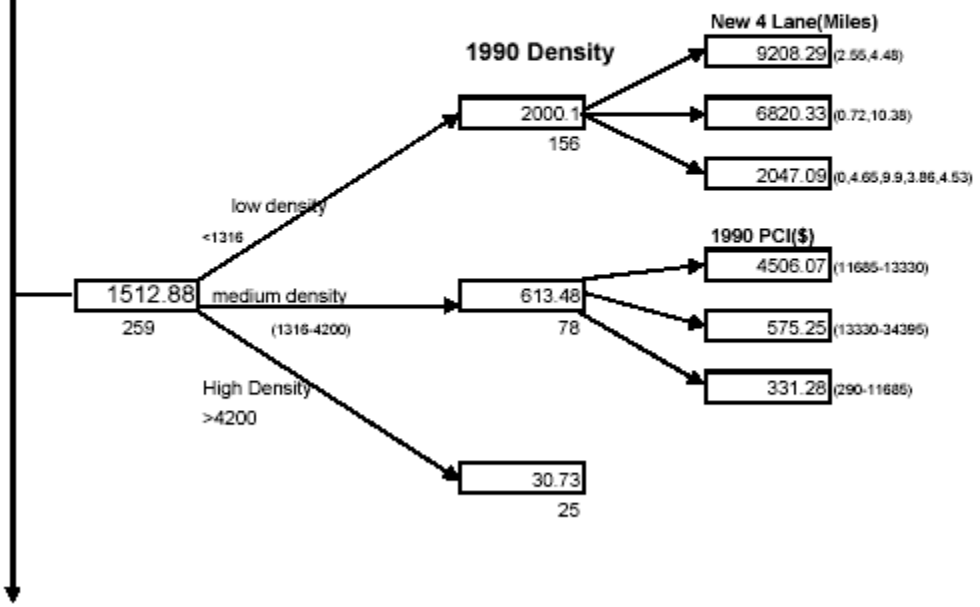
Two road-related variables also have a modest effect on Triangle-area growth. Perhaps not surprisingly given the new freeway construction in the region, we found that each mile of new freeway in a tract is associated with about 354 more persons per decade (about 140 households). This effect, about 8 percent of the average tract population, seems to suggest that in the Triangle area the incremental access caused by new freeway mileage provided a modest incentive for growth during the 1990s. On the other hand, the major widening of existing freeways to 8 lanes had the opposite effect, correlated with a slowing of growth by about 1130 persons per decade for each mile of 8-lane widening. **So, while new freeways opened up land and made growth modestly more likely, the expansion of existing freeways to 8 lanes seems to have slowed growth in adjacent tracts,** presumably by introducing negative impacts such as noise and pollution. This is also reflected in the last term, VMT change, which suggests that the incremental vehicle-miles added to the tract by the road improvement is correlated with increased population. However, this effect is minor, equivalent to about 65 households for the average tract.



In the Raleigh area, widening I-40 to 8 lanes was associated with a decrease of nearby residential population.

The relationship between population growth, density and income is illustrated in the classification analysis in Figure IV.12. Growth rates decline sharply as density increases, with a secondary effect of per-capita income accelerating the growth rate. At lower densities, primarily rural tracts, tract growth averaged 2200 persons per decade, while in dense tracts, previously developed, the next-decade growth rate slowed to a crawl. Higher per-capita income accelerated the growth rate for lower-density tracts. Interestingly, the classification analysis indicates that if low-density tracts have more than 2 miles of urban road widening, their growth rate more than doubles.

Figure IV.12
Classification Tree for Triangle Population Change,1990-2000



H. Triad Commuting Region

1. Growth Patterns

The greater Triad commuting region stretches across the top of northwest North Carolina, from Caswell to Ashe County, and south to Randolph and Wilkes County. On the east, it includes the Burlington-Graham urbanized area, and on the west North Wilkesboro and Sparta. Its central cities, Winston-Salem, Greensboro and High Point, form a loosely integrated economic hub, from which additional connections east and west allow inter-county commuting from longer distances. About 1,538,000 people live in this commuting region.

Figure IV.13 and Figure IV.14 show the major road projects and population change in this region over the last decade. On average, tracts in the region grew by about 708.6 persons per decade, or about 17.4 percent. Growth was greatest in tracts that had low prior population density, and was most rapid in several tracts directly west and northwest of Greensboro, with growth moderating toward the west. Growth in and around Winston-Salem was generally less than in the Greensboro area. The High Point area also registered modest growth in most tracts. A few tracts (in Greensboro, Winston-Salem, High Point, western Ashe County and northern Rockingham County) declined in population. The growth pattern around the major cities follows the familiar pattern of more rapid growth in the suburban tracts with less rapid growth in the inner city and in

Figure IV.13

Triad Commuting Region

Population Change, Density and Major Road Projects, 1990-2000

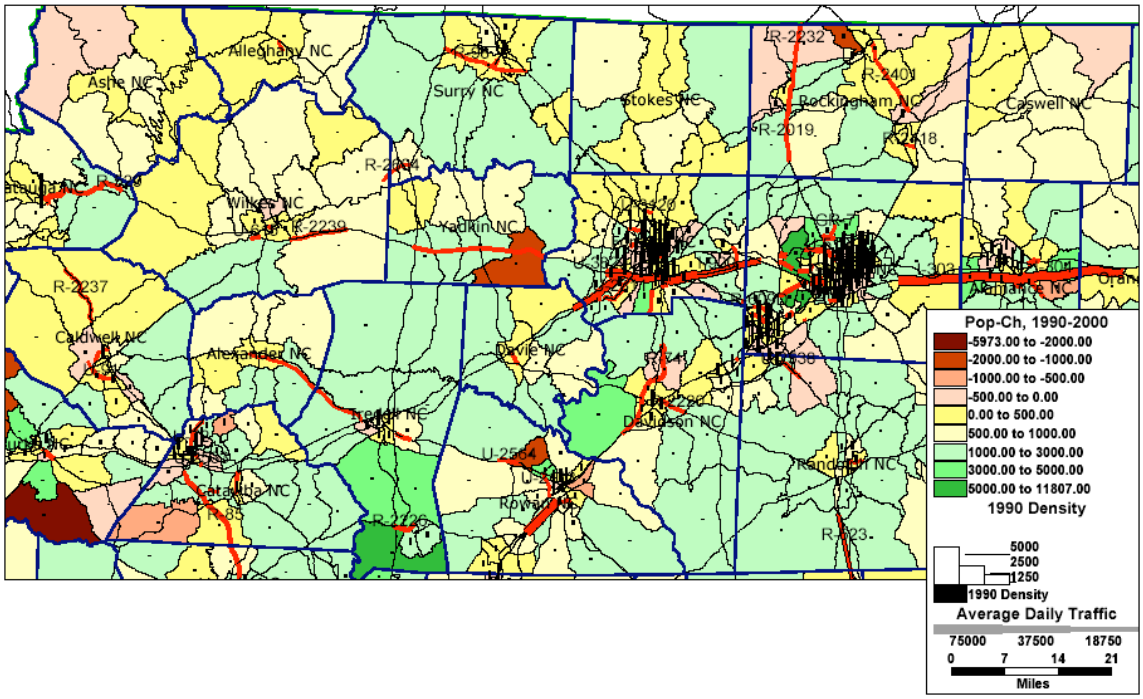
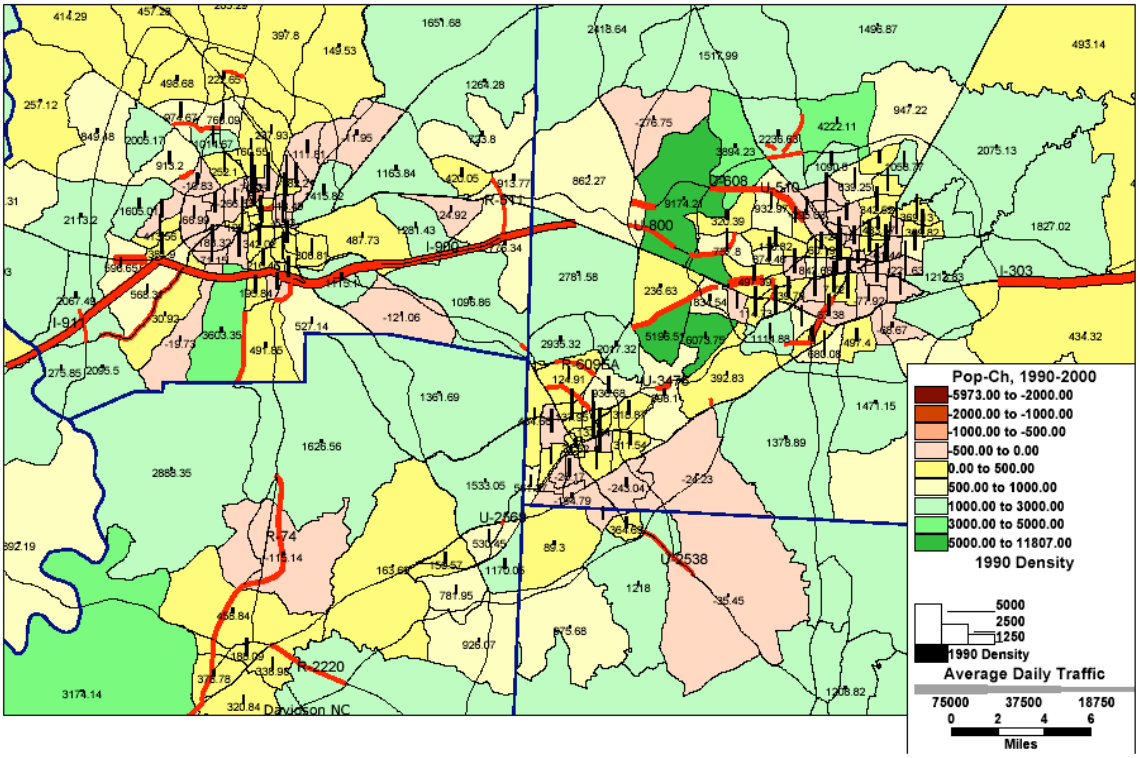


Figure IV.14

Triad Commuting Region (Inner)

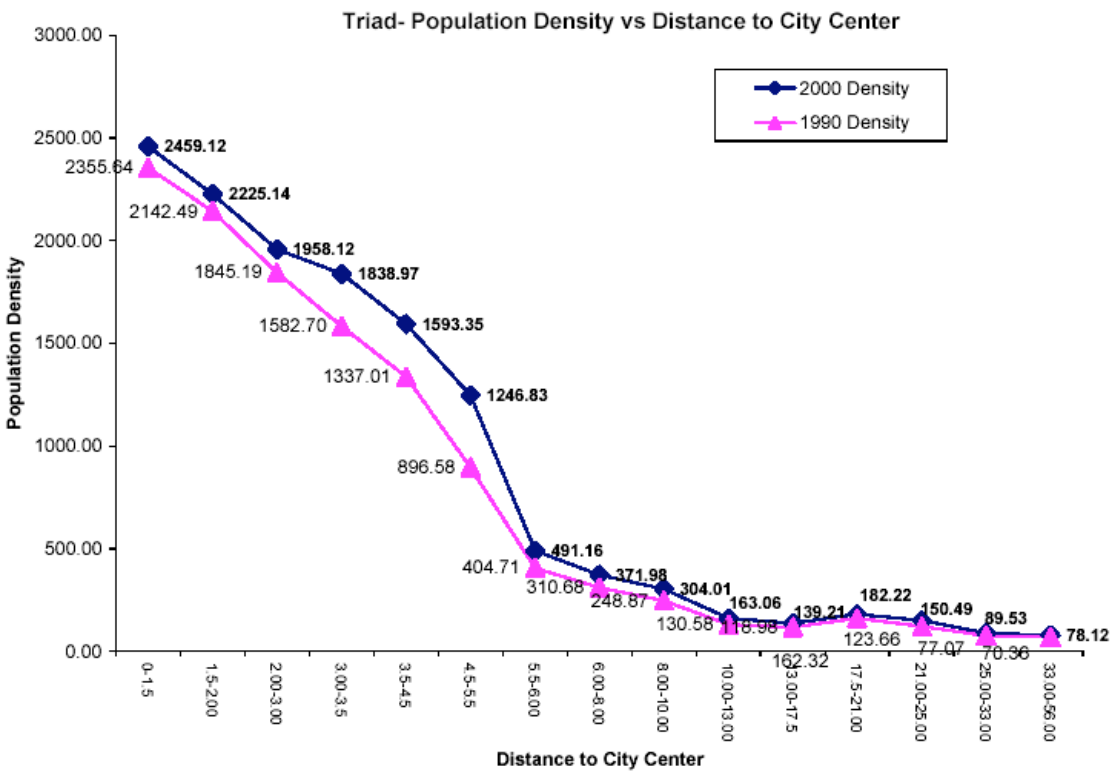
Population Change, Density and Major Road Projects, 1990-2000



the more distant ex-urban tracts. However, growth was also substantial in some rural tracts, for instance lower Rockingham County, Alamance County south of I-85, rural tracts of Randolph County, Davidson County south of Winston-Salem, Surrey County, and southern Wilkes and Yadkin County. Certainly, this region experienced growth in rural suburban and urban tracts.

Although this region registered less growth during the 1990s than either Charlotte or the Triangle, nevertheless population densities generally rose throughout the region. Figure IV.15 indicates that even in the inner rings of urban areas, 0-2 miles from the city centers, population density increased. Relative increases were greater, about 20-35 percent, in the suburban rings 3-5.5 miles from the city centers, then less again for rings farther out from the city. This figure shows the same general pattern as in other larger cities: generally rising densities throughout the region, with the greatest relative increases in the suburban rings, in this case defined as rings nearer the core than for larger cities. So, although the most rapid growth in the Triad region is going to suburban rings, that is by no means the only location increasing in population. Rural tracts some distance from the cores and inner-city tracts within just a few miles of the cores are also increasing in population.

Figure IV.15



Inter-county commuting in the Triad region binds the counties together economically. Figure IV.2 showed that daily commuting from Randolph County to Guilford County (20,000), Guilford to Forsyth (7300), Forsyth to Guilford (16,500) and Davidson to Forsyth (11,000) is each over 7000 daily commuters, among the highest flows in the State. From the north, commuting from Rockingham County to Guilford

(12,000) and from Stokes to Forsyth (10,300) are also over 10,000 commuters daily. About 5500 commuters travel daily from Yadkin County to Forsyth County. These numbers indicate the interdependence of the suburban counties and the central counties in the region.

2. Major Road Improvements

During the 1990s many major road improvements were implemented in the greater Triad region. Table IV.8 indicates the types of projects completed. Of the 57 major projects, over half were widening of rural and urban arterials, but several major new freeway sections and new arterials were also built. Among these were the new section of I-40 south of Winston-Salem, widening of I-40 west of Winston-Salem, improvement to NC 150 and US 158, Bryan Boulevard and Airport Parkway in Greensboro, improvement to Market Street west of Greensboro, widening of Wendover Road west of Greensboro, portions of US 311 north of High Point, widening of I-40/85 from Graham to Greensboro, widening of US 220 in Rockingham County, widening of US 52/64 in Davie County, the connection of US 52 to I-77 in Surrey County, and widening portions of US 421 in Yadkin and Wilkes Counties. About 57 major projects totaling 206.3 miles and costing about $1.06 B were completed during the 1990s in this region.

Table IV.8: Major Road Improvements, Triad Region, 1990-2000

Type of Improvement	Number of Projects	Total Miles	Total Cost, $M
1-New 2L Arterial	3	4.79	23.4
2-Widen Urban Art	25	38.78	85.43
3-New 4L Freeway	8	49.44	432.23
4-Widen Freeway to 8 Lanes	2	31.49	226.13
5-Widen Rural Art	8	60.37	179.59
6-Widen Freeway or Arterial to 6 Lanes	2	9.04	46.50
7-New Exit	1	1.08	7.9
11-New 4L Arterial	8	13.33	60.63
Total	**57**	**206.32**	**$1061.81**

Figure IV.13 showed how these major road projects are aligned with the growth of the region. Although some projects were completed in high-growth areas, other projects were completed in areas that experienced less growth.

3. Factors Influencing Growth

In the greater Triad commuting region, our analysis of the most important factors influencing tract population growth show some familiar and some new results. The model for growth in this region is:

$$\text{Population Growth} = 1218.8 - 0.31_{t=-7.33}\,(\text{1990 Density})$$

- 28.1 $_{t=-4.1}$ (Distance to Interstate)
+ 237.4 $_{t=2.1}$ (Widened Urban Arterial Miles)
+ 4845.7 $_{t=4.1}$ (New Exit Miles)

N = 323, RSQ = 0.217, F = 23.29

Overall, the model is quite weak, explaining only about 22 percent of the variation in tract population: most of the variation is growth is not accounted for by the demographic or location factors, being more site-specific in character. However, of the factors influencing growth, as with other urban regions, the key factor influencing growth is prior density: tracts with higher 1990 density showed slower growth during the subsequent decade. Distance to the Interstate system is also a significant factor: growth is slower farther from the Interstate system, and in this case Distance to City Center is not in the model, indicating the importance of the prior in-place Interstate system in influencing growth in this region. So, for an 'average' tract with a 1990 population density of 1100 persons per square mile and 7.0 miles from an Interstate, the 'baseline' growth would be about:

Population Change = 1218.8 – 0.31(1100) – 28.1(7) = 681.1 persons per decade,

about 16.7 percent. For a rural low-density tract distant from the Interstate, the growth would be about:

Population Change = 1218.8 – 0.31(100) – 28.1(40) = 64 persons per decade

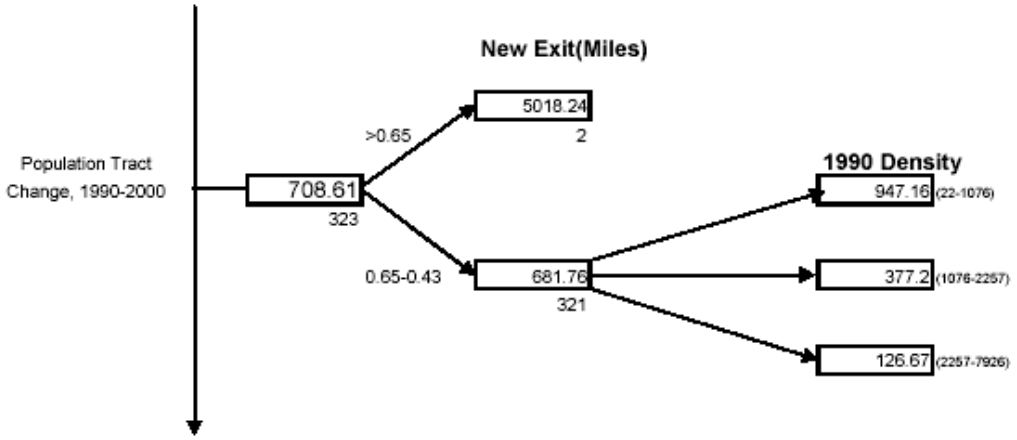
However, in addition to these demographic and location terms, two road-investment terms are also in the model. Widening a mile of urban arterial in a tract is correlated with about 237 more persons per decade, increasing its growth 22.6 percent; for the 'average' urban tract with 0.12 miles of widening, this would add about 28 persons per decade to the growth rate, or about 4 percent. On the other hand, the development of a new freeway exit is associated with very substantial growth, adding 4845 persons to the growth rate per mile of exit-related road work. However, this factor is based on just one new exit in the Greensboro area (the new exit on NC 68 at Airport Road) and so is probably not be typical for the whole region. Nevertheless the impact is substantial[82].

Widening arterials is associated with about 237 more persons per decade in affected tracts. (Alamance Co.)

This effect is also shown in the classification analysis for this region (Figure IV.16), indicating the negative relationship between prior density and subsequent growth. Low-density tracts grew at a substantially faster rate in the subsequent decade than high-density tracts. Income, prior population, and percent non-white also influence the growth rate. Higher initial tract income, larger prior residential population, and lower percent non-white population is also correlated with higher growth rates. However, these and many other factors available to the analysis did not enter the model. This is not to say that

such factors are not locally important and may influence non-residential growth, but on a regional scale they are not as important as the factors identified and discussed above.

Figure IV.16
Classification Tree for Triad Population Change,1990-2000



I. Asheville Commuting Region

1. Growth Patterns

The Asheville commuting region consists of 6 counties surrounding Buncombe County, in western North Carolina, including Madison and Haywood Counties bordering Tennessee south to Jackson, Transylvania, Henderson and Polk Counties bordering South Carolina. About 416,000 persons inhabit the region, up 19.8 percent from 1990.

Although western North Carolina is considerably mountainous and not all land is suitable for development, the natural attractiveness and climate of the region has led to considerable growth over the past decade. Most of the tracts in the region have grown modestly in population, with the exception of several in the core area of Asheville. Figure IV.17 shows the growth pattern for the area, indicating the magnitude of growth in the past decade. On average, tracts grew by about 792 persons per decade, slower than the State average. Growth was most rapid in several tracts southeast of Asheville along US 70, which increased by 4300 persons. Other tracts in the Asheville suburbs and near Hendersonville also increased by 1000-3000 population. To the north and west, growth was slightly slower but still positive, 250-500 persons, in most Madison and Haywood County tracts. Tracts immediately north of Asheville in the I-26 corridor grew by 1000-2000 persons. Jackson and Transylvania County tracts grew less, but still registered positive growth.

Although growth in the Asheville commuting region was slower than in some other regions, nevertheless population densities generally rose during the 1990s. Figure IV.18 shows population density at various distances from city centers. Even in close-in tracts within 2 miles of city centers, densities rose slightly, from 1931 to 1966 persons

per square mile. In tracts 2-3.5 miles out, densities also rose slightly, from 1022 to 1058 persons per square mile. Farther out from the city centers, densities increased

Figure IV.17
Asheville Commuting Region
Population Change, Density and Major Road Projects, 1990-2000

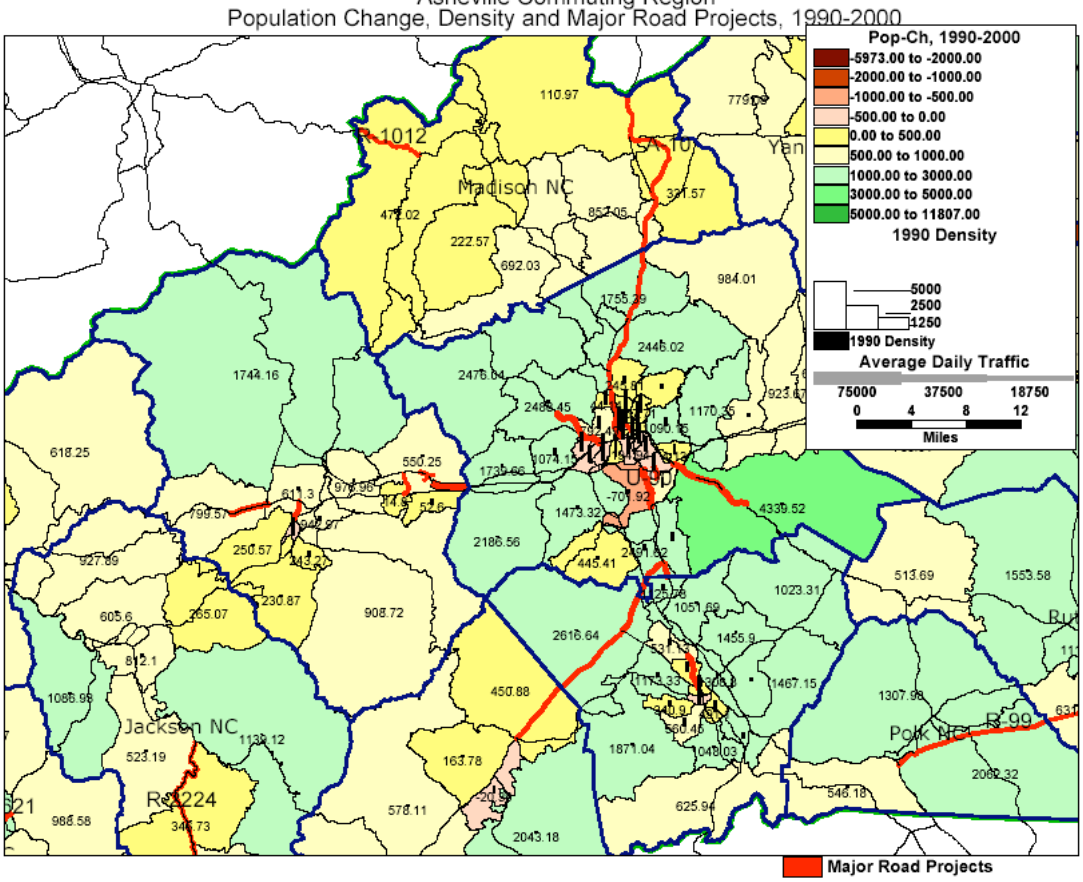
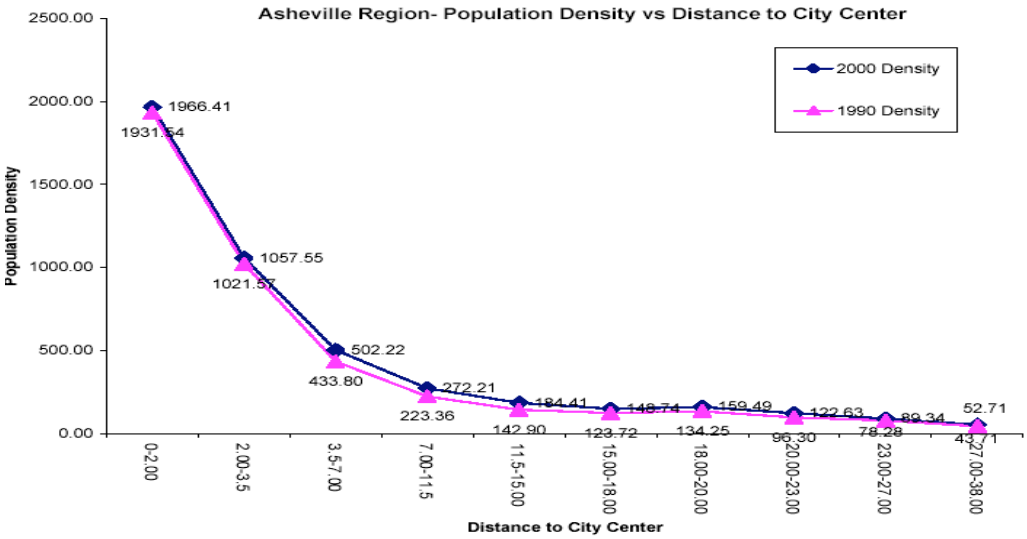


Figure IV.18



sharply but from lower bases. In the 3.5-7 mile range, densities rose from 434 to 502. So although most of the growth took place in suburban tracts within 10 miles of city centers, even most inner-city tracts increased in population and density.

Inter-county commuting in the greater Asheville area is focused along the primary transportation routes. The greatest inter-county flows in the region are between Buncombe and Henderson Counties, about 5000-7000 each way, along the I-26 and US 25 corridors. Close behind are the flows from Haywood to Buncombe County, about 4100 daily commuters in the I-40 US 70 corridor (considerably more Haywood County residents commute to Buncombe County than from Buncombe to Haywood). Commuting from Madison County to Buncombe County, about 4000 daily, has also increased taking advantage of I-26's completion.

2. Major Road Improvements

Figure IV.17 also shows the locations of major road improvements during the 1990s, and the stronger correlation between these improvements and growth patterns is apparent. Table IV.9 indicates the types of improvements made. About 21 major projects, some very substantial, were completed or largely so. Most of the projects completed were widening of urban arterials, climbing lanes, and new exits. However, the largest project was the new freeway extending I-26 (US 23/19) to the Tennessee line, most of which was completed or underway in the 1990s (although the entire route did not open until summer 2003, we included the project because of its local importance). Other major projects included two new exits on I-40 (Exit 51, Sweeten Creek Road, and Exit 33, Newfound Road), widening of NC 200 from Brevard to I-26, widening of NC 63 northwest of Asheville, widening of Broadway Ave in Asheville, and several climbing lane projects (I-40 in Haywood County, US 64 in Transylvania County and NC 107 in Jackson County).

A new exit on I-40 at Newfound Road provided access to mountain residents but did not spur growth.

Table IV.9: Major Road Improvements, Asheville Region, 1990-2000

Type of Improvement	Number of Projects	Total Miles	Total Cost, $M
1-New 2L Arterial	2	7.14	15.90
2-Widen Urban Art	12	40.29	149.30
3-New 4L Freeway	1	29.32	252.47
5-Widen Rural Art	1	6.45	31.10
7-New Exit	2	2.04	13.90
10-Climbing Lanes	3	37.02	9.90
Total	**21**	**122.28**	**472.57**

3. Factors Influencing Growth

Major road projects can have a substantial effect on small communities, particularly in locations where geography constricts growth. In the case of the Asheville region, both prior road investment (the Interstate system) and more recent road investment have affected the location of growth. The population growth model for this region is:

Population Growth = 1188.7

- 0.53 $_{t=-5.7}$ (1990 Density)
- 31.1 $_{t=-2.5}$ (Distance to Interstate)
+ 106.8 $_{t=2.1}$ (Widen Urban Arterial Miles)
+ 86.4 $_{t=2.1}$ (New Freeway Miles)
+ 552.8 $_{t=2.5}$ (Widen Rural Arterial Miles)

N= 87, RSQ = 0.452, F= 15.18

Contrary to the case of other larger regions, the model for the Asheville region has considerable overall strength, explaining about 45 percent of the variation in growth rates. As with the other regions, the key factor influencing growth is prior population density. The rate of growth declines as prior density increases. This is also indicated in the growth patterns shown in Figure IV.17, which shows generally more rapid growth in the suburbs of the urban areas, where densities were initially lower. Another important factor is Interstate access. Growth has been greater in tracts nearer the Interstate system, declining by about 31 persons per decade for each mile distant from the Interstate system. So, for a suburban tract with modest density (say, 300 persons per square mile, and 5 miles from the Interstate system, the expected 'baseline' growth would be about:

Population Growth = 1188.7 – 0.53 (300) – 31.1(5) = 874 persons per decade,

or about 21.9 percent.

In addition, the model contains terms that correlate growth to road investment. Tract growth is increased by 106.8 persons per decade for each mile of widened urban arterial mileage, by 86.4 persons per decade for each mile of new freeway, and by 552.8 persons per decade for each mile of widened rural arterial. The latter term, however is based on just one case, the widening of US 70 southeast of Asheville, and so may not be applicable to other situations.

To put these impacts in perspective, consider the example of a rural tract 15 miles north of Asheville in the I-26 corridor. If the current density is about 500, the "baseline' growth is estimated at:

Population Growth = 1188.7 –0.53 (500) –31.4 (15) = 452 persons per decade.

With the opening of the new I-26 corridor, assuming an average distance of 2 miles from I-26 and 5 miles of freeway in the tract, the expected growth would be:

Population Growth = 1188.7 –0.53 (500) –31.4(2) + 86.4(5) = 1292.9,

or about 841 more persons per decade (about 336 more households). So in the case of the Asheville region, the impact of major road improvements on growth is significant in that these improvements are correlated with increased growth along the major new transportation corridors, while the rest of the region continues to grow at slower rates.

J. Wilmington Commuting Region

1. Growth Patterns

The Wilmington commuting region consists of 4 coastal-area counties (New Hanover, Pender, Brunswick and Columbia) in southeastern North Carolina bordering South Carolina. The 4-county region contains about 329,000 persons but has posted rapid growth, 38.8 percent over the past decade. The region's per-capita income has also posted strong gains, about 78 percent (unadjusted for inflation) in the past decade.

Figure IV.19
Wilmington Commuting Region
Population Change, Density and Major Road Projects, 1990-2000

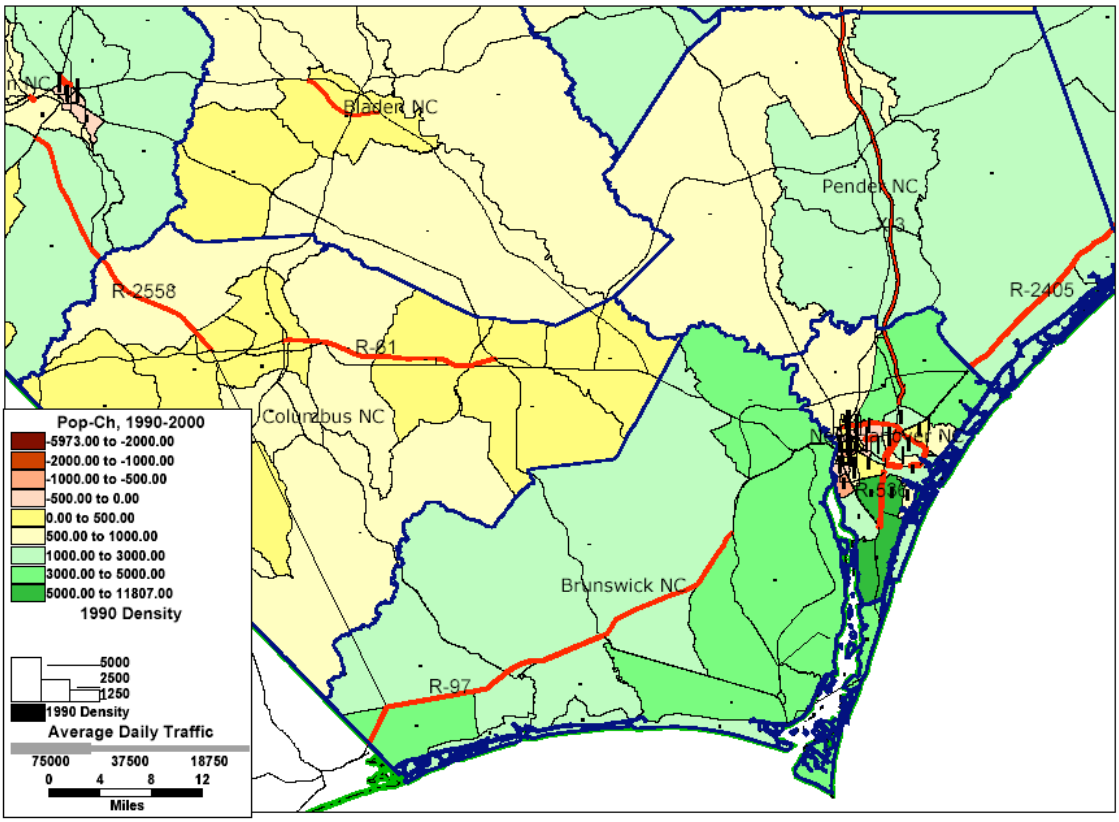


Figure IV.19 and Figure IV.20 show the detailed growth pattern for the region. All but a few of the region's 61 tracts increased in population during the 1990s, posting a strong average gain of 1502.4 persons per decade. Growth was strongest in coastal tracts less rapid for tracts farther inland. New Hanover tracts and Brunswick County tracts grew more rapidly than Pender and Columbia tracts. Several New Hanover and Brunswick County tracts posted gains of over 5000 persons per decade, among the fastest growth in the State.

Figure IV.20

Wilmington Commuting Region (Inner)
Population Change, Density and Major Road Projects, 1990-2000

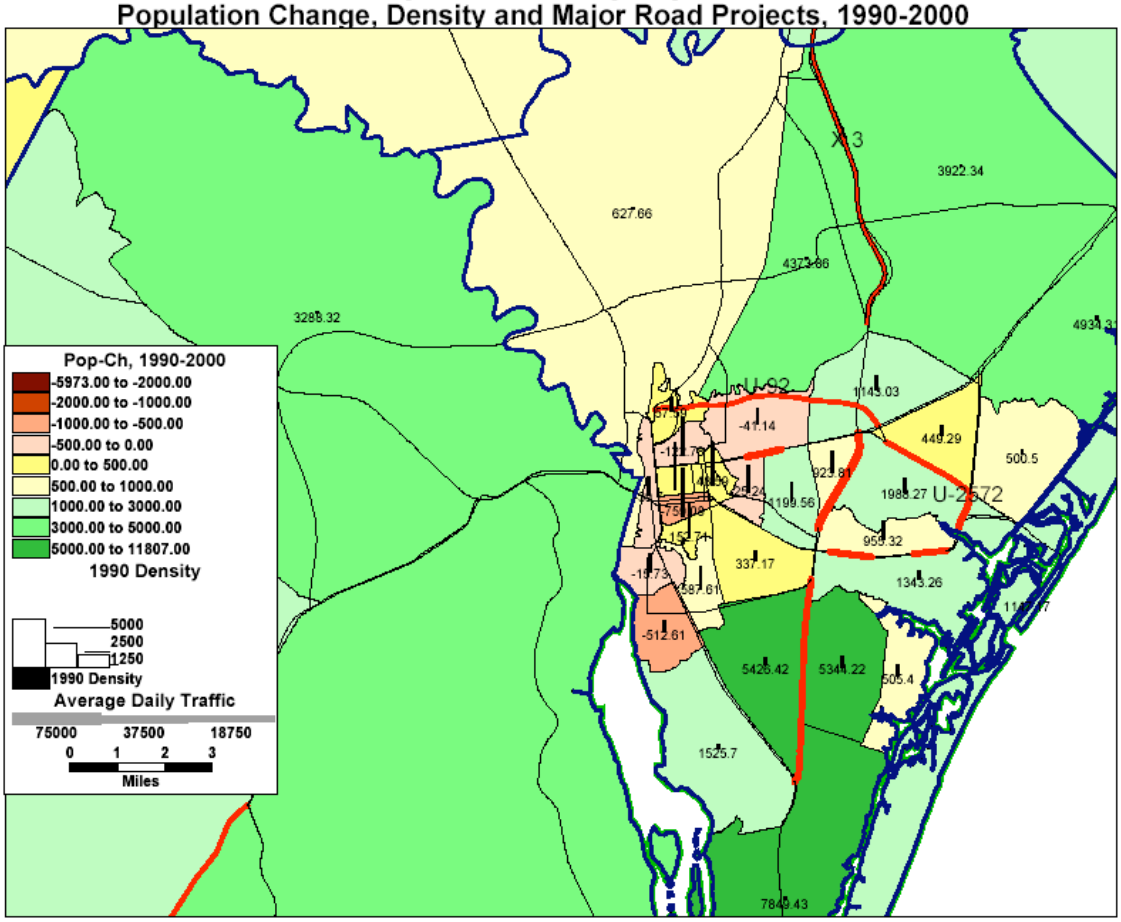
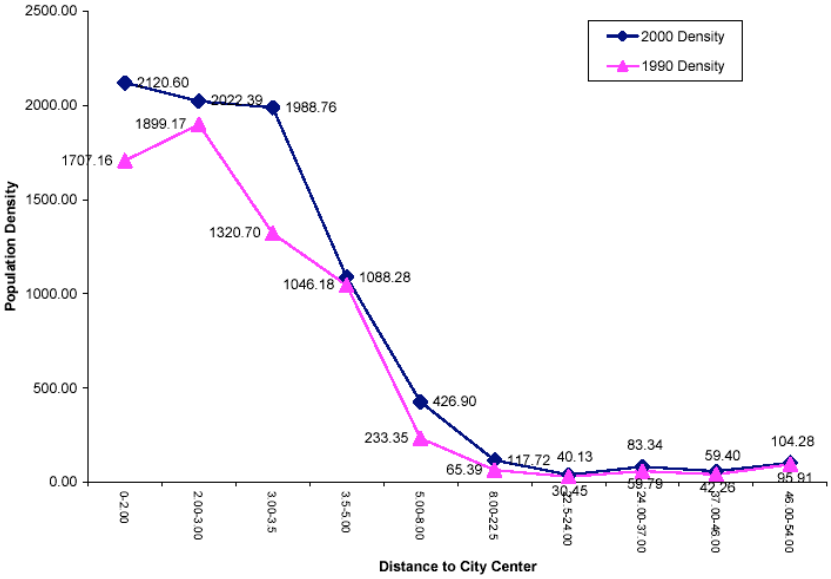


Figure IV.21

Wilmington-4 Population Density vs Distance to City Center



However within New Hanover County tracts with higher initial densities (primarily in the city of Wilmington) grew at slower rates than suburban tracts. Figure IV.21 shows that population densities rose throughout the region, with the greatest relative growth coming in tracts 3-3.5 miles from the city center (density increased from 1321 to 1988 persons per square mile), and in tracts 5-8 miles from the city center (density increased from 233 to 427 persons per square mile). For near-center tracts and tracts farther away, the relative increases in density were less.

Regional inter-county commuting is substantial with the focus on Wilmington. Figure IV.2 indicates that about 8100 workers commute daily from Pender County to New Hanover County and 6700 from Brunswick County to New Hanover County. However the region also draws commuters from Robeson, Duplin and Sampson Counties, and a few from as far away as Wake County and Lee County.

2. Major Road Improvements

Including completion of portions of I-40 in 1990, 12 major road projects were completed or largely completed in the Wilmington region during the 1990s. Table IV.10 indicates that these consisted primarily of widening of urban and rural arterials and new freeway sections.

Table IV.10: Major Road Projects, Wilmington Region, 1990-2000

Type of Project	Number of Projects	Total Miles	Total Cost, $M
2-Widen Urban Arterial	7	41.74	76.63
3-New 4L Freeway	2	22.00	140.93
5-Widen Rural Arterial	3	44.27	93.05
Total	**12**	**108.01**	**310.61**

Smith Creek Parkway provides an east-west connection across Wilmington

In addition to the completion of I-40, major projects included the widening of US 17, widening of portions of US 74 and portions of US 76, widening of College Road in New Hanover County, and the Smith Creek Parkway. Some of these projects were coincident with the growth patterns discussed above, some of which were in congested areas of Wilmington that grew up in earlier decades, and some were in rural areas.

3. Factors Influencing Growth

In spite of the extensiveness of the major road improvements, their impact on growth in specific tracts turned out not to be significant. The model for growth in the Wilmington region relates tract growth not to road improvements, but to prior density and to distance from the city center:

$$\text{Population Change} = 3072.54 - 0.82_{t=-4.6}\,(\text{1990 Density}) - 45.1_{t=-3.4}\,(\text{Distance to City Center})$$

N = 61, RSQ = 0.251, F = 11.08

Although this model is not particularly strong, explaining only about 25 percent of the variation in tract population growth, it indicates that the primary determinants of growth are prior density (tracts previously dense grew less rapidly during the 1990s), and distance to city center (tracts farther away from the city center grew more slowly). No specific road improvement terms, or other demographic terms entered the model, indicating that they were not significant in determining the growth of individual tracts.

Widening US 17 in Brunswick County improved regional access but did not generate growth.

This does not mean that the completion of major road improvements did not influence Wilmington's overall regional growth. Our literature review concluded that good roads are a necessary but not sufficient condition for regional competitiveness. And our prior study[83] predicted rapid overall growth in the Wilmington region as result of the completion of I-40 in 1990 which tied the Wilmington area to Raleigh. I-40 permitted the region's beaches and small-town charm to attract growth, but the region's university, community attractiveness and recreational flavor as well as industrial attractiveness all played a part in its growth. However, most of that growth occurred within a short distance of the city center, as indicated in the density curve (Figure IV.21) So I-40 may have been a key element on the region's growth spurt, but the growth itself tended to follow traditional density and distance relationships. Within Wilmington and along the coast, the road improvements were generally made to address capacity issues rather than spur new development.

Widening of NC 132 south of Wilmington increases capacity.

K. Fayetteville Commuting Region

The greater Fayetteville commuting region extends from Robeson, Bladen and Sampson Counties in southeast North Carolina to Montgomery and Moore Counties in Central North Carolina. (Harnett County, between Fayetteville and Raleigh, is increasingly in the Triangle region, although one tract near Cumberland County has also shown rapid growth). The urban center of the region is Fayetteville in Cumberland County, but the region also includes the smaller urban centers of Southern Pines, Rockingham, Laurinburg, Lumberton, Elizabethtown and Clinton. I-95 bisects the region north-to-south, and US 74 crosses it east-west. About 736,000 people inhabit the region, which reported a slower-than average growth rate during the 1990s (about 15.3 percent), lower than average per-capita income, and a higher-than average percent non-white population. The area is home to Fort Bragg and has a strong economic military component.

Figure IV.22 and Figure IV.23 indicate the general pattern of growth in the region. Overall, growth has been modest, with the average tract growing by about 772

Figure IV.22

Fayetteville Commuting Region
Population Change, Density and Major Road Projects, 1990-2000

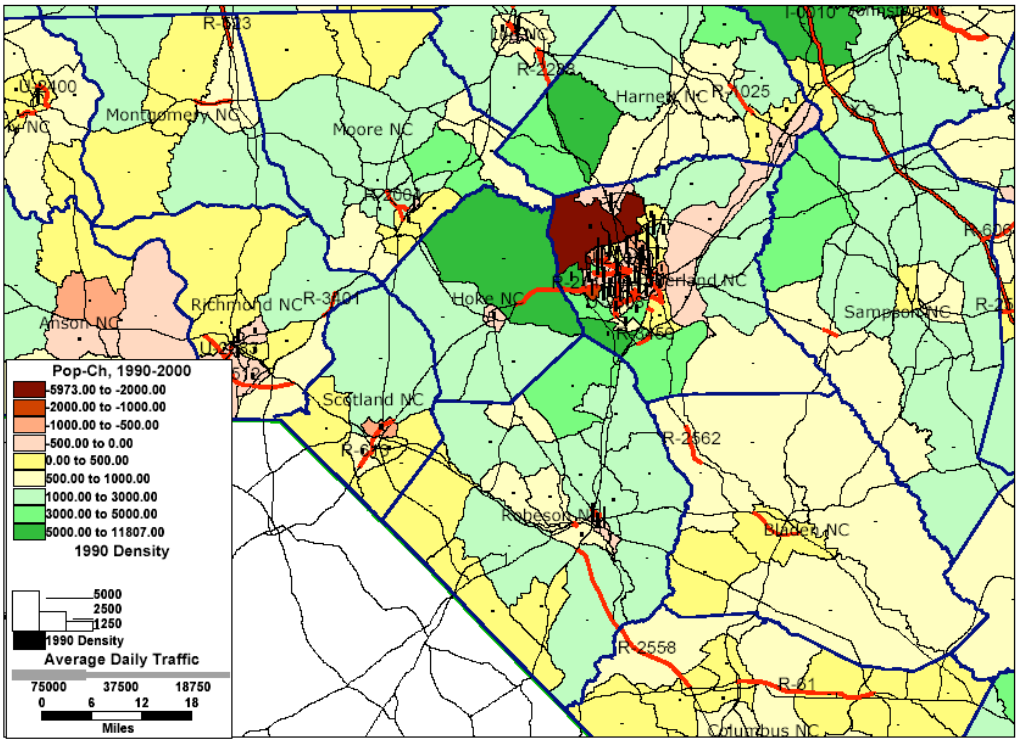
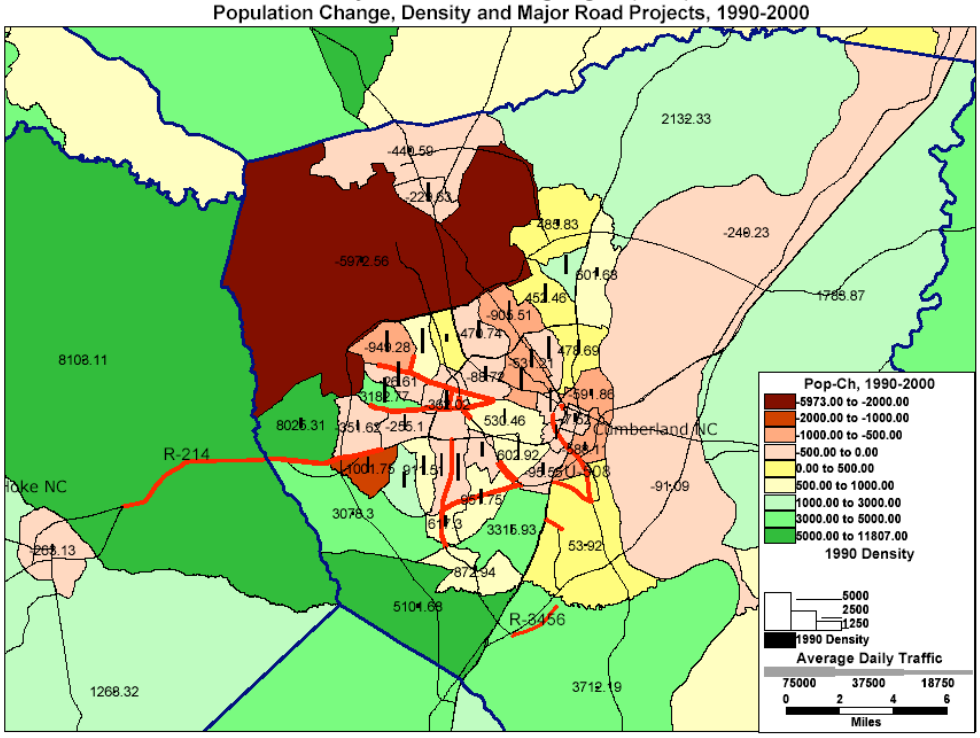


Figure IV.23

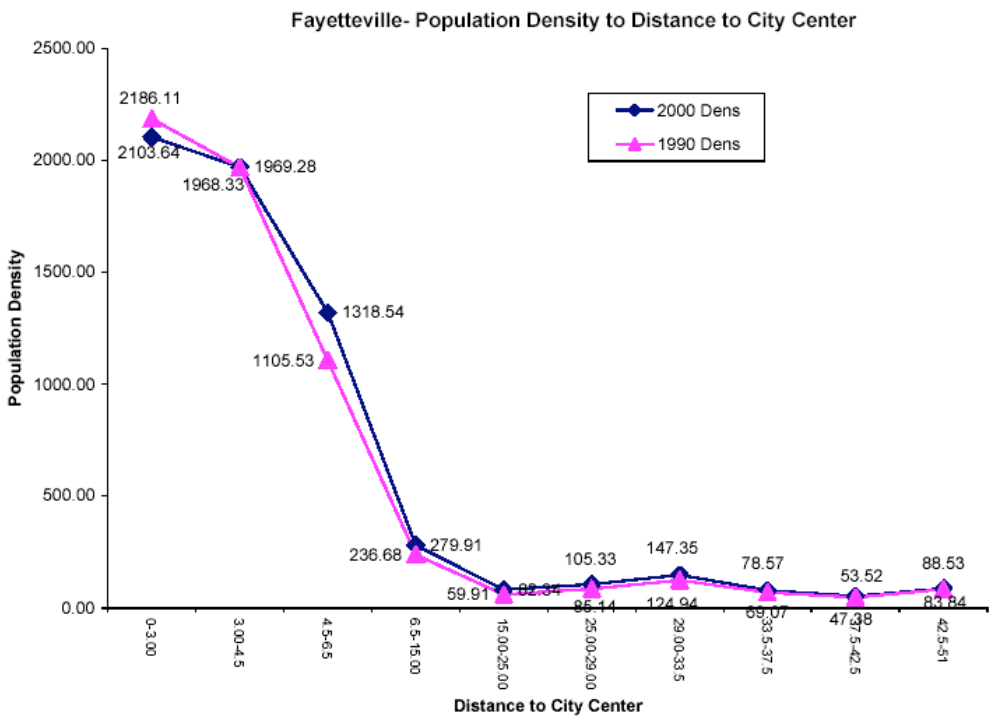
Fayetteville Commuting Region (Inner)
Population Change, Density and Major Road Projects, 1990-2000



persons per decade. The most rapid growth, over 8000 persons per decade, has been in tracts east of Fayetteville, particularly Raeford and Southern Pines. Several tracts south and northeast of Fayetteville have shown growth of 3000-5000 persons, and numerous others report growth of 1000-3000 persons. These increases were partially offset by reductions in populations in several largely military tracts reflecting changes in military deployment. Within the city of Fayetteville, growth was more modest with some tracts increasing slightly but most declining slightly.

Tract densities in the Fayetteville region have increased modestly. Figure IV.24 indicates that the region's density has risen slightly in most distance ranges from the city center. In the innermost ring, 0-3 miles from the city center, densities decreased slightly from 2186 to 2104 persons per square mile, about 3.9 percent. In the 3-4.5 mile ring densities remained virtually unchanged. In the 4.5-6.5 mile ring, the increase was about 19 percent, indicating that the greatest relative increase was in suburban tracts.

Figure IV.24



Inter-county commuting in the Fayetteville is not as strongly focused as in other regions. Indeed, the largest inter-county commute is from Harnett County to Cumberland County, about 7200 commuters; see Figure IV.2 (But even more Harnett residents, about 8000, commute north to Wake County). About 5100 residents of nearby Hoke County commute to Cumberland County and about 3900 residents of Robeson County commute north to Cumberland County.

2. Major Road Improvements

About 38 major projects were undertaken in the greater Fayetteville commuting area during the past decade. Most of these (Table IV.11) were widening of urban and rural arterials, but several were portions of new freeway sections and freeway widening.

Table IV.11: Major Road Projects, Fayetteville Area, 1990-2000

Type of Project	Number of Projects	Total Miles	Total Cost, $M
1-New 2L Arterial	2	2.84	2.70
2-Widen Urban Arterial	16	50.66	121.57
3-New 4L Freeway	6	42.21	202.62
5-Widen Rural Arterial	9	62.87	186.84
6-Widen Freeway or Arterial to 6 Lanes	1	1.27	3.50
7-New Exit	2	1.40	5.70
11-New 4L Arterial	2	2.48	7.00
Total	**38**	**163.71**	**529.93**

Among the major projects were the Rockingham Bypass portion of US 74; portions of US 15-51 bypass of Laurinburg; widening of US 74 in Robeson county; a new exit on I-95 south of Lumberton; upgrading of US 1 and US 64 in Chatham County; Bonanza Road, Skibo Road, Raeford Road and Owen Drive in Fayetteville; Wilkes Road in Fayetteville; NC 87 in Fayetteville; and Airport Road in Fayetteville. The total cost of these major projects was about $530 M.

3. Factors Influencing Growth

The locations of the major road projects along with the growth patterns suggests that many of the urban projects were in locations that grew in prior decades, and so the road projects were implemented to deal with existing congestion rather than spur new growth. This is borne out by the results of the regression modeling, which shows an overall weak model explaining only about 11 percent of the variation in tract growth. Within this weak model, the primary factors influencing growth are prior density, distance to city center, and rural road widening. The model for tract growth in the Fayetteville commuting area is:

$$\begin{aligned} \text{Population Growth} &= 1745.4 \\ &- 0.61_{t=-3.5}\,(\text{1990 Density}) \\ &- 23.8_{t=-2.2}\,(\text{Distance to City Center}) \\ &+ 206.9_{t=2.0}\,(\text{Widen Rural Arterial Miles}) \end{aligned}$$

N = 126, RSQ = 0.107, F = 5.98

This model is interpreted as indicating that tract growth slows as prior density increases (the same finding as in other regions) and as distance to city center increases. There are

no income-related or race-related terms in the model, indicating that these factors are basically unimportant in influencing growth once the basic factors of density and distance are accounted for. So, for an 'average' tract with 1990 density of 800 persons per square mile and about 20 miles from the city center, the 'baseline' expected growth would be about:

Population growth = 1745.4 – 0.61*800 – 23.8*22 = 733 persons per decade,

about 12.5 percent.

The model also contains a term reflecting the influence of rural arterial road widening, increasing tract growth by about 206.9 persons per decade, for each mile of widening. So if the 'average' tract also contained a 1-mile rural road widening, it would be expected to grow by an additional 207 persons (940 total) or about 16.1 percent. This means that the road widening would increase the population of the 'average' about 3.6 percentage points. Of course, less populated tracts would be affected relatively more, while tracts with greater population would show less relative impact.

In the Fayetteville region, widened rural arterials such as US 74 increased access to regional centers.

L. Jacksonville Commuting Region

1. Growth Pattern

The greater Jacksonville commuting region consists of five counties on the eastern shore of North Carolina (Onslow, Jones, Craven, Pamlico and Carteret). About 324,000 people inhabit the region.

The economic base of the Jacksonville commuting region is a mix of military, retail and services, ocean-related businesses and tourism. Onslow County and Jacksonville, the home of Camp Lejeune, are focused on the military economy and have seen reductions in population related to national military staffing trends. However, nearby Carteret County also has military activity at Cherry Point but is also focused on ocean-related industries at the Port of Morehead City. It also has a strong ocean-oriented recreational component focused on Emerald Isle, Atlantic Beach, Beaufort and the outer banks. New Bern and Pamlico and Craven Counties also have a strong tourism focus, while Jones County is more rural in character.

New Bern's historic attractions and charm attract tourism and retirees.

This mix of activities leads to differing sub-regional commuting patterns and different growth rates. Overall the region's population growth was slightly faster than the State, 25.4 percent in the last decade, but lagged the State in per-capita income. Figure IV.25 shows that the most rapid growth, 3000-5000 persons, occurred in several shore tracts in Carteret and Pamlico Counties. More modest growth, 1000-3000 persons,

occurred in Craven County, northwestern Carteret County, and western Onslow County. Jones County tracts generally grew more modestly, 0-500 persons per decade. Within the City of Jacksonville, population declined in line with national military trends and some overseas assignments. Figure IV.26 shows that densities are highest near the city center,

Figure IV.25
Jacksonville Commuting Region
Population Change, Density and Major Road Projects, 1990-2000

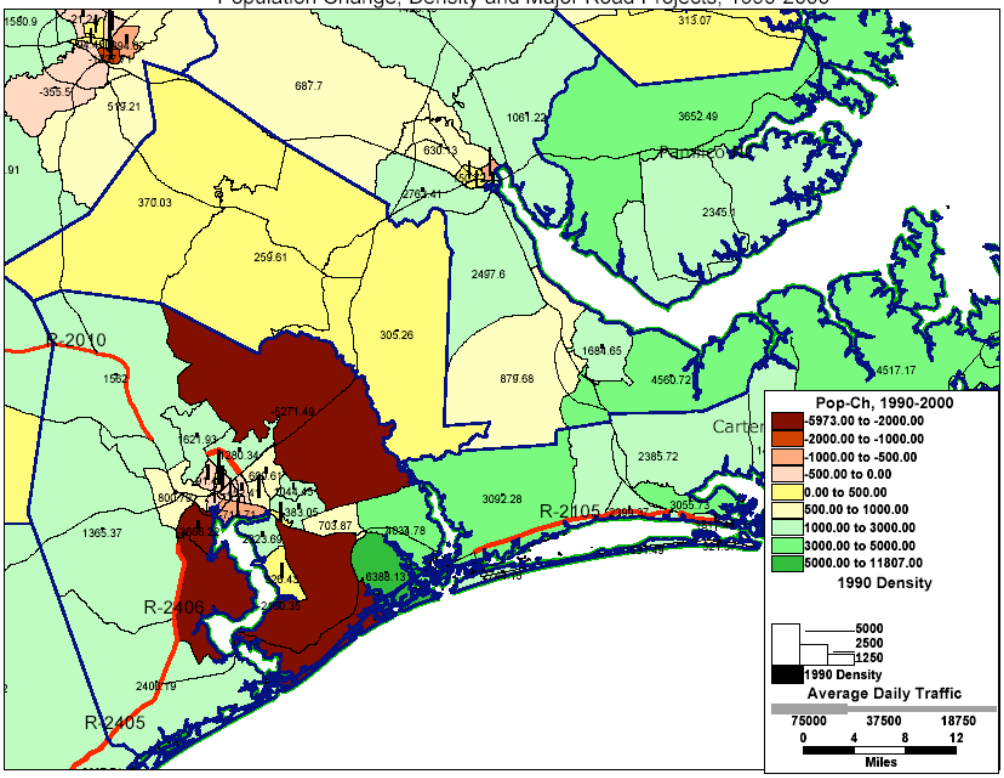
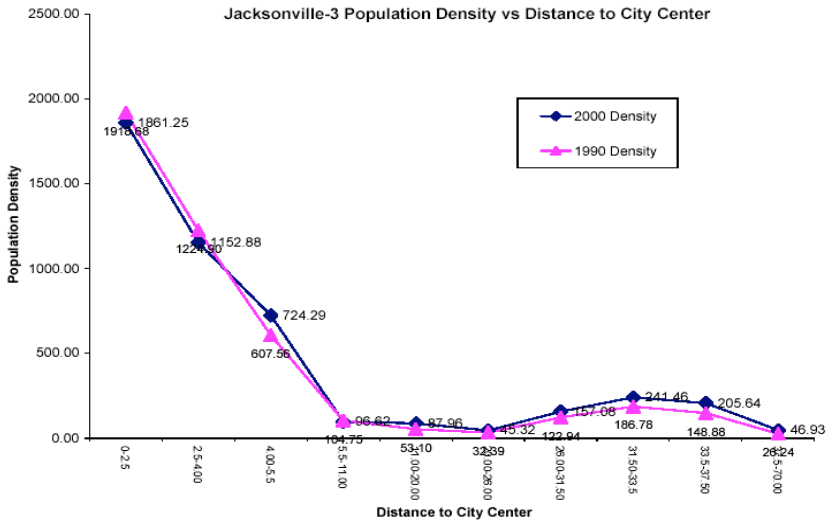


Figure IV.26



are declining slightly in the first 4-mile rings, but are increasing slowly in the remainder of the region. The greatest relative rise, about 40 percent, was in the 31-37 mile range, corresponding to the rapid population growth on the ocean islands some distance from Jacksonville.

This economic structure, geographically dispersed and focused on separate economic sectors, yields less inter-county commuting than might be expected otherwise. Figure IV.2 indicates that the greatest inter-county flow, about 1800 workers, is from Craven to Carteret County. Fewer commuters, about 1600, commute daily from Carteret to Onslow, the nominal central county of the region. The region also has some out-commuting to nearby Kinston (500 to Duplin County), Greenville (74 to Pitt County), and even a few long-distance commuters to the Raleigh area.

2. Major Road Projects

There were five major road projects implemented in the region during the 1990s. These were primarily widenings of urban and rural arterials. In Onslow County NC 24 was widened from Beaulaville to Jacksonville, and US 17 was widened from Holly Ridge to Jacksonville. In Jacksonville, Western Boulevard was extended to Gum Branch Road. In Carteret County, portions of NC 24 were widened between Swansboro and Morehead City.

Table IV.12: Major Road Projects, Jacksonville Commuting Region, 1990-2000

Project Type	Number	Total Miles	Total Cost, $M
1-New 2L Arterial	1	3.54	2.80
2-Widen Urban Arterial	2	18.82	46.9
5-Widen Rural Arterial	2	24.64	63.60
Total	**5**	**47.00**	**113.30**

3. Factors Affecting Growth

Given the relative dearth of major road projects in this region during the 1990s and the concentrations of growth along coastal tracts, it might be expected that the resulting model of growth would be only modestly strong. This is confirmed by the model:

Population Growth = 3171.84
- 63.7 $_{t=-3.85}$ (Distance to Coast)
+ 192.6 $_{t=1.92}$ (Widen Rural Arterial Miles)

N = 55 RSQ = 0.199 F=7.71

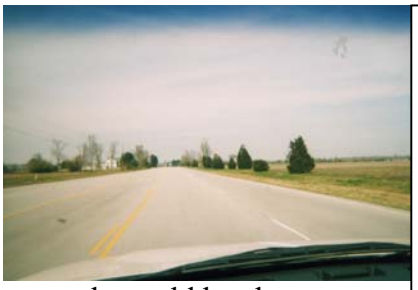
This model is only modestly strong, explaining about 20 percent of the variation in tract growth. However, the model does not contain terms for density or distance from city center, indicating the diffuse nature of growth relative to the location of city center. Instead, the model contains terms indicating the importance of distance from the coast,

and mileage of rural arterial widenings. Growth declines sharply with distance from the coast, but increases modestly with increased rural arterial widenings. So, for an 'average' tract 33 miles from the coast the expected growth would be:

Population Growth = 3171.8 – 63.7 (33) = 1069 persons per decade,

or about 22.5 percent. If a 1-mile rural road widening improvement is made, the expected growth in the 'average' would be:

Population Growth = 1069 + 192.6 = 1260 persons per decade,



NC 24 between Beaulaville and Jacksonville was widened to a 5-lane rural arterial, increasing access .

about 26.5 percent, 4 percentage points faster than the baseline growth.

On the other hand, if the tract were located near the oceanfront but had no road improvements, the growth would be about:

Population growth = 3171.8 – 63.7(2) = 3044 persons per decade.

The Jacksonville analysis indicates the importance of coastal access in recreational areas relative to the effect of road improvements, which are about 1/10 as much an impact. It also illustrates the weaker impact of density on growth in rural areas where the traditional density relationships no longer hold.

M. Hickory-Morganton Commuting Region

1. Growth Pattern

The greater Hickory-Morganton commuting area consists of five counties in west central North Carolina (Alexander, Caldwell, Catawba, Burke and McDowell) for which Hickory and Morganton are the principal urban areas. The region is bounded on the east by the Catawba River and the west by the line of the Blue Ridge Mountains. On the north, the eastern Continental Divide (essentially the Blue Ridge Parkway) forms the border, and on the south the region's border is the piedmont plain. Interstate 40 is the principal road traversing the region east-to-west and forms the major commuting axis. The major north-south roads are US 321 through Hickory and Lenoir and US 221/NC 226 through Morganton.

Historically, the region's economy has been heavily tied to the furniture industry focused on Hickory although in recent years other economic activity has increased its presence. Given national downturn in manufacturing it is perhaps not surprising that the region's economic growth has lagged the State. During the 1990s the population of the region increased about 17.0 percent to 384,000. However, the region's per-capita income is close to the state average and it posted one of the highest gains in PCI during the 1990s.

Figure IV.27 shows the pattern of growth. Overall, the 'average' tract increased population by about 727 persons per decade. The fastest growth, 1700-2500 persons per decade, took place in tracts near Interstate 40 in suburban tracts on the edges of

Morganton and Hickory. Densities generally rose throughout the region during the 1990s, although modestly. Figure IV.28 indicates that in-city tracts, 0-3 miles from city centers, increased their densities by about 6 percent, while suburban tracts 3-5.5 miles from city centers increased their densities by about 23-29 percent.

Figure IV.27

Hickory Commuting Region

Population Change, Density and Major Road Projects, 1990-2000

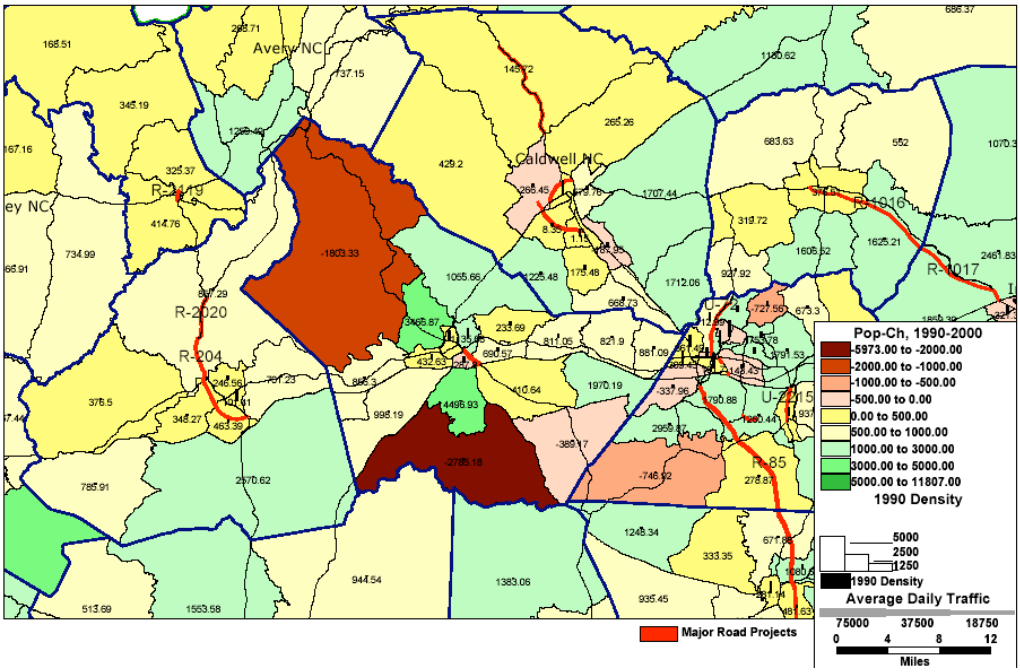
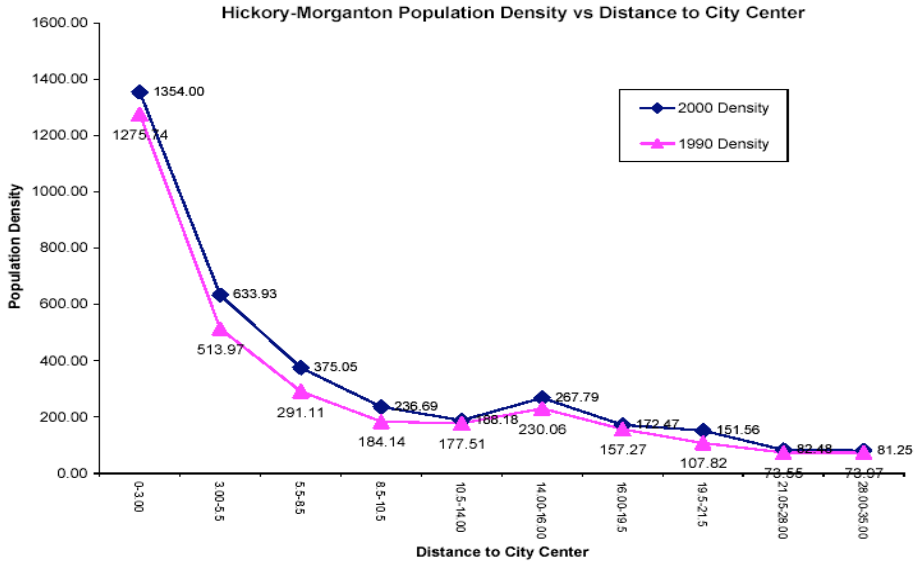


Figure IV.28



Inter-county commuting is largely focused on Hickory, the largest city. Figure IV.2 indicates that about 8000 residents of Caldwell County commute daily to Catawba

County, 8400 commute daily from Burke County to Catawba County, and about 5700 commute daily from Alexander County to Catawba County. Longer-distance commuting to the greater Charlotte region is also apparent, but of smaller magnitude.

2. Major Road Improvements

During the 1990s about 13 major road projects were implemented in the Hickory-Morganton commuting area. Table IV.13 indicates that these were primarily urban and rural road widenings.

Table IV.13: Major Road Projects, Hickory-Morganton Region, 1990-2000

Project Type	Number	Total Miles	Total Cost, $M
1-New 2L Arterial	3	12.46	31.41
2-Widen Urban Arterial	6	12.84	58.80
5-Widen Rural Arterial	2	12.95	37.80
11-New 4L Arterial	2	11.17	63.40
Total	**13**	**49.45**	**191.41**

Among these were the widening of NC 226 from Marion to Woodlawn, completion of US 321 in Catawba County, portions of US 64 in Alexander County, Lenoir Rhyne Drive in Hickory, US 127 in Hickory, US 321B in Newton, and new arterials in Lenoir. However, clearly these projects were not in the areas of greatest growth during the 1990s.

3. Factors Influencing Growth

The above maps and discussion suggest that the relationship between major road projects and 1990s growth is likely to be weak at best. The modeling analysis for the region confirms, producing a very weak model that explains only 7 percent of the variation in tract growth:

Population Growth = 1289.9
- 0.54 $_{t= -2.4}$ (1990 Density)
- 53.9 $_{t= -2.2}$ (Distance to Interstate)

N = 77, RSQ = 0.074, F = 4.03

This is one of the weakest models in our analysis, indicating that almost all of the variation in tract growth in the region is related to factors not in the model or in the list of other terms. As with other regions, the primary factor is prior density, indicating that tract growth spills over to less dense tracts as denser ones fill up. Distance to Interstates is also a mildly important factor in tract growth. Tract growth slows as distance to the interstate system increases. However, no road-project variables entered the model, indicating that from a regional perspective they are not significant factors in directing tract growth.

Those familiar with the Hickory area may be surprised at these findings, since US 321connecting the region to Charlotte-Gastonia was opened early in the 1990s. However, the region's overall growth has been slow and no major residential development has yet

occurred in the US 321 corridor, so the model accurately reflects the recent growth pattern.

N. Greenville-Rocky Mount Commuting Region

1. Growth Patterns

The Greenville-Rocky Mount commuting region covers a broad area in east central North Carolina, stretching from Bertie, Edgecombe and Beaufort Counties on the east to Nash, Wilson and Wayne Counties on the west, and from the Virginia state line south to Duplin County in the I-40 corridor. About 784,000 people inhabit the region. The economy consists of a mix of agriculture (historically cotton and tobacco but increasingly grain crops) manufacturing, government, education and services. Several mid-sized cities (Greenville, Rocky Mount, Tarboro, Roanoke Rapids, Kinston, Wilson, and Goldsboro) constitute the region's urban structure, but their spread-out geography creates a relatively low-density urban pattern. Growth has been relatively slow. The region gained just 11 percent in population during the 1990s, about _ the State's average, and per-capita income lagged the State. Of the State's 100 counties, two of the three that lost population during the 1990s were in this region.

Figure IV.29 shows the patterns of growth in the region's census tracts. Overall, the average tract grew about 495 persons per decade. The most rapid growth (1000-3000 persons per decade) was in Nash County north and west of Rocky Mount, within commuting distance of Raleigh via US 64. Wayne County northeast of Goldsboro and Pitt County near Greenville also reported strong growth. But many other tracts in the western half of the region recorded gains of 500-1000 persons. On the eastern side of the region, however, growth was much slower or even negative, with tracts loosing population in Martin, Bertie, Northampton, Hertford, and Edgecombe Counties.

Population densities rose very modestly in this region during the 1990s. Figure IV.30 shows that densities increased slightly in all distances from city centers, although the largest relative increase (about 33 percent) was in the 3-7 mile range, corresponding to city suburbs in these relatively small cities.

Although the overall region is quite large, the dispersed location of the larger cities leads to relatively short distances between the larger urban areas and makes inter-county commuting possible. Commuting flows are not concentrated on just one urban county but are more dispersed throughout the region (see Figure IV.2). The largest inter-county commuting, about 6800 workers, is from Edgecombe County (Tarboro) to Nash County (Rocky Mount). About 3700 workers commute in the opposite direction. Other large flows are from Wilson County to Nash County (2500) and from Beaufort County to Pitt County (2600).

Figure IV.29

Greenville-Rocky Mt Commuting Region

Population Change, Density and Major Road Projects, 1990-2000

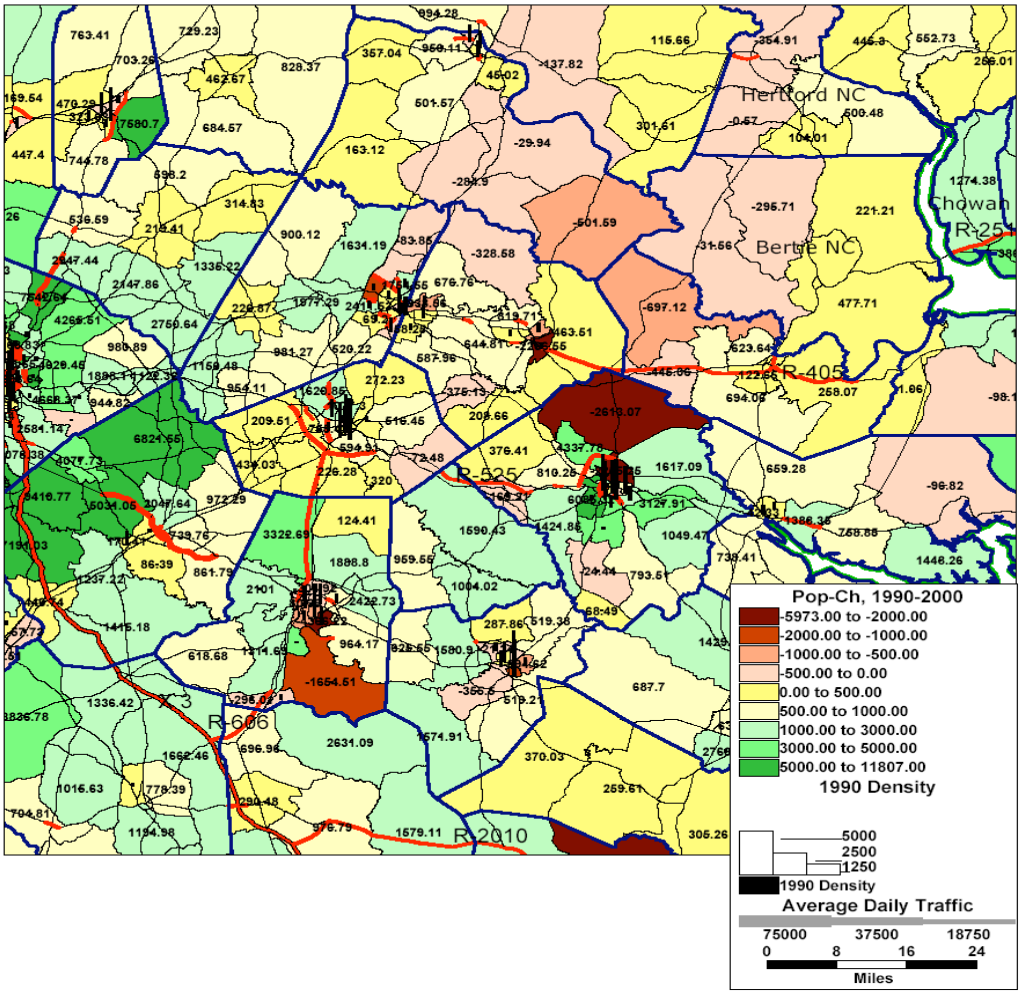
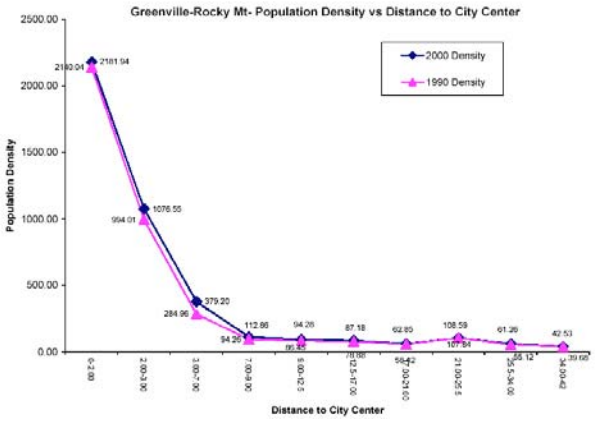


Figure IV.30



2. Major Road Improvements

A number of major road improvements were made in the region during the 1990s. All total about 35 major projects were undertaken as indicated in Table IV.14. Most of these were widenings of urban and rural arterials but several new freeway sections and arterials were also built and several new exits on existing freeways were also developed. On the western edge of the region, I-40 was also completed from Raleigh to Wilmington.

Table IV.14: Major Road Projects, Greenville-Rocky Mount Region, 1990-2000

Project Type	Number	Total Miles	Total Cost, M$
1-New 2L Arterial	1	1.55	8.40
2-Widen Urban Arterial	15	30.92	72.50
3-New 4L Freeway	7	155.10	555.59
5-Widen Rural Arterial	2	19.34	78.60
7-New Exit	4	6.81	30.40
9-One Way Pair	1	2.38	4.20
11-New 4L Arterial	5	50.83	156.47
Total	**35**	**266.83**	**906.16**

Among the projects were widening of NC 48 and a partial loop in Roanoke Rapids; a bypass around Murfreesboro; portions of US 64 and two new exits between Tarboro and Williamston; portions of US 70 in Kinston; widening NC 24 between I-40 and Warsaw. Widening of NC 24 between I-40 and Beaulaville; portions of US 117 between I-40 and Wilson; portions of US 264 around Greenville; widening of arterials in Rocky Mount; widening portions of US 258 in Kinston; and widening of arterials in Wilson.

Widened NC 24 between I-40 and Warsaw connects the town to the Interstate.

3. Factors Influencing Growth

Although many projects were completed in this region, a glance at Figure IV.29 suggests that the growth pattern of the region is only loosely correlated with these specific improvements. Indeed, the modeling analysis found no significant correlation between road projects and the growth pattern, which was so dispersed that even the 'density' relationship found in other regions did not hold. The model for tract growth in this region is:

$$\text{Population Growth} = 306.3 + 0.079_{t=2.26}\,(\text{1990 Per-Capita Income}) - 13.1_{t=-2.7}\,(\text{Percent Nonwhite Population})$$

N = 157, RSQ = 0.162, F=16.11

So, an 'average' tract with 1990 per-capita income of $10,279 and 47.9 percent nonwhite population would be expected to grow by about:

Pop Growth = 306.3 + 0.079 (10279) – 13.1(47.9) = 491 persons per decade.

However, the overall relationship between growth of tracts and the demographic variables is quite weak, explaining only about 16 percent of the variation in tract growth. Further, the only variables correlated with growth were found to be 1990 Per-Capita Income (positive relationship) and Percent Nonwhite Population (negative relationship). This means that the growth in this region, while modest, was quite dispersed with respect to the road improvements, which did not enter the model, and was largely determined by demographic and local factors. Tracts with higher prior income grew more rapidly, while tracts with higher nonwhite percentages grew less rapidly. The lack of correlation with road improvements suggests that the large number of such improvements had the effect of increasing access everywhere and influencing retail and service development rather than residential growth. Alternatively, other local factors were considerably more important than road improvements in directing growth to specific tracts.

Development near I-40 at Warsaw has been retail and service, not residential growth.

O. Eastern North Carolina Commuting Region

1. Growth Patterns

Eastern North Carolina consists of a group of counties on the shoreline (Hyde, Dare and Currituck) and counties immediately inland on the coastal plain (Tyrrell, Washington, Camden, Pasquotank, Perquimans, Gates, and Chowan) adjacent to Pamlico and Albemarle sounds. About 131,000 people inhabit the region. The largest city is Elizabeth City. Relatively isolated from the rest of North Carolina by water and distance, these counties' economies are increasingly recreation-based although agriculture also plays a major part. As a group the region has lagged the State in per-capita income, but overall has seen quite rapid population growth in tracts on the coast and sounds have grown quite rapidly. The region is a study in contrast, with some tracts growing rapidly and others growing slowly or declining.

Figure IV.31 shows the growth pattern for the region. Overall, growth was quite high, averaging 1499 per tract. However, growth has been concentrated in tracts that border the Atlantic Ocean and Pamlico and Albemarle Sounds, some of which grew by 3000-6000 persons in just one decade. The coastal areas of Manteo and Kill Devil Hills showed particularly strong growth. Inland and north, however, growth was less spectacular, and some tracts back from the shoreline lost population. Since the region does not have any major cities the usual relationship between density and distance to city center does not hold.

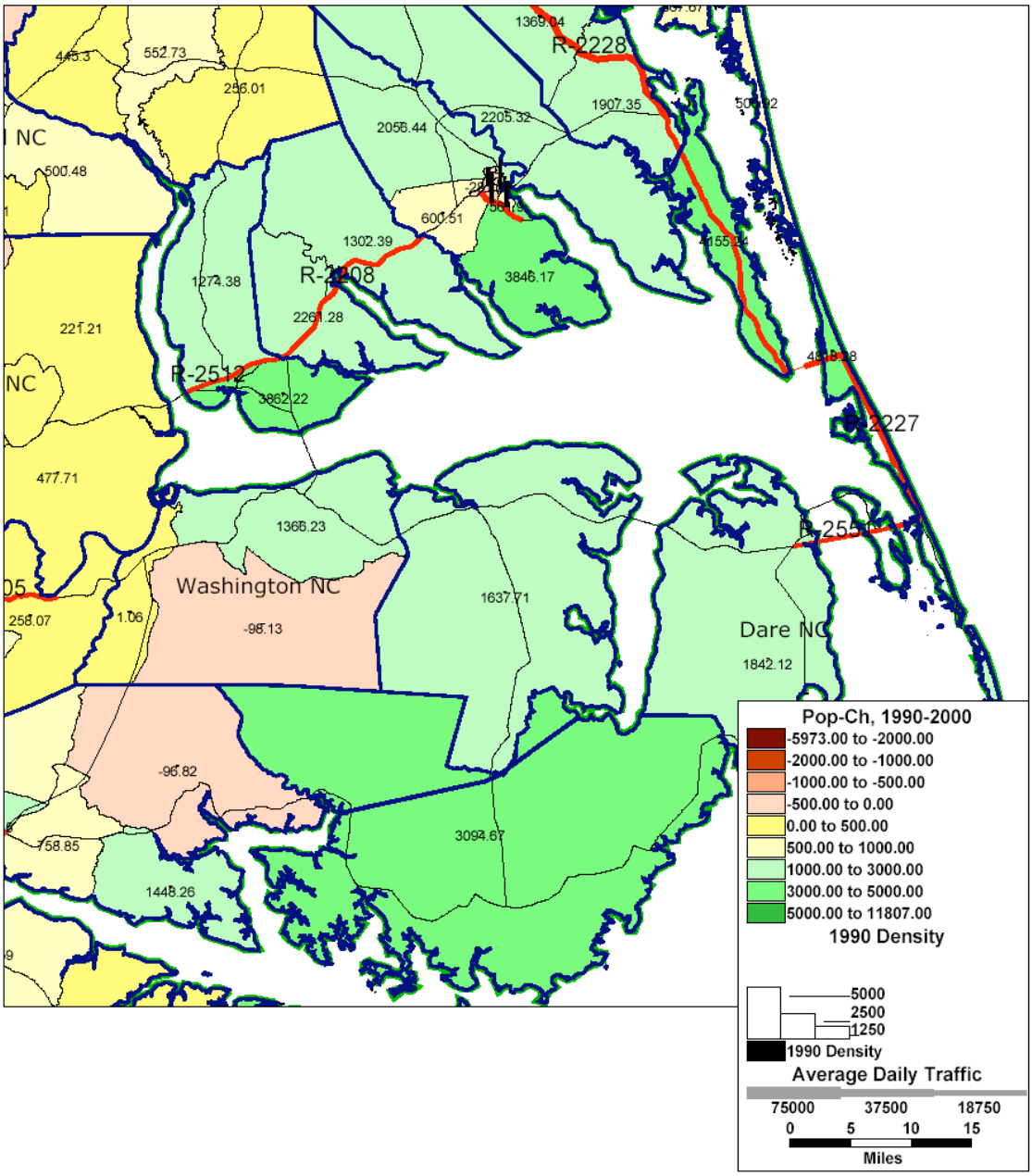
Inter-county commuting in the region (Figure IV.2) shows modest flows between all the counties of the area and across the State line to the Newport News-Norfolk, VA region. The largest inter-county flows are from Pasquotank County north to Chesapeake

County, VA (1270 daily workers), and from Pasquotank County to Virginia Beach (1032 workers). This region has the highest percentage of carpooling in North Carolina, and one of

Figure IV.31

Eastern NC Commuting Region

Population Change, Density and Major Road Projects, 1990-2000



the longest average travel times, as some local residents commute long distances for jobs in larger cities in Virginia.

2. Major Road Improvements

A number of major road projects have been implemented in the 1990s. Of the total 11 major projects (Table IV.15), most were widenings of urban and rural arterials.

Table IV.15: Major Road Projects, Eastern North Carolina, 1990-2000

Project Type	Number	Total Miles	Total Cost, $M
1-New 2L Arterial	2	4.93	31.08
2-Widen Urban Arterial	3	28.42	30.70
3-New 4L Freeway	1	8.72	118.68
5-Widen Rural Arterial	5	59.22	182.92
Total	**11**	**101.29**	**363.38**

Among the major projects were the widening of NC 168, NC 3 and NC 12 in Currituck and Dare Counties; expansion of the Point Harbor-Southern Shores bridge; a new crossing for US 64/264 at Manteo; widening of US 17 in Chowan and Perquimans Counties; and widening of NC 34 in Elizabeth City. Although the region does not, generally, have the traffic loads of other regions, these improvements were undertaken to improve access under the State's Infrastructure Act, to encourage tourism, and to provide capacity for emergency evacuations.

3. Factors Affecting Growth

The complex nature of growth in this region, affected by coastline, local economy, density and road improvements leads to a more complex model than in most regions:

Population Growth = 1807.99
- 0.58 $_{t=-2.16}$ (1990 Density)
- 16.1 $_{t=-0.94}$ (Distance to Coast)
+ 50.7$_{t=0.71}$ (Widen Rural Arterial Miles)
+ 143.9 $_{t=2.36}$ (Widen Urban Arterial Miles)

N = 27, RSQ = 0.335, F = 4.32

This model is modestly strong, explaining about 34 percent of the variation in tract growth. Two terms, prior density and urban arterial mileage, are particularly significant, while two other factors, distance to coast and rural arterial mileage, are less important. So, for a coastal tract with density of 1000 persons per square mile, the 'baseline' expected growth would be:

Population Growth = 1808 –0.58 (1000) – 16.1 (1) = 1211 persons per decade,

or about 35.8 percent. However, if the tract also had a 1-mile urban arterial widening, the growth would be:

Population Growth = 1211 + 143.9 = 1355 persons per decade

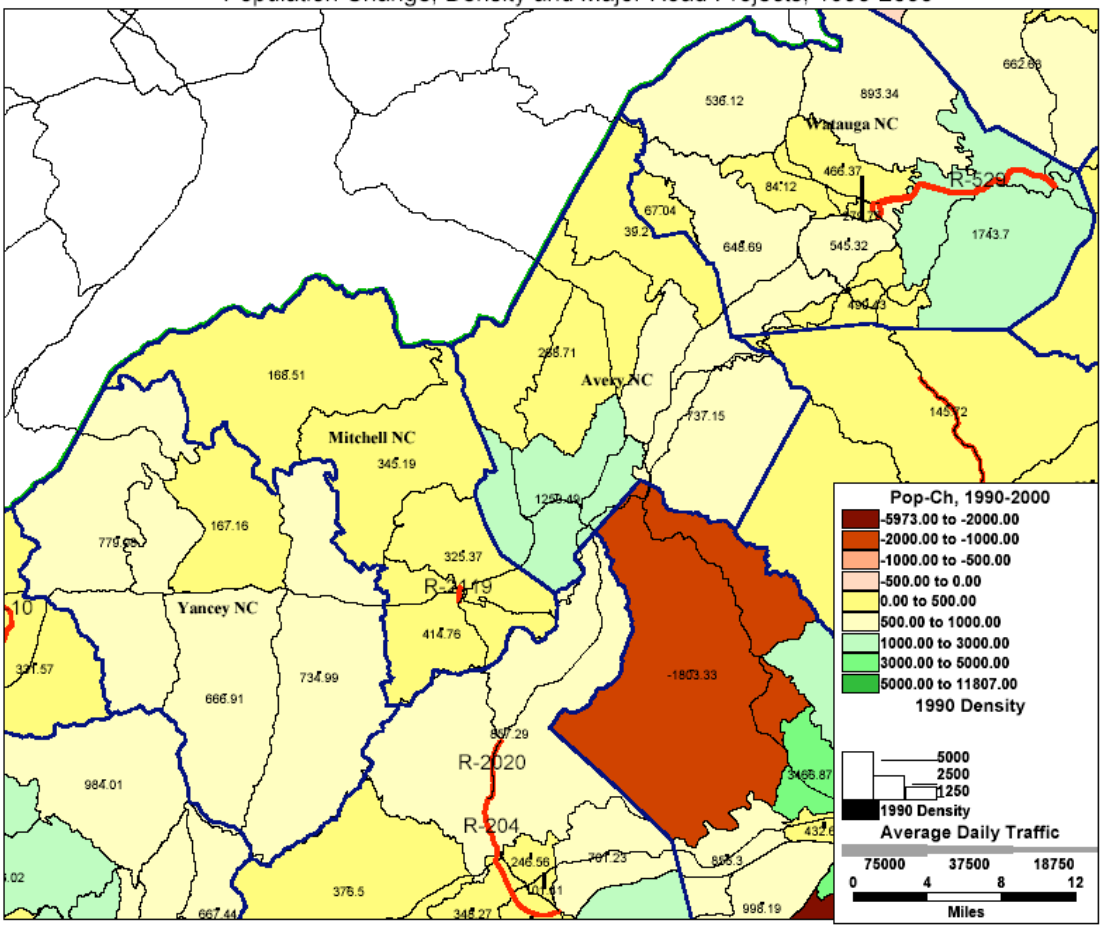
or about 40.0 percent. So, while location and prior growth are the key factors influencing eastern NC tract growth, major road improvements can accelerate that growth by about 3.2 percentage points over what it would have been without the improvement.

P. Boone-Spruce Pine Commuting Region

1. Growth Patterns

The Boone-Spruce Pine commuting region is a group of just four counties (Yancy, Mitchell, Avery and Watauga) between the eastern continental divide and the Tennessee state line, on the far northwest corner of North Carolina. Although some analysts would the split the region between Asheville and Hickory areas, our review of the commuting patterns suggests that it operates more as a separate region than as an adjunct to those other areas, relatively isolated by distance and the eastern continental divide.

Figure IV.32
Boone- Spruce Pine Commuting Region
Population Change, Density and Major Road Projects, 1990-2000

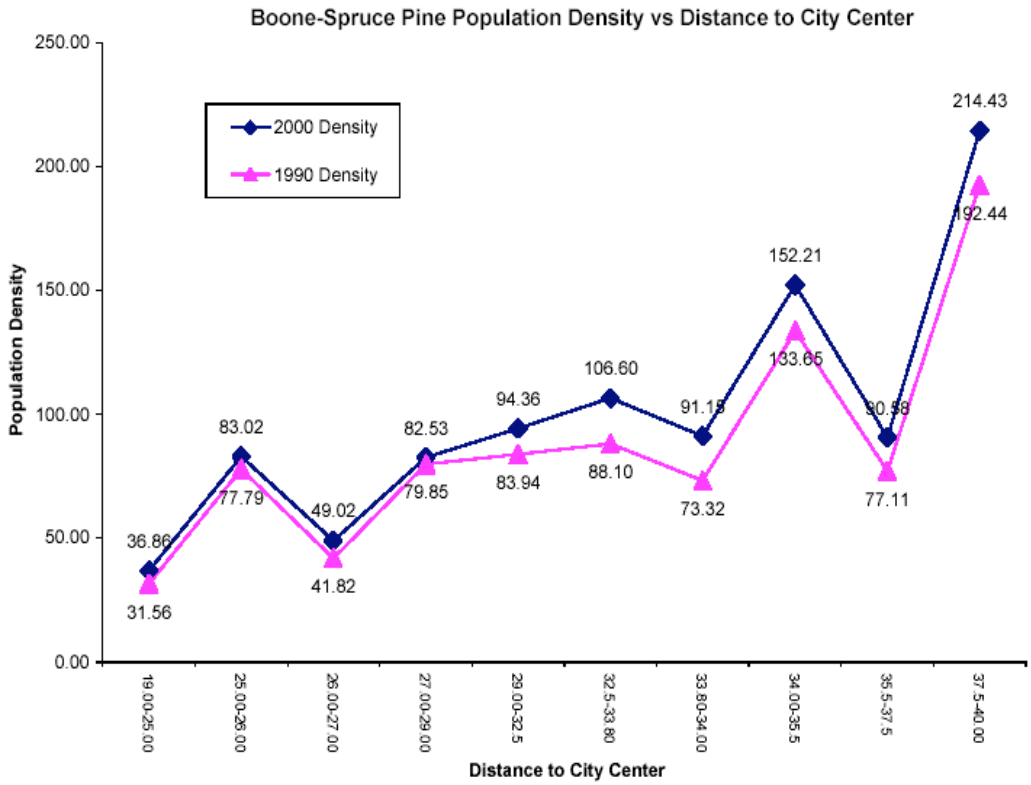


About 93,000 people inhabit the region. The area economy is a mixture of recreation, tourism, education, government and services. It has experienced just modest growth in the past decade (14.8 percent, slower than the State as a whole), but has

become more recreational and tourist in its focus. The largest urban areas, Boone-Blowing Rock and Spruce Pine-Penland, are increasingly thought of as mountain craft and culture areas.

Figure IV.32 shows the pattern of growth for the tracts in this largely rural area. Overall the growth has been modest, just 530 persons per decade for the average tract. The fastest growth, close to 1000 persons per decade, has been in the two tracts comprising Spruce Pine and Boone-Blowing Rock. More modest but still positive growth was experienced in the more western tracts near the Tennessee line. Densities have been rising throughout the region (Figure IV.33), but because of the small size of local cities, the normal density decay curves are not apparent.

Figure IV.33



Inter-county commuting is generally less significant than in larger regions, yet Figure IV.2 shows that the region's residents commute within counties, between counties, and between regions, particularly to the Asheville and Hickory regions. There is even some cross-state commuting to larger cities (Johnson City, Bristol) in Tennessee. The largest inter-county commuting flows are from Yancy to Mitchell County (1000 daily workers), Avery to Mitchell County (640) and Avery to Wautauga County (560).

2. Major Road Improvements

Four major road projects were implemented in this region during the 1990s and shortly thereafter. These consisted of improvements to US 421 between Boone and Deep Gap, several urban widening projects in Boone, and portions of NC 226 bypass around Penland.

Table IV.16: Major Road Projects: Boone-Spruce Pine Region, 1990-2000

Project Type	Number	Total Miles	Total Cost, $M
2-Widen Urban Arterial	2	1.17	10.7
5-Widen Rural Arterial	1	10.84	78.9
11-New Arterial	1	0.85	13.5
Total	**4**	**12.86**	**103.10**

These projects were implemented for traffic, safety, and connectivity purposes.

3. Factors Influencing Growth

The road improvement projects were generally in the areas of highest growth, and so some correlation between the road projects and growth is apparent in the model of growth for this region:

Population Growth = 617.2
- 22.0 $_{t=-1.50}$ (Distance to Blue Ridge Parkway)
+ 122.9 $_{t=3.53}$ (Widen Rural Arterial Miles)

N = 22 RSQ = 0.448 F = 9.51

This model, while quite strong overall (explaining about 45 percent of the variation in tract growth), does not have the 'density' term observed in other regions. Instead, the model relates tract growth to distance from the Blue Ridge Parkway (the farther away, the slower the growth), and widened rural arterial miles. For an 'average' tract 7 miles from the Blue Ridge Parkway, the expected growth would be:

Pop Change = 617.2 – 22.0 (7) = 463 persons per decade,

or about 12.5 percent. However, if a 1-mile section of rural arterial in the tract is widened, the growth increases to 586 persons per decade, or about 15.8 percent. Thus, the road widening would add about 3.3 percentage points to the growth that might be expected otherwise.

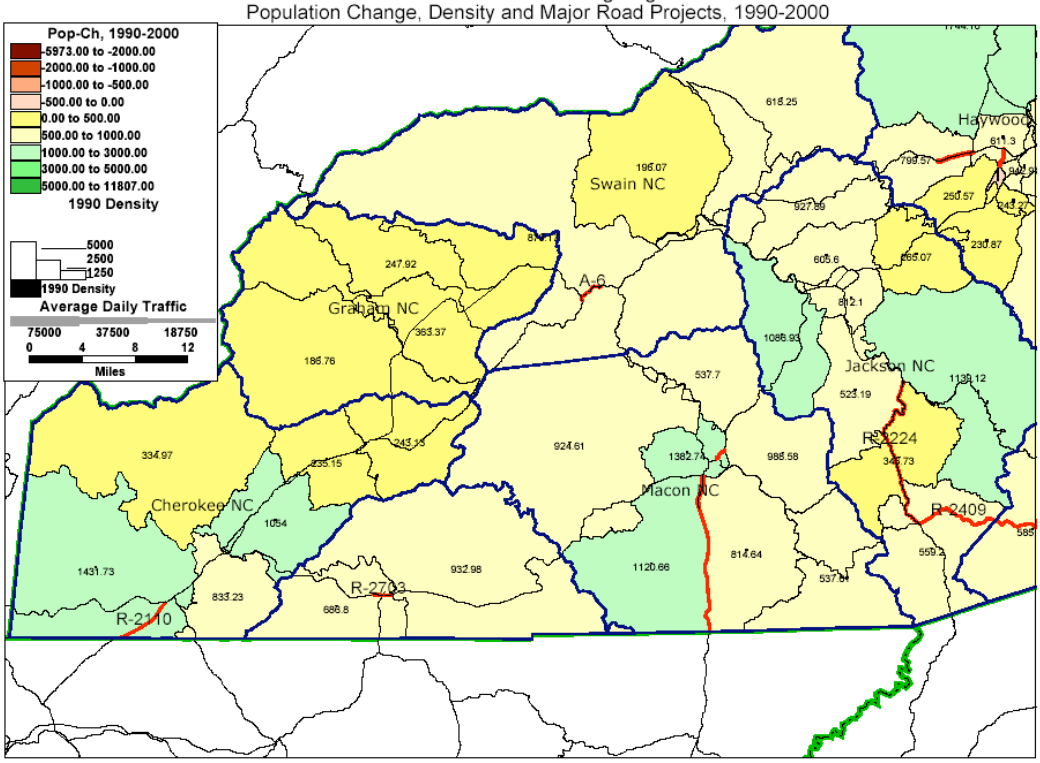
Q. Western NC Commuting Region

1. Growth Patterns

The Western North Carolina commuting region consists of six counties in far western NC, between Georgia to the south and Tennessee to the north and west. About 117,000 people inhabit the area. The western NC economy is a mixture of recreational, service, education and government. Much of the region is national and state forest, and the region has only a few small urban centers. The region's growth rate during the 1990s, 21.8 percent, was close to the overall State average. However, growth in per-capita

income was greater than the State average, even though the region lagged the state in 2000 PCI, at $17,482.

Figure IV.34
Western-NC Commuting Region
Population Change, Density and Major Road Projects, 1990-2000



Growth patterns in western North Carolina can be characterized as uniformly modestly positive. Figure IV.34 shows the growth of these tracts, along with the major road projects. Overall, the change in population was about 694 persons per decade, about 21.6 percent. Most tracts changed less than 1000 persons, but a few tracts in Cherokee County and Macon County reported increases of 1100-1400 persons. Several of these faster-growing tracts are adjacent to or contained major road projects. Farther north, in Swain and Graham counties, population growth was more modest. Because of the relatively longer distances from major cities, the usual density relationships do not hold for this region. However, Figure IV.35 indicates that densities increased uniformly throughout the region by about 25-35 percent.

Regional commuting patterns show only modest inter-county connectivity: the largest inter-county flows are from Jackson to Swain County (1523 daily commuters), from Jackson to Macon (715), and from Jackson to Haywood County (674) in the Asheville region.

2. Major Road Improvements

There were only 6 major road projects in this commuting region during the 1990s. However three of these were major road widening, totaling about 20 miles and costing over $60m. For the region, the average cost was about $1.47m per lane mile, close to the state average of $1.52 M per lane mile.

Figure IV.35

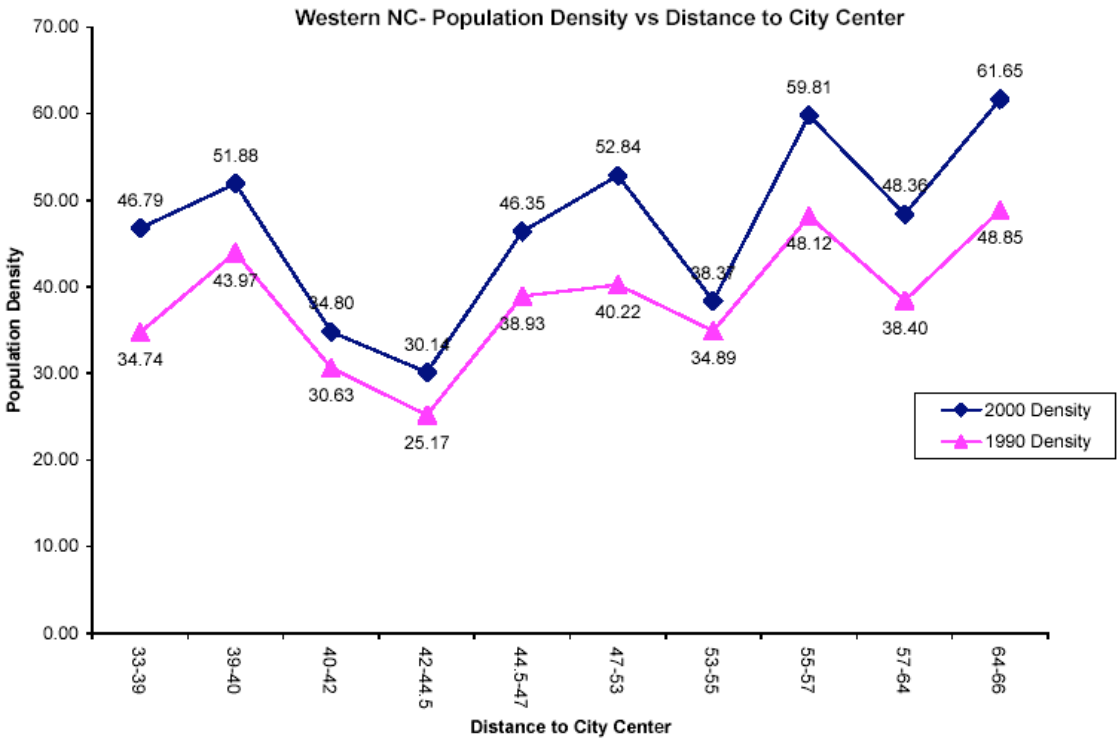


Table IV.17: Major Road Projects, Western North Carolina, 1990-2000

Project Type	Number	Total Miles	Total Cost, $M
2-Widen Urban Arterial	3	5.07	11.50
5- Widen Rural Arterial	3	16.96	62.60
Total	**6**	**22.03**	**74.10**

The major projects included the widening of US 23-441 south of Franklin (R-2103/R-504), and the widening of US 19-129 southwest of Murphy (R-2110). These were done partially for reasons of accommodating traffic and partially to alleviate slow traffic problems in mountainous terrain. These projects might also be interpreted to improve tourist and traffic flow from Georgia into western NC, thus increasing economic activity.

3. Factors Influencing Growth

The generally weak correlation between road improvements and growth is reflected in the weak model of growth for the region:

Population Growth = 728.9
- 1.25 $_{t=-0.38}$ (Distance to Blue Ridge Parkway)
+ 78.1 $_{t=2.32}$ (Widen Rural Arterial Miles)

N = 30, RSQ = 0.105, F=2.70

So, for an "average' western NC tract, 62 miles distant from the Blue Ridge Parkway, the expected growth would be:

Population Growth = 728.9 –1.26 (62) = 650 persons per decade,

or about 16.6 percent. If the tract also has a 1-mile road widening, the growth would be:

Population Growth = 650 + 78.1 = 728 persons per decade,

or about 18.7 percent. So, a modest road improvement would add about 2.1 percentage points to the tract's growth rate.

However, this model explains only 10 percent of the variation in tract growth and contains no demographic terms such as tract density. Distance to Blue Ridge Parkway is included, but it has a weak and very shallow coefficient. This means that the growth of tracts in the Western NC region is largely uniform and generally independent of the spatial data found to influence growth in more urban regions. However, the model does contain a modest road improvement term, which adds 78 more persons to the growth rate for each mile of widened rural arterial. So, although growth in the Western NC region is independent of demographics, it does have some mild correlation with major rural road widening.

V. Conclusions and Policy Implications

A. Conclusions

1. State and County Trends

- Overall, North Carolina's growth in population, households, and employment substantially out-performed the US during the 1990's. **Population increased 21.4 percent in the 1990s, compared with the US growth rate of 13.2 percent.**
- Generally, growth was the **strongest** in and **around large metro regions**, the **coastline**, and **several mountain counties**.
- But North Carolina's **patterns of population growth are complex**. While almost all of the state's counties increased population during the 1990s' the growth rates varied considerably. **Urban core counties, suburban counties, rural and recreational counties all showed growth.** The largest absolute growth was in urban core counties for Charlotte, Raleigh-Durham and Wilmington, while the greatest relative growth was in a combination of suburban, urban and rural counties.
- Major **cities grew faster** than the state averages, and the Hispanic population has been one of the most rapidly-growing segments of the population.
- **In-migration is a major factor** in population growth. Military, education, and recreation-related migration are all underlying causes.
- **Interstate access was only mildly correlated with county population growth** during the 1990s. While some of the fastest growing counties were those with Interstate access, other rapid growers had no access. Similarly, many slow-growing counties had Interstates but others did not.
- Household change generally mirrors but is slightly faster than population change.
- **Employment growth was greatest in the major metropolitan and suburban counties**. However, employment change also reflected shifts in the underlying economy, toward services and away from manufacturing. The patterns of individual regions varied considerably, but within regions the greatest relative job growth was generally in suburban counties.
- **Per-capita income growth during the 1990s was about 18 percent in real terms.** The rate of growth was greatest in small rural counties albeit from lower initial levels.
- **Travel times to work have been increasing**, as commute distances lengthened and congestion increased. However, **carpooling has declined** overall, from 16 percent to about 12 percent of workers. Counties with the **longest average commute times and highest carpooling** were typically relatively **isolated rural counties** whose residents commute to distant metro regions for jobs.
- Inter-county commuting patterns are a complex result of wage differentials, inter-county access, and job availability. As access has

increased, **inter-county commuting has increased** during the 1990's. **Almost 2/3 of worker travel is across county lines**.

2. Urbanized Area Trends

- North Carolina's **urbanized areas continued to spread out** and increase in population during the 1990's. Perhaps surprisingly, the **growth has been most rapid in western and smaller regions**, slowest in the largest and eastern regions.
- Overall **average densities are declining**, but the **smaller regions are increasing in overall density while the larger regions are declining in overall density**.
- **Urban travel has been increasing about as fast as urban population**. However, **rural travel has been increasing almost 10 times faster than the rural population**.
- Within urbanized areas, freeway travel is increasing as a share of total travel. **Freeway travel has increased 126 percent in 11 years**.
- Expansion of **freeway capacity**, particularly the widening of freeways in urban areas, **has resulted in only modest growth in average freeway traffic per lane, about 28 percent in 11 years.**
- Most of the state's **urbanized areas have less freeway traffic per lane than the national averages.** Only three urbanized areas (Concord, Charlotte, and Gastonia) have average freeway traffic per lane greater than the national averages.
- Generally, freeway **traffic congestion is less in the smaller regions than in the larger ones**.

3. Growth Patterns Within Regions

- North Carolina can be divided into **12 relatively distinct "commuting regions"** based on **mutual economic inter-dependence** of counties. These regions define areas within which most inter-county commuting occurs. Within each region, the core county depends on the surrounding county for workers, and the surrounding counties depend on the core county for jobs.

- **Population growth is occurring in tracts throughout the State**, in urban, suburban, and rural tracts, in isolated and accessible tracts, in high-income and low-income tracts, in dense and less dense tracts. The **average change in tract population during the 1990s was 972 persons per decade, about 21 percent**, varying from 495 (Greenville-Rocky Mount region) to 1512 (Triangle region). A **few tracts lost population.** With just one exception (northeast coastal plain) these tracts were scattered throughout the state.

- **Within each region, some tracts are growing quite rapidly while others are growing more slowly.** There is wide variation in growth rates of individual tracts.

- Generally, **tract population densities are rising** throughout the State, with the greater increases in suburban tracts and lower increases in in-city and rural tracts. However, **overall regional densities are falling even as tract densities are increasing because more growth has been in the lower-density tracts.**

- **Growth was greatest in tracts with mid-range densities**, from about 133-433 in density, but less in low-density rural or high-density urban tracts. These are generally suburban tracts near the edges of urban regions.

- The **populations of some urban tracts are declining** as land is converted to non-residential use and family size decreases. However, most of these declines are small. In other urban tracts, populations are increasing.

4. Factors Affecting Growth

- All of the **models of population growth** developed for the 12 regions of the state, and for the State as a whole, **were relatively weak in strength**. The best of these models explained about 45 percent of the variation in tract growth, but most explained just **10-25 percent** of the variation in tract growth.

- This key finding means that **numerous site-specific and local factors determine most of the variation in the growth of tracts**. Among the likely factors influencing tract growth are:
    - Broad national economic trends and trends in industrial sectors.
    - Overall economic health of the community.
    - Overall community growth rates.
    - Tax rates and base.
    - Quality of schools.
    - Community and neighborhood crime rates and trends.
    - Community attitudes toward growth.
    - Local political climate relative to growth.
    - Community growth incentives.
    - Competition between communities for growth.
    - Competition between parcels on price, availability and suitability.
    - Land availability and relative price.
    - Local sewer, water and other utility service.
    - Zoning and allowable development.
    - Recent development on nearby parcels.
    - Characteristics of nearby parcels.

- In spite of the overall weakness of our models, several factors did seem to have some influence on tract growth. In 8 regions, "**prior density" was**

found to be an important factor that slows growth. As tracts fill up toward their practical or zoned maximum density their growth slows down. This slow-down occurs because parcels become harder to assemble, prices rise, remaining lots are less desirable, some residential lots get converted to non-residential use, and family size declines as neighborhoods mature. Although in-fill development and up-zoning to multi-family housing can continue to add population in fully developed tracts, this process is slower than the development in more open tracts.

- The **slow-down of growth as density rises varies from region to region**, but generally ranges between 0.3 and 0.8. That is, for each 1000 person-per square mile increase in density, growth in the next decade slows by between 300 and 800 persons per decade. The Triad region has the shallowest slow-down factor, Wilmington has the steepest.

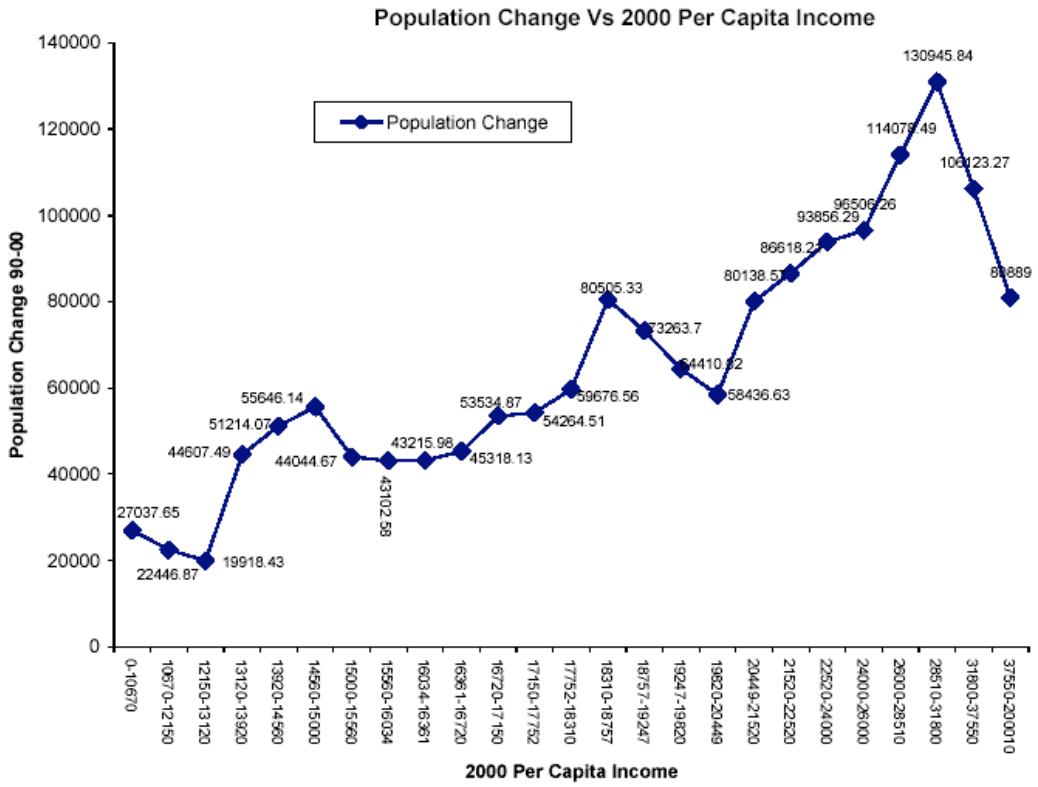
- The **inner-ring (0-2 miles) density** of most regions was found to be about **1800-2700 persons per square mile**; however, within each region a few generally smaller tracts had considerably higher densities. These inner-ring densities reflect lot sizes and home sizes prevalent between 1900 and 1945, when most of these inner rings were developed.

- **The major cities of North Carolina differ** not in inner-ring density (all are about 1800-2700 persons per square mile), nor outer-ring densities (all are about 50-150 persons per square mile), but **in the density of the mid-range rings**. In the larger cities (Charlotte, Triangle, Triad) the 1000-density contour extends out to about 6 miles, but in the smaller cities the mid-distance densities are lower, 400-700 persons per square mile. These differences reflect the time period when the mid-rings developed: in larger cities, these mid rings developed earlier at higher densities. **Mid-distance tract densities are effectively capped at lower levels than that of inner-city tracts.**

- As growth slows in near-full tracts **regional growth must necessarily go to tracts that have available space.** Thus, an inevitable result of population growth in regions with limited space in urban tracts is growth in nearby suburban and rural tracts. Since growth can only go "up" or "out", **if density is effectively capped in most tracts regions cannot grow without spreading out.**

- **In two regions (Charlotte and Greenville-Rocky Mount), per-capita income is an additional demographic factor influencing growth.** Figure V.1 shows that for the State as a whole, growth was generally higher in tracts with higher incomes. However, in most regions tract demographics were not significant in determining growth rates, and were certainly not as important as prior density.

Figure V.1



- **Distance to the City Center is a factor influencing growth in several urban regions (Charlotte, Triangle, Wilmington, Fayetteville). G**rowth slows by about 25-45 persons per decade for each mile out from the city center.

- **Distance to Interstates is a factor influencing growth in three regions (Triad, Asheville, Hickory).** Growth slows by 28-50 persons per decade, for each mile distant from the Interstate System.

- **Distance to key recreational features (the Blue Ridge Parkway and the coastline) is a factor influencing growth in those regions.** In those regions growth slows with increasing distance from the Blue Ridge Parkway or coast. However, the effect is minor and varies widely, the largest being the coastal effect in the Jacksonville region.

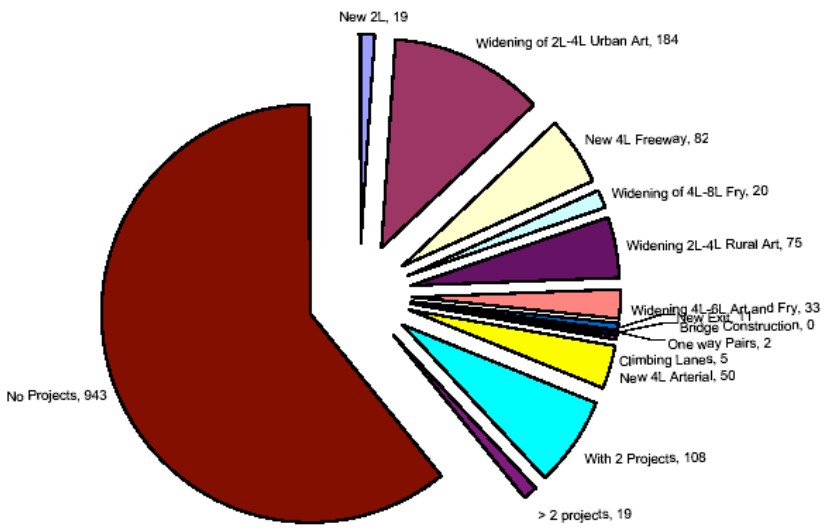
5. Effects of Major Road Improvements on Growth

- **Population growth occurs without major road improvements**. Figure V.2A and Figure V.2.B indicate that during the 1990's, **about 61 percent of North Carolina's 1551 tracts received NO major road improvement, but about _ of the population growth was in those**

tracts. Only about 30 percent of the growth occurred in tracts that had urban or rural arterial widening, the types of road improvements most associated with growth.

Figure V.2a

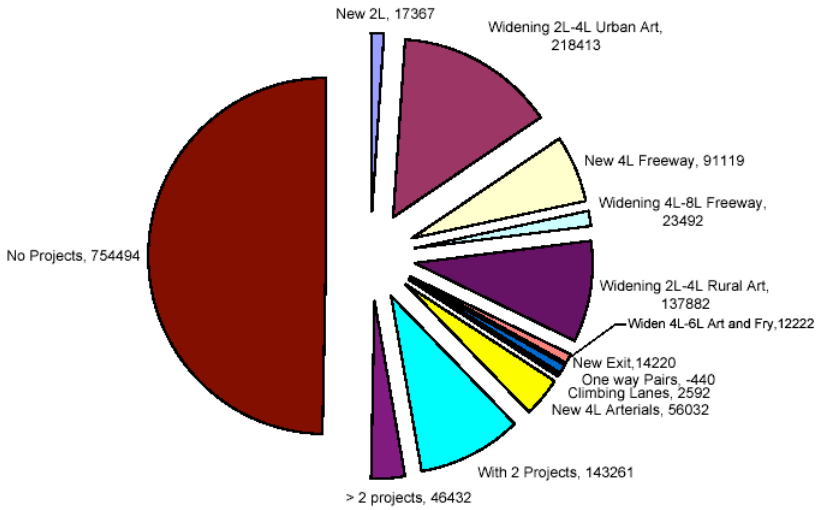
NC Number of Tracts by Type of Projects



Total Tracts = 1551

Figure V.2b

North Carolina Population Change, 1990-2000 by Road Project Type



Total Growth = 1.518 Million

- **Urban arterial widening is weakly correlated with tract growth in 4 regions.** In four regions (Charlotte, Triad, Asheville, Eastern NC) urban tract growth was higher by 106-525 persons per decade, per mile of urban arterial widening. The effect is highest in the Charlotte region and lowest in the Asheville region. Within each city, the effect is lowest in in-city tracts (those already largely built up) and highest in suburban tracts. Since agencies typically add capacity to deal with existing congestion, it is more likely that growth generated the widening need than vice versa.

- **Rural arterial widening is weakly correlated with tract growth in 6 generally more rural regions.** Tract growth is higher, by 50-550 persons per decade, per mile of rural arterial widening**.** The effect is greatest in the Asheville area, lowest in Eastern NC. Within each region, the effect is lowest in tracts distant from urban regions and highest in tracts close to the edges of urban regions. Since most rural road widening is done for access, it is more likely that rural widening induced growth than vice versa.

- **The effect of urban and rural arterial widening, new arterials or new freeways is about a 2-14 percentage point increase, per mile of improvement, in the decade growth rate** in most regions**.** Table V.1 summarizes these relative impacts.

Table V.1: Summary of Incremental Effects of Road Improvements

Commuting Region	Type of Road Improvement	Growth Effect, 10-yr Pop Change per mile of Improvement	'Baseline' Decade Growth Rate, 1990-2000	Decade Growth Rate with the Improvement	Difference in Percentage Points
Statewide	1-mile of Rural Arterial Widening	123	20.4	22.5	2.1
Charlotte	1-mile of Urban Arterial Widening	525	38.1	50.9	12.8
	1-mile of New Arterial	456	38.1	49.2	10.9
Triangle	1-mile of New Freeway	354	31.7	40.1	8.4
	1-mile of Freeway: Widen to 8 Lanes	-1130	31.7	4.6	-28.1
Triad	1-mile of Urban Arterial Widening	237	16.7	22.6	5.9
	New Exit – 1 mi. work	4846	16.7	136.3	119.6
Asheville	1-mile of Urban Arterial Widening	107	21.9	24.6	2.7
	1-mile of Rural Arterial Widening	552	21.9	35.8	13.9
	1-mile of New Freeway	86	21.9	24.1	2.2
Wilmington	- (no road effects)	-	38.8	38.8	(no effects)
Fayetteville	1-mile of Rural Arterial Widening	207	12.5	16.1	3.6
Jacksonville	1-mile of Rural Arterial Widening	193	22.5	26.5	4.0
Hickory-Morganton	- (no road effects)	-	17.0	17.0	(no effects)
Greenville-Rocky Mt	- (no road effects)	-	11.0	11.0	(no effects)
Boone-Spruce Pine	1-mile of Rural Arterial Widening	123	12.5	15.8	3.3
Eastern NC	1-mile of Urban Arterial Widening	144	35.8	40.0	3.2
	1-mile of Rural Arterial Widening	51	35.8	37.3	1.5
Western NC	1-mile of Rural Arterial Widening	78	16.6	18.7	2.1

Overall, the effect of rural and urban road widening on growth is modest compared to the background growth, which was typically about 20-40 percent per decade.

- **Other types of road projects generally had little or no impact on growth in most regions.** But in a few other cases, other project types are correlated with growth. In Charlotte, new 4-lane arterials are correlated with an increase of about 456 persons per decade, per mile of improvement. In the Triad region, 1 mile of roadwork for a new exit was correlated with about increased growth of 4845 persons per decade. But this improvement occurred late in the decade and was the largest effect observed in the entire analysis.

- **Widening freeways to 8 lanes was correlated with a slow-down of growth** in nearby tracts in the Triangle region.

- **No other factors related to major roads (their cost, impact on VMT, timing) were found to be correlated with growth.**

6. Cost of Major Road Projects

- **The major road projects implemented in North Carolina during the 1990s vary widely in their cost-effectiveness.** Table V.2 summarizes the average costs and cost-effectiveness of different project types in terms of traffic served per dollar invested.

Table V.2: Cost Effectiveness of NC Road Project Types, 1990-2000

Improvement Type	GIS Sections	Total Length, Miles	Total Cost, $M	Total Lane-Miles Added	Cost Per Lane-Mile, $M	Total Daily VMT Served (K)	Daily VMT Served per $M	20-Year Cost To Serve, Per VMT
New Exit	20	17.8	100	21.5	$ 4.64	177	1771	**7.7 ct**
New 4L Fry	145	405.3	2284	1577	1.45	6911	3027	**4.5 ct**
New 4L Art	85	133.7	564	488	1.16	1982	3517	**3.9 ct**
New 2L Art	24	58.9	136	119	1.14	538	3954	**3.5 ct**
Widen Rur Arterial	110	396.2	1209	804	1.50	5096	4215	**3.3 ct**
Widen Urb Arterial	228	388.2	1032	864	1.19	6389	6192	**2.2 ct**
Widen Frwy to 8 Lanes	26	61.6	533	246	2.17	5964	10675	**1.3 ct**
Widen Frwy to 6 Lanes	39	57.5	340	115	2.96	5299	15584	**0.9 ct**

- On average, **4-to-6 lane freeway widenings have been the most cost-effective major actions over the past decade**, costing about 0.9 cents per vehicle-mile served. On the other hand, **new exits have been the least**

cost-effective, costing about 7.7 cents per vehicle mile served. (For comparison, vehicle operating costs typically average about 50 cents per vehicle-mile).

- Within each group, there is also a **wide range of cost-effectiveness of individual projects**. More study is needed to determine why these projects vary so much in cost-effectiveness and how the State can improve the delivery of more cost-effective projects.

B. Policy Implications

This study has significant implications for North Carolina's road and growth policies for the future.

First, **the determinants of tract growth are largely local.** Tract growth is influenced largely by local economic health, housing quality, schools, taxes, infrastructure provision and a host of other factors. This means that local governments hoping to spur growth should generally look within, not to Raleigh or Washington, for the key actions needed.

Second, **the prior growth of a tract is critical in determining its future growth.** When local planners set zoning, they are essentially specifying its residential capacity. Growth slows as it nears this limit, because land prices rise and parcels get harder to assemble. Developers sometimes receive variances to increase development above current zoning limits but they also look to nearby less-developed tracts. N**ear urban regions this growth goes primarily to the edges of urban areas where tracts that have room for it**. Near urban regions, tracts that had higher density or were full at the beginning of the 1990s grew little during the 1990s, and tracts that had lower mid-range density in 1990 generally experienced more rapid growth during the 1990s. **This means that actions to direct growth to in-city tracts with little space available are likely to be largely ineffective**. In rural areas, prior density has less impact in slowing growth.

A third key finding is that the **location of growth is only modestly correlated with major road improvements.** For most of the cities and most of the improvements reviewed, the correlation between growth and major road improvements was found to be quite weak. Even where correlation was found, it does not indicate causality: of course roads are being widened where there is growth, but this can be in response to the growth, not a spur to it. Our models did not find strong correlations between either lag or lead effects. Since many factors influence tract growth, it would be a rare tract for which development was critically dependent on major road improvements.

Fourth, we also found cases in which road improvements, particularly urban and rural widenings, were positively correlated with growth. **In 4 regions a mile of urban road widening was correlated with an additional 100-525 persons per decade. In 6 regions a mile of rural widening was correlated with an additional 50-550 persons per decade.** These effects are likely to be largest in suburban tracts where growth is rapid and where congestion relief increases the area's attractiveness.

However, the relative **impact of these effects is modest, about 2-14 percentage points** added to baseline growth. And the overall effect is typically small. **An additional**

500 persons (a large effect of a road improvement) would generate about the same traffic as a single small McDonald's restaurant, about 1500 trips per day. So, even a very large road improvement would have much less effect on traffic generation ('induced traffic') than a modest commercial strip with just 5-6 restaurants or stores. Since the capacity expansion of a typical 2-to-4 lane road widening is in the range of 20,000 trips per day, the effect of the widening itself is small relative to the carrying capacity of the expansion.

Fifth, the models developed here demonstrate that prior Interstate investments did not generally correlate with subsequent growth. In only a few cases were a tract's location relative to the Interstate system a factor in its growth rate. As US cities grew over time family wealth rose, and zoning shifted from higher density living patterns in tracts developed earlier to lower-density living patterns in tracts developed later. Over time as people wanted more home space and surrounding lot space, the residential densities of new development fell. These locations tended to be in the tracts further out from the city center, since inner-city tracts were already developed. So the evolution of density and living preferences produced the present pattern of lower densities on the outer rims of the regions. **It is largely coincidental, not causal, that the Interstate system, when laid on top of this pattern, shows apparent spatial correlation with growth or lower density.**

Sixth, our study suggests that **transportation investments are a generally blunt and inefficient means of spurring development or preventing it.** Even a major road investment is likely to have only modest effect on the growth of a tract compared to zoning limits or exemptions. And the analysis also showed that almost _ of the population growth in North Carolina in the 1990s went into tracts that had NO major road improvements during the decade. So the lack of a major transportation project is not likely to prevent development of otherwise viable tracts. Road investments are made for many reasons, primarily to reduce congestion and save travel time, operating costs and accidents. When a road is widened and speeds are increased, travelers save time and divert to the improved facility, loosening the traffic elsewhere and saving travel time, travel cost and accidents throughout the area. This is precisely the function of the improvement. **Transportation investments should generally be made to improve transportation access and community mobility.** Growth policies are more effectively addressed by local government actions regarding education, infrastructure, taxes, zoning, and the like.

When people see development at new intersections and new subdivisions along widened roads, they sometimes blame the road improvement for causing it. They do not observe that development did NOT occur at other sites already available on previously widened roads or that less spectacular in-fill development occurred elsewhere. Roads sometimes direct some new growth to specific locations, but our study shows that the magnitude of this growth is modest compared to the overall population growth of most tracts. Further, the effect is small compared to other factors such as the attractiveness of the tract. Therefore, elected and/or appointed **officials should cautiously consider proposed changes in road funding policy that offer hope of slowing or stopping sprawl or growth since such policies are likely to be unsuccessful**.

This analysis raises fundamental questions about our lack of knowledge about the linkages between growth, sprawl, and infrastructure investments. More research is needed on a variety of issues, for instance:

- The relative influence of numerous factors not included here (such as land availability and zoning, taxes, school quality, infrastructure provision, traffic, crime, utility rates, community and business attitudes toward growth, cultural/ethnic effects, income, housing quality) on the location of urban growth;
- Factors influencing non-residential growth;
- The role of changing tastes and housing preferences on development rates;
- The role of community density restrictions or variances.

Studies of these and other issues are important possible extensions of the current work, which, hopefully, will prove helpful in understanding these relationships.

In conclusion, this study of the linkage between growth and road improvements in North Carolina finds only a modest correlation between road investments and growth. Major road improvements can have a modest effect on the magnitude of growth and its specific location, but they are not in and of themselves either sufficient or necessary for growth. Most growth will occur in the absence of road improvements, going to locations in urban areas where space is available.

Appendices

About the Author

David T. Hartgen, Ph.D., P.E. is Professor of Transportation Studies at the University of North Carolina at Charlotte, where he established the Center for Interdisciplinary Transportation Studies and now teaches and conducts research in transportation policy. He is the author of 315 papers and reports on a wide variety of topics in transportation policy and planning, is US Editor of the international journal *Transportation,* and is active in professional organizations, particularly the Transportation Research Board. He is a frequent media interviewee in local and national publications. Before coming to Charlotte in 1989 he was a Transportation Planner with the New York State Department of Transportation and a policy analyst at the Federal Highway Administration. He holds engineering degrees from Duke University and Northwestern University, has taught at SUNY Albany, Union University, Syracuse, and lectures widely. He is an Adjunct Scholar at the John Locke Foundation. He can be contacted at **dthartge@email.uncc.edu**, or by telephone at 704-687-4308.

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Methodology

1. Overview

The basic method of analysis used in this study is a "geographic information system" (GIS). This is a computer-based mapping system capable of assembling, storing, manipulating, and displaying geographically referenced information, i.e. data identified according to their locations. This means of storing data as connected maps makes it possible to perform complex spatial analyses. The GIS relates information from different sources, treating them as 'transparent maps' containing geographically aligned data. For example, in this research information on existing roads, major road projects, tracts, counties, urbanized areas, commuting flows and states are joined from their respective layers into a single layer to conduct statistical analysis for tracts.

For this application, a special transportation GIS, TransCAD©, was used extensively. TransCAD is a GIS marketed by Caliper Corporation (http://www.caliper.com) designed especially for storing, displaying, managing, and analyzing transportation data and supporting information for small geographies such as census tracts. TransCAD combines GIS and transportation modeling capabilities in a single integrated platform. It can be used for all modes of transportation, at any scale or level of detail. It is used for mapping, visualization, and analysis for different transportation applications.

2. Data sources

- **State and county data:** The basic source of the state and county data is the U.S. Census and Bureau of Labor Statistics. Population, household and income data are from the 2000 Census of Population and Housing, File 3, Demographic Profiles. As noted in the Census tables, the income tables are based on samples and are subject to variability.

- **Urbanized area data**: Transportation-related data for North Carolina's urbanized areas comes from several sources. The basic source is Highway Statistics, from the Federal Highway Admin, http://www.fhwa.dot.gov containing detailed tabulations of the year-2000 and 2001 travel-related parameters of each of the 440 U.S. urbanized areas. Corresponding 1990 data was obtained from FHWA using special tabs available to Prof. Hartgen. These publications contain data such as population, geographic area, mileage, travel (VMT), and traffic density. Additional urbanized area information, including areas and population, are available from the U.S. Census, and Caliper, which supplies the software used for mapping. Specialized GIS layers showing the boundaries of the year-2000 urbanized areas were also obtained form this vendor.

- **Traffic trend data**. The source of the traffic trends was from Federal Highway Administration, U.S department of Transportation and special 1990 tabulations prepared for Professor Hartgen. A separate spread sheet was prepared having information about the total vehicle miles, total freeway miles

traveled, freeway capacity and freeway traffic per lane for the year 1990 and 2000.

- **Tract data**: Most of the 2000 data was taken from data discs provided by Caliper, which contain information about:
    - Tract population,
    - Sex, age, income,
    - Race, Hispanic or Latino,
    - Household relationship, Household type, housing occupancy,
    - Travel time
    - Location codes and tract identifiers.

  For 1990 tract data, we used TransCAD's 1990 tract layer, then consolidated the information from the 1990 layer to the 2000 layer using the 'edit-fill' function in TransCAD. This procedure adds up the data from the 1990 layer proportionally to the portions of 1990 tracts that correspond to the 2000 tract areas. Because some tract locations are slightly different, or tract IDs are changed, this process produces slightly different results that would be obtained from a direct ID-based matching approach. The largest differences occur when 1990 tracts were split and the underlying data is disproportionate to area, as in the case where a small town was given a new tract ID. Sometimes, large apparent and 'reductions in population' can result from this process.

- **Major road improvements**: Information on changes in the North Carolina road system during the 1990s was obtained in several ways. Initially, major changes were listed by reviewing Transportation Improvement Program from 1990 to 2002, carefully inspecting the whole state for major road improvements and additions. Then, each Metropolitan Planning Organization in the state was contacted, through North Carolina DOT, and requested to prepare lists of major road improvement, by map location. The MPOs provided maps and lists of major projects completed in their areas. These were compared with the prior lists and revised accordingly. Phone calls to clarify the location or nature of projects were also made where needed. Road improvements were categorized into several types:
    - Construction of new two lane arterial;
    - Urban arterial miles added;
    - Freeway mileage added;
    - Widening of four lanes to eight lanes Freeway;
    - Rural arterial miles added;
    - Widening of four lanes to six lanes freeway and arterials;
    - Freeway exits/interchanges added;
    - Bridge widening;
    - Construction of one way pairs;
    - Construction of climbing lanes;
    - New four lane miles added;

The goal in this exercise was to capture all major road jobs undertaken during the 1990s that would have been likely to influence land use and growth locations. Therefore, the effort **did not include**:

- Additions of local or subdivision road additions, which are done generally in response to growth;
- Road resurfacings;

In the course of the review, we found a number of projects that were completed before 1990 were removed and few projects completed after 2000 were included in the analysis to ensure consistency between regions. In total, 312 separate projects were identified for the period 1990-2000.

3. Consolidation of data

- **Exporting:** The first step in data consolidation was to export the different GIS layers such as State Layer, Tract Layer, County Layer, City Layer, Highway Layer, Urbanized Area layer for the year 2000 and Tract Layer, County Layer for the year 1990 from the database discs provided by Caliper.

- **Tract merging:** The 1990 data was consolidated with the 2000 data for further analysis, using the "edit-fill" procedure. This permits the automatic aggregation of data by geography, accounting for slight changes in tract locations, and new tract numberings. Tracts surrounding the state border outside North Carolina were trimmed off. With help of the "tag" tool in TransCAD, distance to the city center, distance to Interstate, distance to the nearest project, distance to the coast and distance to the Blue Ridge Parkway was measured and added to the tract layer. The tract merging process identified a number of tracts, generally on the edges of the State and some inside urbanized areas, where changes in tract identifier number resulted in inconsistent swings in population from 1990 to 2000. This has occurred primarily where the Census has added tracts for the 2000 Census by breaking a larger tract into several smaller ones, thus creating mismatches between the tract ID numbers. Some of these were resolved through careful inspection, but a few, inside and near urban areas, remain. In the process of tract merging, we also added the variables like race and income to enhance our analysis for good results. For some of the tracts military population was counted in 90's and was removed later.

- **Road project locations**. As noted above, lists and locations of major improved roads were put together by carefully reviewing the Transportation Improvement Program (TIP). The bigger cities had large lists of projects, whereas the smaller urban cities had small list of projects in the year 1990-2000. These projects included added freeway mileage, added urban and rural arterial mileage, widening of urban arterials, freeway exits, major 2-lane roads and bridge widening. A few small projects small were not included. Locating each project was done with the help of the complete street network for each area, taken from Caliper database disc. The street layer was used to locate the project improvement exactly in the tract layer. For each project, type of

improvement, mileage, year of improvement, cost of the project, average daily traffic before and after the project completion are marked.

- In the case where a road improvement project traversed several tracts, the total mileage of the improvement was partitioned to the tracts proportionally to mileage in each tract.

- We also calculated a "spur effect" (growth occurred after the improvement as:

  Spur effect = (road project mileage)* (2000- Year of Implementation)

  The "speculative effect" (growth occurred in advance of the improvement) is calculated as:

  Spec effect = (road project mileage)* (Year of Implementation – 1990)

  A separate spreadsheet listing all projects was prepared showing where, when and which type of project took place; this includes the mileage and cost the tracts which were affected by the improvement. This listing is in the Appendix.

- **Commuting area codes**. The commuting areas are divided into 12 groups depending upon the commuter patterns of the cities; Analysis was done separately for each group.

4. Analysis

- For the analysis tract data fields are:
  1. **Tract ID**
  2. **Tract geographic area** (from the Caliper data disc)
  3. **1990_Population** (source was from the Caliper data disc, aggregated to 2000 tract geography)
  4. **1990 Population Density** (calculated from population and area)
  5. **2000_Population** (source was from the Caliper data disc)
  6. **2000 Population Density** (calculated from population and area)
  7. **Population Change, 1990-2000** (calculated from 1990 and 2000 population). This is the primary dependent variable used in the study.
  8. **Percent Population Change, 1990-2000**
  9. **2000 Non-White Population**(source was from the Caliper data disc)
  10. **1990 Non-White Population**(source was from the Caliper data disc, aggregated to 2000 tract geography)
  11. **2000 Per Capita Income** (source was from the Caliper data disc)
  12. **1990 Per Capita Income** (source was from the Caliper data disc, aggregated to 2000 tract geography)
  13. **Distance to Coast** (the distance from the nearest roads near the coast)

14. **Distance to Parkway** (the distance from the Blue Ridge Parkway from the western NC)
15. **New two lane arterial Miles Added**(the mileage added, if tract had any new two lane miles added improvement, else "0")
16. **Urban Arterial Miles Widened** (the mileage of any Urban Arterials widened improvement, else marked "0")
17. **New Freeway Miles Added** (the mileage added, if tract had any new freeway miles added improvement, else "0")
18. **Widening From four to Eight Lanes Freeway miles added (**the mileage added, if tract had any freeway miles added improvement, else "0")
19. **Rural Arterial Miles Widened (**the mileage added if tract had any Urban Arterials miles added improvement, else "0")
20. **Widening from Four to Six Lanes Freeway and Arterials miles added (**the mileage added, if tract had any freeway miles added improvement, else "0")
21. **Interstate Exits Added** (marked "1.0" if tract had a full new exits added improvement, 0.5 for a 2-ramp new exit, 0.25 for a 1-ramp new exit, else marked "0")
22. **Bridge improvement miles Added or Widened**
23. **Construction of one-way pairs(**the mileage added, if tract had any one-way pairs miles added improvement, else "0")
24. **Construction of climbing lanes(**the mileage added, if tract had any climbing lane miles added improvement, else "0")
25. **New Four Lane Arterial Miles Added (**the mileage added if tract had any Urban Arterials miles added improvement, else "0")
26. **Total Miles + Exits** (added all the miles improved and the exits. Note that a full exit (1) is treated as I mile of road)
27. **Year of Improvement** (the year in which project was opened)
28. **Spur Effect** (calculated the value, see above)
29. **Speculative Effect** (calculated the value, see above)
30. **ADT 1 year (**year in which average daily traffic before improvement has been recoded)
31. **ADT 1 (**average daily traffic before improvement)
32. **ADT 2 year (**year in which average daily traffic after the improvement has been recoded)
33. **ADT 2 (**average daily traffic after the improvement)
34. **VMT_CH** (change between Vehicle traveled miles before and after the improvement)
35. **VMC_CH** (change between Vehicle miles Capacity before and after the improvement)
36. **Distance to Interstate** (perpendicular distance from the tract centroid to the nearest Interstate)
37. **Distance to Major City** (the distance from the tract centroid to the center of the nearest major city)
38. **Cost** (cost for the each project section, computed proportionally based on total project cost and the length of each segment of the project.)

39. **Distance to Project** (the distance from the tract to the midpoint of the road section containing the nearest improvement)
40. **Percent non White** (calculated as (Total population – White)/Population)

- **Analysis methods**

  In this analysis different methods were used,
  - Cloropleth mapping (that is, maps showing thematic data for tracts or counties);
  - Simple statistics: mean, medial, standard deviation, maximum and minimum;
  - Overlays, showing several statistics together for tracts;
  - Tabulations ;
  - Regression models, statistical routines within the TransCAD software.
  - Knowledge Seeker, a classification model that searches for the most important explainers of a dependent variable.

  All analysis was done on **Population Change 1990-2000** as a dependent variable. Tabulations were done for each city by distance to the city center. These results were useful to find the population in different intervals of distance to the city center.

  In the regression and classification models, population change is treated as the dependent variable and rest of the variables were taken as independent variables. Each independent variable was then eliminated in order of increasing strength, to determine a final regression model. This procedure was necessary because the TransCAD regression procedure does not have a forward-stepwise function.

State and County Data

County Data

NAME	AREA	1990_Pop	2000_Pop	POP_CH	PerPop_Ch	1990_HH	2000HH	HH_CH	JOBS1990	JOBS2000	Job_Ch	1990_PCI	2000 PCI	PCI_Ch	2000 MTT	1990MTT
Alamance NC	434.7	108161	130800	22639	20.93	42776	51584	8946	68621	82220	19.82	13290	19391	0.2	21.6	21
Alexander NC	263.1	27551	33603	6052	21.97	10385	13137	2792	14438	15469	7.14	11617	18507	0.07	22.9	22
Alleghany NC	235.45	9590	10677	1078	11.23	3914	4593	687	5389	6745	25.16	10229	17691	0.25	24.1	21
Anson NC	537.17	23478	25275	1797	7.66	8478	9204	735	10976	10910	-0.6	9398	14853	-0.01	27.5	23
Ashe NC	426.68	22204	24384	2180	9.82	8870	10411	1524	11181	13441	20.21	9547	16429	0.2	26.6	26
Avery NC	247.16	14891	17167	2276	15.28	5448	6532	1073	8498	12162	43.12	9726	15176	0.43	22.9	23
Beaufort NC	835.62	42033	44958	2925	6.96	16004	18319	2291	23416	24276	3.67	10669	16722	0.04	25.4	24
Bertie NC	707.22	20414	19773	-641	-3.14	7510	7743	224	9204	8996	-2.26	8403	14096	-0.02	28.5	25
Bladen NC	887.26	28788	32278	3490	12.12	10850	12867	2023	11066	17366	56.83	9504	14735	0.57	26.9	27
Brunswick NC	864.84	50891	73143	22252	43.72	20056	30438	10399	20368	32682	60.47	11661	19857	0.6	24.6	25
Buncombe NC	659.76	174644	206330	31686	18.14	70683	85776	15093	110173	138317	25.55	13219	20384	0.26	21.1	21
Burke NC	514.84	75772	89148	13376	17.65	29248	34528	5318	43453	47709	9.79	11612	17397	0.1	21	20
Cabarrus NC	364.97	98897	131063	32166	32.52	37584	49519	12000	50935	75558	48.34	13547	21121	0.48	27	25
Caldwell NC	474.22	70662	77415	6753	9.56	27095	30768	3727	36738	43517	18.45	11529	17353	0.18	21.6	21
Camden NC	241.43	5957	6885	928	15.59	2185	2662	484	1694	2531	49.41	10448	18681	0.49	32.4	33
Carteret NC	514.13	50483	59383	8900	17.63	20359	25204	4866	24301	32447	33.52	12643	21260	0.34	23	21
Caswell NC	428.32	20778	23501	2723	13.11	7531	8670	1139	5010	6545	30.64	9832	16470	0.31	30.6	29
Catawba NC	413.48	118305	141685	23380	19.76	45733	55533	9807	98798	115576	16.98	13752	20358	0.17	20.7	20
Chatham NC	708.98	38009	49329	10320	26.46	15434	19741	4308	18379	24333	32.4	13335	23356	0.32	27.3	25
Cherokee NC	466.69	20155	24298	4143	20.56	7913	10336	2388	9846	12436	26.27	9256	15814	0.26	24.1	22
Chowan NC	172.98	13471	14526	1055	7.84	5167	5580	387	6532	7606	16.43	10582	15027	0.16	27.4	22
Clay NC	220.61	7171	8775	1604	22.37	2924	3847	918	2346	3291	40.28	9455	18221	0.4	26.2	25
Cleveland NC	468.59	84927	96287	11360	13.38	32059	37046	4988	44445	47249	6.31	11889	17396	0.06	23.5	22
Columbus NC	953.82	49585	54749	5164	10.42	18502	21308	2803	22322	25244	13.09	9137	14415	0.13	27.1	25
Craven NC	728.53	82594	91436	8842	10.71	29861	34582	4825	46122	58887	22.37	11966	18423	0.22	20.6	21
Cumberland NC	658.5	274235	302963	28728	10.48	91715	107358	15676	146198	181788	24.34	11095	17376	0.24	21.9	20
Currituck NC	263.36	13749	18190	4441	32.31	5014	6902	1882	4062	6481	59.55	12457	19908	0.6	35	37
Dare NC	386.57	22425	29967	7542	33.63	9227	12690	3458	17145	24795	44.62	14894	23614	0.45	19.9	19
Davidson NC	566.71	126921	147246	20325	16.01	49984	58156	9148	61489	71033	15.52	12611	18703	0.16	22.8	21
Davie NC	266.85	27835	34835	7000	25.15	10734	13750	2990	13397	16271	21.45	14630	21356	0.21	23.9	23
Duplin NC	819.18	40093	49063	8970	22.37	14888	18267	3395	21183	26785	26.45	9415	14499	0.26	26.6	24
Durham NC	297.74	181489	223314	41825	23.05	72240	89015	16761	146608	199162	35.85	15002	23156	0.36	21.2	21
Edgecombe NC	506.51	56502	55606	-896	-1.59	20422	20392	-10	26210	29671	13.2	9523	14435	0.13	21	20
Forsyth NC	412.84	265811	306067	40256	15.14	107430	123851	16593	192073	223901	16.57	16151	23023	0.17	21.2	21
Franklin NC	494.5	36650	47260	10610	28.95	13510	17843	4333	10946	17497	59.85	10971	17562	0.6	33.2	30
Gaston NC	363.54	174788	190365	15577	8.91	65081	73936	8755	96050	99803	3.91	12424	19225	0.04	24.6	22
Gates NC	343.92	9360	10516	1156	12.35	3428	3901	462	2400	2580	7.5	11576	15963	0.08	37.7	37
Graham NC	301.6	7195	7993	798	11.09	2776	3354	599	2552	3737	46.43	8872	14237	0.46	27.9	21
Granville NC	536.44	38369	48498	10129	26.4	13045	16654	3618	18786	23660	25.94	10945	17118	0.26	27.4	24
Greene NC	265.88	15436	18974	3538	22.92	5429	6696	1252	5248	8001	52.46	9560	15452	0.52	27.6	23

Guilford NC	657.59	347249	421048	73799	21.25	137559	168667	31151	280535	334684	19.3	15376	23340	0.19	21.4	20
Halifax NC	731.19	55490	57370	1880	3.39	20334	22122	1800	24669	24443	-0.92	8977	13810	-0.01	24.2	22
Harnett NC	601.29	67910	91025	23115	34.04	25221	33800	8616	25535	35110	37.5	10054	16775	0.37	29.2	26
Haywood NC	554.6	46962	54033	7071	15.06	19170	23100	3943	21081	25146	19.28	11728	18554	0.19	22.7	22
Henderson NC	375.04	69362	89173	19811	28.56	28797	37414	8670	35520	45250	27.39	13703	21110	0.27	22.2	22
Hertford NC	356.79	22458	22601	143	0.63	8162	8953	793	10255	11847	15.52	8991	15641	0.16	25.1	23
Hoke NC	392.36	22942	33646	10704	46.66	7389	11373	3985	8290	10847	30.84	8686	13636	0.31	26.4	24
Hertford NC	356.79	22458	22601	143	0.63	8162	8953	793	10255	11847	15.52	8991	15641	0.16	25.1	23
Hyde NC	687.39	5379	5826	447	8.3	2080	2186	99	2697	3279	21.58	9321	13164	0.22	21.5	22
Iredell NC	596.94	94031	122660	28629	30.45	35911	47360	11464	53121	71221	34.07	13054	21148	0.34	24.5	23
Jackson NC	494.51	26869	33121	6252	23.27	9765	13191	3403	12622	18646	47.73	10332	17582	0.48	20.6	21
Johnston NC	795.76	81251	121965	40614	49.92	31539	46595	15161	36236	51179	41.24	11844	18788	0.41	31.3	27
Jones NC	473.35	9557	10381	824	8.62	3522	4061	570	2723	3065	12.56	8807	15916	0.13	29.7	27
Lee NC	259.32	41327	49040	7713	18.66	15747	18466	2757	26143	34331	31.32	12027	19147	0.31	24.1	23
Lenoir NC	402.09	57239	59648	2409	4.21	21980	23862	1894	35130	36772	4.67	10645	16744	0.05	23.8	21
Lincoln NC	307.02	50339	63780	13441	26.7	18759	24041	5301	20398	25074	23.48	12432	18877	0.23	27.1	25
Macon NC	519.49	23502	29811	6309	26.84	9843	12828	3012	10958	15605	42.41	11019	18642	0.42	20	20
Martin NC	461.44	24957	25593	636	2.55	9277	10020	752	13545	12358	-8.76	9442	15102	-0.09	24.3	22
McDowell NC	446.38	35703	42151	6448	18.06	13728	16604	2858	19370	22170	14.46	10518	16109	0.14	25.3	23
Mecklenburg NC	546.23	510326	695454	185128	36.28	199691	273416	73870	437193	614564	40.57	16885	27352	0.41	26	25
Mitchell NC	222.1	14457	15687	1230	8.51	5738	6551	842	7260	8470	16.67	10224	15933	0.17	24.9	26
Montgomery NC	501.63	23452	26822	3370	14.37	8308	9848	1547	12883	14936	15.94	10714	16504	0.16	24.5	22
Moore NC	705.67	59000	74769	15769	26.73	23676	30713	7131	33040	41608	25.93	14928	23377	0.26	22.8	21
Nash NC	542.61	76650	87420	10770	14.05	28963	33644	4699	50668	51325	1.3	12679	18863	0.01	22.7	21
New Hanover NC	202.84	119495	160307	40812	34.15	47958	68183	20573	76950	110095	43.07	13774	23123	0.43	20.7	21
Northampton NC	550.47	20861	22086	1225	5.87	7541	8691	1137	6683	6889	3.08	8275	15413	0.03	27.2	24
Onslow NC	768.99	148497	150355	1858	1.25	40185	48122	7922	74045	88581	19.63	10637	14853	0.2	21.2	21
Orange NC	401.14	93947	118227	24280	25.84	36318	45863	9598	56264	78155	38.91	15779	24873	0.39	22	21
Pamlico NC	342.5	11205	12934	1729	15.43	4423	5178	731	3855	4612	19.64	10499	18005	0.2	28.9	28
Pasquotank NC	227.67	31175	34897	3722	11.94	11393	12907	1532	16510	19737	19.55	10688	14815	0.2	22.8	23
Pender NC	875.58	28955	41082	12127	41.88	11126	16054	4931	9416	13091	39.03	11452	17882	0.39	29.2	28
Perquimans NC	247.89	10449	11368	919	8.79	3987	4645	675	3207	3338	4.08	9798	15728	0.04	33.1	29
Person NC	403.99	30174	35623	5449	18.06	11416	14085	2677	14832	16539	11.51	11153	18709	0.12	29.7	27
Pitt NC	654.73	107846	133798	25953	24.07	40402	52539	12201	62661	80621	28.66	11641	18243	0.29	20.7	20
Polk NC	238.6	14437	18324	3887	26.93	6056	7908	1821	5492	6887	25.4	14202	19804	0.25	26.2	24
Randolph NC	789.86	106642	130454	23812	22.33	41146	50659	9491	54316	67742	24.72	12107	18236	0.25	23.6	22
Richmond NC	479.61	44538	46564	2026	4.55	16853	17873	1060	21917	20495	-6.49	9850	14485	-0.06	21.6	20
Robeson NC	951.17	105198	123339	18141	17.24	36158	43677	7470	45173	51854	14.79	8882	13224	0.15	28.1	22
Rockingham NC	572.19	86035	91928	5893	6.85	33375	36989	3673	41531	43051	3.66	11549	17120	0.04	26.1	23
Rowan NC	523.82	110506	130340	19834	17.95	42358	49940	7647	49623	58397	17.68	12019	18071	0.18	23.3	22
Rutherford NC	565.89	56962	62899	5937	10.42	22173	25191	3001	30035	31506	4.9	11290	16270	0.05	22.1	21
Sampson NC	947.52	47407	60161	12754	26.9	17967	22273	4559	22116	23583	6.63	9485	14976	0.07	25.1	25
Scotland NC	320.68	33743	35998	2255	6.68	11735	13399	1672	17840	21053	18.01	9763	15693	0.18	22.4	19

Virginia Beach VA	263.41	389414	425257	35843	9.2	134474	154455	20161				15101	22365		23.9	25
Washington VA	565.8	45704	51103	5399	11.81	17524	21056	3507				11013	18350		24.2	23
Patrick VA	485.72	17492	19407	1915	10.95	6858	8141	1283				10407	15574		27.9	25
Galax VA	8.23	6624	6837	213	3.21	2736	2958	202				10403	17447		15.7	15
Cherokee SC	397.3	44516	52537	8021	18.02	16493	20495	4010	22070	25951	17.58	10403	16421	0.18	23	21
Chesterfield SC	805.9	38571	42768	4197	10.88	13922	16557	2676	18163	20686	13.89	9454	14233	0.14	25.7	24
Dillon SC	406.62	29149	30722	1573	5.4	9924	11199	1286	11530	12938	12.21	8073	13272	0.12	28.5	22
Greenville SC	795.04	319086	379616	60530	18.97	122570	149556	27111	230055	291837	26.86	13886	22081	0.27	21.6	21
Horry SC	1144.38	144030	196629	52599	36.52	55655	81800	26130	88094	129097	46.69	12392	19949	0.47	23.7	21
Lancaster SC	555.36	54622	61351	6729	12.32	19791	23178	3436	22801	25486	11.78	11045	16276	0.12	27	27
Marion SC	494.22	33938	35466	1528	4.5	11885	13301	1392	14845	14578	-1.8	8188	13878	-0.02	24.7	22
Marlboro SC	485.35	29419	28818	-601	-2.04	10156	10478	302	11439	10214	-10.71	7963	13385	-0.11	24	22
Oconee SC	673.66	57519	66215	8696	15.12	22546	27283	4772	31158	32507	4.33	12357	18965	0.04	23.3	23
Pickens SC	511.9	94027	110757	16730	17.79	33478	41306	7882	43323	50344	16.21	11427	17434	0.16	24	22
Spartanburg SC	819.21	226703	253791	27088	11.95	84431	97735	13227	130220	150117	15.28	12225	18738	0.15	22.5	21
York SC	695.77	131570	164614	33044	25.12	47025	61051	14069	61881	79769	28.91	13310	20536	0.29	27.2	25
Fannin GA	391.47	15661	19798	3807	23.81	6341	8369	2027	5210	8028	54.09	9431	16269	0.54	31.8	25
Murray GA	346.92	26126	36506	10380	39.73	9349	13286	3956	10661	16095	50.97	10567	16230	0.51	24.6	23
Rabun GA	377.03	11657	15050	3393	29.11	4580	6279	1627	6011	8293	37.96	11160	20608	0.38	24.1	22
Towns GA	172.02	6757	9319	2562	37.92	2817	3998	1188	2790	4399	57.67	10774	18221	0.58	28.5	23
Union GA	329.06	11987	17289	5302	44.23	4630	7159	2545	5070	7922	56.25	10973	18845	0.56	27.3	24

Stanly NC	404.26	51715	58100	6385	12.35	19913	22223	2390	27043	28208	4.31	11253	17825	0.04	25.3	24
Stokes NC	455.77	37232	44711	7479	20.09	14255	17579	3322	10775	13388	24.25	12178	18130	0.24	30.7	28
Surry NC	537.65	61710	71219	9509	15.41	24181	28408	4211	41491	46054	11	11349	17722	0.11	25.5	23
Swain NC	540.62	11306	12968	1662	14.71	4259	5137	872	6377	6957	9.1	8927	14647	0.09	20.8	20
Transylvania NC	380.57	25569	29334	3765	14.73	10021	12320	2349	12858	14651	13.94	12736	20767	0.14	22.1	22
Tyrrell NC	390.95	3845	4149	304	7.92	1508	1537	37	1367	1478	8.12	7869	13326	0.08	32.5	32
Union NC	639.63	84214	123677	39463	46.86	29402	43390	13988	44584	58011	30.12	13137	21978	0.3	29	27
Vance NC	269.76	38846	42954	4108	10.58	14125	16199	2048	22064	23230	5.28	10448	15897	0.05	23.6	19
Wake NC	857.16	423083	627846	204763	48.4	165944	242040	76489	317111	481726	51.91	17201	27004	0.52	24.7	23
Warren NC	443.69	17274	19972	2698	15.62	6352	7708	1363	5524	5901	6.82	8498	14716	0.07	30.4	24
Washington NC	377.21	14014	13723	-291	-2.07	5089	5367	293	4856	5111	5.25	9830	14994	0.05	28.3	24
Watauga NC	312.66	36928	42695	5767	15.62	13546	16540	2906	21399	28551	33.42	10623	17258	0.33	20.4	20
Wayne NC	556.68	104615	113329	8714	8.33	36899	42612	5642	53644	60992	13.7	10850	17010	0.14	21.5	20
Wilkes NC	759.77	59400	65632	6232	10.49	22946	26650	3721	31727	35915	13.2	10828	17516	0.13	24	24
Wilson NC	374.23	66036	73814	7778	11.78	25097	28613	3563	40689	45907	12.82	11637	17102	0.13	21	20
Yadkin NC	337.43	30464	36348	5884	19.31	12109	14505	2378	12369	15147	22.46	11832	18576	0.22	27.5	26
Yancey NC	313.07	15416	17774	2358	15.29	6389	7472	1388	6884	7885	14.54	9459	16335	0.15	27	27
Blount TN	566.6	85940	105823	19883	23.14	33479	42667	9355	34826	50723	45.65	12671	19416	0.46	24	25
Carter TN	347.54	51499	56742	5243	10.18	20175	23486	3337	15199	18884	24.25	9808	14678	0.24	24.1	24
Cocke TN	443.09	29140	33565	4425	15.19	11182	13762	2579	11372	13092	15.12	8573	13881	0.15	28.5	28
Greene TN	623.99	56877	62909	7032	12.59	21553	25756	4139	33200	38120	14.82	10164	15746	0.15	22.4	23
Johnson TN	302.65	13816	17499	3683	26.66	5548	6827	1289	6013	6242	3.81	7534	13388	0.04	32	31
Monroe TN	652.56	30515	38961	8446	27.68	11345	15329	3979	12648	16414	29.78	9073	14951	0.3	26	27
Polk TN	442.37	13642	16050	2408	17.65	5079	6448	1379	4206	4337	3.11	9309	16026	0.03	30.1	30
Sevier TN	597.68	51021	71170	20149	39.49	19455	28467	9029	29700	45348	52.69	10844	18064	0.53	25.3	26
Sullivan TN	429.57	143472	153048	9576	6.67	56533	63556	7069	85834	89880	4.71	12717	19202	0.05	21.3	20
Washington TN	329.73	92303	107198	14895	16.14	35768	44195	8443	59635	75008	25.78	11948	19085	0.26	20.6	21
Unicoi TN	186.45	16566	17667	1101	6.65	6592	7516	952	6456	6588	2.04	10721	15612	0.02	21.2	22
Brunswick VA	569.18	15979	18419	2440	15.27	5573	6277	689	5962	6945	16.49	8873	14890	0.16	30.8	28
Carroll VA	477.49	26572	29245	2673	10.06	10522	12186	1666				9701	16475		26.5	25
Chesapeake VA	350.79	152316	199184	46868	30.77	52405	69900	17430				13817	20949		25.1	26
Danville VA	43.92	52814	48411	-4403	-8.34	21565	20607	-957				11292	17151		18.7	18
Emporia VA	6.96	5252	5665	413	7.86	2011	2226	211				10369	15377		19.6	16
Franklin City VA	8.4	7780	8346	566	7.27	2932	3384	453				11077	18573		20.9	20
Grayson VA	445.77	16321	17917	1596	9.78	6564	7259	697				9034	16768		29	25
Greensville VA	296.71	8898	11560	2662	29.92	3148	3375	229				9596	14632		22.4	22
Halifax VA	829.29	36008	37355	1347	3.74	13475	15018	1522	18178	18832	3.6	21823	16353	0.04	25.1	42
Henry VA	384.27	57025	57930	905	1.59	21734	23910	2212				11610	17110		22.5	22
Martinsville VA	11	16019	15416	-603	-3.77	6783	6498	-277				13611	17251		18.1	16
Mecklenburg VA	679.08	29219	32380	3161	10.82	11298	12961	1603				10501	17171		25.5	21
Pittsylvania VA	977.84	55795	61745	5950	10.66	20707	24684	3959				11228	16991		25.7	25
Southampton VA	602.16	17599	17482	-117	-0.67	6011	6279	268				11053	16930		26.6	25
Suffolk VA	411.48	52221	63677	11456	21.94	18677	23283	4613				11828	18836		27.3	27

Project List

		Master list of NC projects 1990-2000					37784										
	Total	Todd+Ranj	Done		DTH's	% Comp	Countdown				Sum L				Sum DLM	Sum $	
	312		312	DOT							1563	Infra	Lan	Lane	4123.13	6233.57	Compl
Source	FFY	158	158	Div	Comm	LI Numb	Route/City	From	To	Work Desc	Length	Syst	Bef	After	Add LM	Cost (3m)	Year
		Bertie		1	2		No major projs compl in 90s										
		Camden		1	1		No major projs compl in 90s										
91-97	1990	Chowan	1	1	1	R-2512	US 17, W of Edenton	W of Chowan River	US 17 Bus E. of Edenti	Widen 2L to 4L, rur art	7.6	Yes	2	4	15.2	101.3	1999
91-97	1990	Currituck/Dare	1	1	1	R-2418	Wright Mem Bridge	Point Harbor	Kitty Hawk	Widen Bridge, new parall	2.8	Yes	2	4	5.6	24.2	1997
91-97	1990	Currituck	1	1	1	R-2228	NC 168	US 158 Barco	VA state line	Widen 2l to 4L, rur art	18.5	Yes	2	4	37	55.1	1999
91-97	1990	Currituck	1	1	1	R-520	N CNC 158	Barco	Point Harbor	Widen 2l to 5L, urb art	21.1	Yes	2	5	63.3	23.7	1991
91-97	1990	Dare	1	1	1	R-2227	US 158	NC 12 Whalebone	Southern Shores	Widen 2L to 5L, rur art	15	Yes	2	5	45	2.1	1991
91-97	1990	Dare	1	1	1	R-2304	US 64-264	NC 345	US 158 Whalebone	Const bridge approaches	2.2	Yes	0	2	4.4	7.2	1995
91-97	1990	Dare	1	1	1	R-2551	US 64-264	US 264	East City Limits of Man	4L fwd+new bridge over	10	Yes	2	4	20	130.1	2003
		Gates		1	1		No major projs compl in 90s										
91-97	1990	Hertford	1	1	2	R-600	US 158, Murfreesboro	US 158 E of Murf.	US 158 W. of Murf.	New 4L Fry on new loc	5	Yes	0	4	20	12.9	1998
		Hyde		1	1		No major projs compl in 90s										
97-03	1996	Martin	1	1	2	R-2112	US 64	E. of SR 1303, Rober	US 17, s of Williamsto	New 4L Fry on new loc	12.6	Yes	0	4	50.4	78.5	2001
91-97	1990	Martin	1	1	2	R-405	US 64	US 17 in Williamstove	E. of Jamesville	Widen 2L to 4L, rural art	10.5	Yes	2	4	21	62.98	1993
91-97	1990	Martin/Edgeco	1	1	2	R-2111	US 64	US 258 Tarboro	SR 1302 in Martin Co	New 4L Fry on new loc	16.1	Yes	0	4	64.4	50.8	1999
97-03	1996	Northampton	1	1	2	R-2613	NC 46, Gaston	NC 48 e to...	Gaston City Limits	Widen 2L to 4L, urb art	1	No	2	4	2	0.9	1997
91-97	1990	Pasquotank	1	1	1	R-2244	NC 34, Elizabeth city	Halston Bvld Ext	Coast Guard Station	Widen 2L to 5L, urb art	2	No	2	5	6	3.5	1995
91-97	1990	Pasquotank	1	1	1	U-1003	Halstead Bvld, Elizabeth	US 17 Bypass	NC 34	Widen 2L to 4L, urb art	2.2	No	2	4	4.4	2.9	1993
91-97	1990	Perquimans	1	1	1	R-1009	US 17	US 17 Bus n of Hertfo	Woodville SR 1347	Widen 2L to 4L, rur art	8.5	Yes	2	4	13	11.4	1991
91-97	1990	Perquimans/Ch	1	1	1	R-2208	US 17	East of Edenton	Winfall	Widen 2L to 4L, rur art	11.3	Yes	2	4	22.6	29.7	1998
		Washington		1	1		No major projs compl in 90s										
91-97	1990	Beaufort	1	2	2	R-2021	US 264	SR 1501 in Washingt	NC 32	Widen 2L to 4L rur art	5.3	No	2	4	10.6	8.8	1994
91-97	1990	Carteret	1	2	3	U-2226	Bridges St (Morehead	35th st	Arendell St and w to US	Widen 2l to 4L, curb-gutte	2.9	No	2	4	5.8	9.5	1999
91-97	1990	Carteret/Onslo	1	2	3	R-2105	NC 24	Swansboro	US 70 at Morehead Cit	Widen 2l to 4L	20	Yes	2	4	40	12.01	2000
		Craven		2	2		No major projs comp in 90s										
91-97	1990	Greene/Pitt	1	2	2	R-525	US 264	Wilson Co Line	E. of NC 121 in Pitt Co	New 4L Fry on new loc	9.9	Yes	0	4	39.6	32.1	1997
		Jones		2	3		No major projs comp in 90s										
97-03	1996	Lenoir	1	2	2	U-2542	US 258, N of Kinston	US 70, north to...	SR 1575 (Poole Rd)	Widen 2L to 5L urb art	2.7	No	2	5	8.1	7.2	2000
91-97	1990	Pitt	1	2	2	R-1022	US 264 Greenville Byp	US 264 W. of Gr	US 13 N of Greenville	New 4L Fry on new loc	7.5	Yes	0	4	30	42.4	1995
91-97	1990	Pitt	1	2	2	R-2252	NC 43, Greenville	Bells Fork Rd	Grvle South City Limits	Widen 2L to 5L urb art	1.1	Yes	2	5	3.3	2.4	1997
97-03	1996	Pitt	1	2	2	R-526	US 264	New exits, SR 1221 and SR 1210		New exits (2)	2	Yes	2	2	0	6.8	1999
91-97	1990	Pitt	1	2	2	U-2105	Arlington Bvld, Grnvle	Stantonsburg Rd	Mem Drive	New 4L urb art	1.5	No	0	4	6	4.1	1994
91-97	1990	Brunswick	1	3	4	R-53	US 17	NC 211 (Supply)	NC 87 (Bell Swamp)	Widen 2L to 4L + bypass	13.7	Yes	2	4	27.4	25.5	1992
91-97	1990	Brunswick	1	3	4	R-97	US 17	SC state line	NC 211 (Supply)	Widen 2L to 4L + bypass	21.5	Yes	2	4	43	43.5	1997
91-97	1990	Duplin	1	3	2	R-2211	NC 24-11-903	I-40	Beulaville	Widen 2L to 4L+ byp of K	15.4	Yes	2	4	30.8	27.7	1999
91-97	1990	Duplin	1	3	2	R-2524	NC 24	I-40	Warsaw west City Limit	Widen 2L to 4L urb art	1	No	2	4	2	0.5	1997
91-97	1990	Duplin	1	3	2	R-606	US 117	I-40	Mount Olive Connector	New 4L rur art, new loc	9.7	No	2	4	19.4	35.9	1994
91-97	1990	Duplin/New Ha	1	3	2	X-3	I-40	I-95 Benson	Wilmington, north	New 4L Freeway on new	91.4	Yes	0	4	365.6	185.1	1990
91-97	1990	Duplin/Onslow	1	3	2	R-2010	NC 24	Beulaville	US 258 Richlands	Widen 2L to 4L div rur art	10	Yes	2	4	20	15.7	1994
91-97	1990	New Hanover	1	3	4	R-536	NC 132	US 421	Shipyard Bvld 4L	Widen 2 to 4/5L rur art	4.8	No	2	4	9.2	8.5	1998
91-97	1990	New Hanover	1	3	4	U-2570	US 17	30th St	CSX Railroad	Widen 2l to 5L	0.8	No	2	5	2.4	0.95	1998
91-97	1990	New Hanover	1	3	4	U-2571	US 76	NC 132 E 1.5 mi		Widen 2L to 5L urb art	1.5	No	2	5	4.5	0.6	1998
91-97	1990	New Hanover	1	3	4	U-2572	US 76	Bradley Crk Bridge	Military Cutoff	Widen 2L to 4L	1	No	2	4	2	1.6	1997
91-97	1990	New Hanover	1	3	4	U-2701	NC 132	S of US 17-74	S. of Wilshire Bvld	Widen 2l to 4L + safety	1.5	No	2	4	3	1.5	1991
97-03	1996	New Hanover	1	3	4	U-2733	US 74	Smith Creek Pkwy	Military Cutoff	Widen 2l to 4L urb art	1.6	No	2	4	3.2	1.7	1998
91-97	1990	New Hanover	1	3	4	U-92	Smith Creek Parkway	23rd St	US 74	New 4L fwy on new locati	4	No	0	4	16	35.1	1999
91-97	1990	New Hanover/P	1	3	4	R-2405	US 17	Scotts Hill (Pender Co	Holly Ridge	Widen 2L to 4L rur art+re	16.6	Yes	2	4	33.2	38.3	2000
91-97	1990	Onslow	1	3	3	R-1021	US 258/NC24	NC 111	NC 24 W. of Richlands	Widen 2l to 4L rur art	9.3	No	2	4	18.6	13.8	1992
97-03	1996	Onslow	1	3	3	R-2406	US 17	E. of Holly Ridge	4L S of Jacksonville	Widen 2L to 4L rur art	17	Yes	2	4	34	49.8	2000
91-97	1990	Onslow	1	3	3	U-1253H	Western Bvld	Gum Branch Rd	US 17	New 2L rd on 4L ROW	3.2	No	0	2	6.4	2.8	1991

Source	FFY	158	158	Div	Comm	D Numb	Route/City	From	To	Work Desc	Length	Syst	Bef	After	Add LM	Cost ($m)	Year
91-97	1993	Sampson	1	3	6	U-2526	NC 24 in Roseboro	SR 1401	SR 1216	Widen to 3L curb-and-gut	2	No	2	3	2	2.1	1993
91-97	1993	Edgecombe	1	4	2	R-509	US 64	Rocky Mt	Tarboro	2 new exits at SR 1207 a	2	Yes	4	4	0	15.4	1998
91-97	1993	Edgecombe	1	4	2	U-2118	US 64 Bus (Main St. T	NC 44	US 64 Bypass	Widen 2L to 5L, urb art	1.5	No	2	5	4.5	2.6	1991
91-03	1998	Halifax	1	4	2	U-1007	Boiling Rd, Roanoke R	Tenth St in Boiling	NC 48 n of Roa Rap	Widen 2L to 4L, urb art	2.5	No	2	4	5	4.3	1999
91-03	1998	Halifax	1	4	2	U-2120	Old Farm Rd Ext, Roan	NC 132 n to...	US 158, w of I-95	New 5L urb art on new lo	0.8	No	0	5	4	3.4	2000
91-97	1993	Johnston	1	4	5	R-54	US 70, Smithfield Byp	US 70 w of Smithfield	US 70 E of Smithfield	4L div fwy, part on new l	17.6	Yes	2	4	35.2	82.3	1997
91-97	1993	Johnston	1	4	5	U-2114	US 301	US 70 north to...	Hospital St	Widen 2l to 5L, urb art	0.8	No	2	5	1.6	1.7	1992
	1993	Nash	1	4	2	U-2111	NC 43-48, Rocky Mou	US 301 Business	US 64 Bypass	Est a 1-way pair	1.2	No	2	4	2.4	4.2	1998
91-97	1993	Nash	1	4	2	U-2117	Sunset Ave, Rocky Mo	SR 1544	Westridge Circle	Widen 2L to 4L urb art	0.9	No	2	4	1.8	3	1995
91-97	1993	Nash	1	4	2	U-2219	Bethlem Rd, Rocky Mo	SR 1806	Tar River	Widen 2L to 5L urb art	1.4	No	2	5	4.2	1.9	1992
91-97	1993	Nash	1	4	2	U-2310	NC 79	US 301	Nashville Ave	Widen 2l to 5L urb art	1.4	No	2	5	4.2	3.3	2000
91-03	1998	Nash	1	4	2	U-2561	NC 43 w of Rocky Mou	NC 48 (Gold Rock Rd	I-95	Widen 2L to 5L urb art	3.9	No	2	5	11.7	14.2	2001
91-97	1993	Nash	1	4	2	U-2562	NC 48	NC 43	SR 1535	Widen 2L to 3L urb art	1.9	No	2	3	1.9	1.6	1991
91-97	1993	Wayne	1	4	2	R-1030	US 117	US 70	US 301	New 4L rur art, new loc	21	Yes	2	4	42	77.4	2001
91-97	1993	Wayne	1	4	2	R-2422	NC 581	SR 1915	SR 1960, over Neuse R	New 2L rd	1.6	No	0	2	3.2	8.4	2000
91-97	1993	Wayne	1	4	2	U-2409	US 70 and Spence Rd	(SR 1565)		New Interchange	1	Yes	2	2	0	5.6	1998
91-97	1993	Wilson	1	4	2	R-1023	US 264, Wilson bypass	I-95	NC 58 s of Wilson	New 4L Fry on new loc	13.1	Yes	0	4	52.4	97.8	2000
91-97	1993	Wilson	1	4	2	R-2222	Airport Rd, SR 1320	SR 1321	NC 58	Widen 2L to 3L urb art	1.5	No	2	5	4.5	3	1992
91-97	1993	Wilson	1	4	2	U-2573	NC 58	Wilson City limits	Silver Lake	Widen 2l to 5L urb art	3.1	No	2	5	9.3	10.9	1999
91-03	1998	Wilson	1	4	2	U-2922	SR 1165 (Forest Hills	SR 1166 (Forest Hills	US 264	Widen 2L to 4L urb art	3.3	No	2	4	6.6	10.1	1998
91-03	1998	Wilson	1	4	2	U-3345	Menck Rd, Wilson	U 264 e of I-95	SR 1158, sw of Wilson	Widen 2L to 4L urb art	2.2	No	2	4	4.4	7	1999
91-97	1993	Durham	1	5	5	R-2109	NC 54	NC 55 Lowes Grove	NC 54 at Nelson in RTP	Widen 2L to 4/5 L urb art	2.2	No	2	4	4.4	5.1	1994
91-03	1998	Durham	1	5	5	U-2102	NC 157 (Guess Rd, n	SR 1407 (Carver St)	SR 1449 (Umstead Rd	Widen 2L to 4L urb art	3.1	No	2	4	6.2	13.8	2000
91-97	1993	Durham	1	5	5	U-2206	Southern Pkwy Interch	US 15-501	Shannon Rd	Revise interchange + 4L	1.3	No	0	4	5.2	19.2	1994
91-97	1993	Durham	1	5	5	U-2517	NC 147 (Ellis Rd			Const interchange	1	No	4	4	0	3.5	1992
91-97	1993	Durham	1	5	5	U-77	NC 147 (Buck Dean Rd	I-85	Durham Fwy (Erwin Rd	New 4L Frw	4	No	0	4	16	81.3	1997
	1993	Durham	1	5	5	W-2306	US 15-501 Business	James St	Legion Ave	Widen 2L to 3L urb art	0.58	No	2	5	1.74	2	1990
91-97	1993	Durham/Wake	1	5	5	R-2204	I-40	NC 147 in RTP	Wade Ave (I-40), Raleig	Widen 4L to 8L fwy	9.4	Yes	4	8	37.6	50.5	1998
91-97	1993	Durham/Wake	1	5	5	R-2121	Davis Drive Ext, RTP	SR 1835, Wake	Hopson Rd (SR 1978)	New 2L on 4L ROW	3.8	No	0	2	7.6	5.4	1991
91-97	1993	Franklin/Vance	1	5	5	R-607	US 1	US 1A S of Franklinto	US 1 Bus S of Henderso	Widen 2L to 4L rur art	13.4	Yes	2	4	26.8	27.9	1997
91-97	1993	Franklin/Wake	1	5	5	R-205	US 1	1 mi N of Wyatt in Wa	US 1A N of Youngsville	Widen 2L to 4L rur art	7.6	Yes	2	4	15.2	16.1	1994
91-97	1993	Granville	1	5	5	I-2515	I-85 Exit 189, E of Butner			New Exit	1	No	4	4	0	2.6	1993
91-97	1993	Granville	1	5	5	R-2257	US 158, Oxford Outer	US 15	US 158	2L on new location	3	Yes	0	2	6	7.2	1993
91-97	1993	Granville	1	5	5	U-233	Spring St, Oxford	Hillsborough St	Linden Ave	4L fwy on new location	0.5	No	0	4	2	2.1	1998
		Person		5	5		No major projs compl in 90s								0		
91-97	1993	Vance	1	5	5	R-501	US 1 Henderson Bypa	US 1 Bus s of Hende	S of US 158, N of H.	Widen 2l to 4L fwy	7.6	Yes	2	4	15.2	18.3	1992
91-97	1993	Wake	1	5	5	R-2000	I 540 Northern Wake E	I-40	Leesville Blvd	New 4L fwy on new loc	7	No	0	4	28	122.8	1998
91-97	1993	Wake	1	5	5	R-2026	US 401	4-L in Fuquay Varina	NC 42-55	Widen 2L to 5L urb art	1.9	No	2	5	5.7	6	1993
91-97	1993	Wake	1	5	5	R-2402	US 70, Interch w Gree	East of I-40		New Interchange	1	Yes	4	4	0	3.9	1991
91-97	1993	Wake	1	5	5	R-2416	US 401	NC 42-55	North 1.8 miles	Widen 2L to 4L rur art	1.8	No	2	4	3.6	6.7	1998
91-03	1998	Wake	1	5	5	R-2634	Aviation Pkwy, RDU Ai	I-540 (N. Wake Expy)	RDU Airport Connector	New 4L fwy on new loc	1	No	0	4	4	5.7	1999
91-03	1998	Wake	1	5	5	R-2828	Fuquay Varina Loop	US 401 s of F.V.	US 401 N of F.V. (E. Ai	New 2L rur art on 4L ROW	1.9	No	0	2	3.8	3	2000
91-97	1993	Wake	1	5	5	U-2108	I-440 Raleigh Loop	US 70	US 64	Widen 4L to 6L	7	Yes	4	6	14	75.3	1997
91-97	1993	Wake	1	5	5	U-2109	NC 50 (Creedmore Rd	US 70	Strickland Rd	Widen 2L to 4L urb art	4.1	No	2	4	8.2	17.3	1991
91-97	1993	Wake	1	5	5	U-2301	Hunter St Ext, Apex	Salem St	Old Raleigh Rd	New 2L	0.5	No	0	2	1	1.3	1994
91-97	1993	Wake	1	5	5	U-2403	Evans Rd Ext, Cary	Aviation Pkwy	Weston Pkwy	New 4L urb art	0.7	No	0	4	2.8	2.5	1992
91-97	1993	Wake	1	5	5	U-2503	Maynard Rd	High House Rd	NC 54	New 3L urb art	1.5	No	0	3	4.5	1.6	1992
91-03	1998	Wake	1	5	5	U-2824	Durnleigh Rd-Edwards	Blue Ridge Rd (SR 1	Kidd/Hill Plaza Entr	Widen 2L to 4L urb art	1.8	No	2	4	3.6	7.7	2000
91-03	1998	Wake	1	5	5	U-2920	New Hope Rd (SR 200	Willow Oak Rd (SR 2	Buffaloe Rd (SR 2215)	Widen 2L to 5L urb art	1.7	No	2	5	5.1	4.5	2000
91-03	1998	Wake	1	5	5	U-3325	Centerial Pkwy	Lake Wheeler Rd	Avent Ferry Rd	New 4L urb art	1.7	No	0	4	6.8	7	1998
91-03	1998	Wake	1	5	5	U-3426	Cary Parkway, Cary	High House Rd	Evans Rd	New 4L urb art	2.1	No	0	4	8.4	11.7	1999
91-03	1998	Wake	1	5	5	U-3474	US 1 n of Raleigh	Spring Forest Rd (SR	Old Wake Forest Rd (S	Widen 4L to 6L urb art	1.1	No	4	6	2.2	4.5	1999
91-97	1993	Wake	1	5	5	U-515	Hammond Rd, Raleigh	US 70	Rush St	New 4L urb art	2.3	No	0	4	9.2	25.9	1998

Source	FFY	158	158	Div	Comm	ID Numb	Route/City	From	To	Work Desc	Length	Syst	Ber	ATar	Add LM	Cost ($m)	Year
91-97	1990	Wake	1	5	5	U-604	Timber Drive, Garner	US 70	NC 50	New 4L urb art	3.8	No	0	4	15.2	10	1995
91-97	1990	Wake/Chatham	1	5	5	R-2500	US 1 in Wake, Chatha	4-Lane N of US 15-50	US 64 in Wake Co	Widen 2l to 4L hwy	26.5	Yes	2	4	53	66.8	1999
DOT list	1990	Wake/Johnstor	1	5	5	I-0010	I-40	Raleigh Beltline	I-95 at Benson	New 4L hwy on new loc	27	No	0	4	108	55.9	1998
91-97	1990	Bladen	1	6	6	R-522	NC 87 Elizabethtown B	NC 41	Old NC 87 South	New 4L	7.4	Yes	0	4	29.6	21.5	1999
91-97	1990	Bladen	1	6	6	R-2552	NC 87	NC 20	NC 131 at Tarheel	Widen 2L to 4L rur art	5	Yes	2	4	10	9.3	1999
91-97	1990	Columbus	1	6	4	R-61	US 74	Whiteville	E of Bolton	New 4L rur art	18.6	Yes	0	4	74.4	50.5	1999
91-97	1990	Columbus/Rob	1	6	4	R-2558	US 74	NC 41 Robeson Co	US 76 Columbus Co	Widen 2L to 4L rur art	21.2	yes	2	4	42.4	55.98	2000
97-03	1996	Cumberland	1	6	6	R-2426	SR 2333 Wallmart Acc	NC 59 just e. of I-95	e. to Walmart Dist Ctr	New 2L urb art on new lo	1.6	No	0	2	3.2	0.8	1998
91-97	1990	Cumberland	1	6	6	U-2103	Western Network	Morgantown Rd	Reilly Rd, Cliffdale Rd	Widen 2L to 4L urb art	8.4	No	2	4	16.8	20.9	1993
97-03	1996	Cumberland	1	6	6	U-2207	US 401 Bypass, w of B	US 401 Business	NC 24 (Bragg Blvd)	Widen 4L to 6L urb art	3.5	No	4	8	7	6.6	1999
91-97	1990	Cumberland	1	6	6	U-2304	SR 1141	NC 59	SR 1007	Widen 2L to 5L urb art	3	No	2	5	9	8.8	1999
91-97	1996	Cumberland	1	6	6	U-2308	NC 59 (Hope Mills Rd)	Ex 4L s of Camden R	US 401 Business	Widen 2L to 4L urb art	4	No	2	4	8	14	2003
91-97	1990	Cumberland	1	6	6	U-2518	Bonanza Dr, Fayettev	SR 1464	Santa Fe Rd	Widen 2L to 5L urb art	0.7	No	2	5	2.1	1	1995
91-97	1990	Cumberland	1	6	6	U-2709	US 401 Bus	Rankin Rd	Rowan	Widen 2L to 4L urb art	0.8	No	2	4	1.2	1.5	1994
97-03	1996	Cumberland	1	6	6	U-2812	Owen Dr (s of Fay)	Village Dr (s of All Ar	CSX RR tracks	Widen 2L to 4L urb art	1	No	2	4	2	1.6	1997
97-03	1996	Cumberland	1	6	6	U-2912	Owen Dr Extension	I-95 Business	SR 2283 e of NC 87	New 4L urb art on new lo	2.1	No	0	4	8.4	4.5	1999
97-03	1996	Cumberland	1	6	6	U-3106	SR 1400 (Cliffdale Rd	All American Frwy	McPherson Church Rd	New exit at AAF and widi	1.3	No	2	5	3.9	3.9	2000
97-03	1996	Cumberland	1	6	6	U-3107	Glenford Dr Extension	Cliffdale Rd n to...	SR 1404 (Morganton R	New 4L urb art on new lo	0.7	No	0	4	2.8	2.5	1998
97-03	1996	Cumberland	1	6	6	U-3806	Airport Road	US 301 Business	Fay. Regl Airport	Widen 2L to 4L urb art	1.1	No	2	4	2.2	1.9	1997
91-97	1990	Cumberland	1	6	6	U-503	CBD Loop	Mountain Dr	Hay St	New 4L freeway	3.9	Yes	0	4	15.6	53.2	1998
91-97	1990	Cumberland/Ri	1	6	6	R-214	US 401	Raeford Bp, Hoke Co	71 St Schl, Cumb Co	Widen 2L to 4L div rur art	10.6	No	2	4	21.2	21.7	1994
91-97	1990	Harnett	1	6	6	R-1025	US 421	NC 27-55 Erwin	SR 1008 s of Buies Cre	Widen 2L to 4L rur art	4.7	No	2	4	9.4	9.1	1992
91-97	1990	Robeson	1	6	6	U-1005	NC 211 (Roberts St, L	NC 72	SR 1997 (near I-95)	Widen 2L to 4L urb art	2.4	No	2	4	4.8	3.3	1993
91-97	1990	Robeson	1	6	6	U-2415	NC 211 (Roberts St, L	Roland Ave	w of SR 1586	Widen 2L to 5L, + Int imp	0.5	No	2	5	1.5	6.9	2000
91-97	1990	Robeson	1	6	6	U-2416	NC 72-711 at I-95	SR 1593	SR 2501	Widen 2L to 4L rur art, + i	0.8	No	2	4	1.6	7.9	2000
97-03	1996	Alamance	1	7	6	R-2538	NC 54	SR 2106 Whitmore L	NC 119	Widen 2L to 5L urb art	3.3	No	2	5	9.9	9.7	2001
91-97	1990	Alamance	1	7	7	R-611	US 70, Haw River Byp	Hanover Rd w of Haw	NC 49 e of Haw Riv	New 4L rur art	1.5	No	0	4	6	7.6	1994
91-97	1990	Alamance	1	7	7	U-2305	Maple St Ext, Graham	Maple St	over I 85	New 4L urb art, +bridge	0.2	No	0	2	0.4	1.5	1992
97-03	1996	Alamance	1	7	7	U-2411	Maple Ave Ext, Graham	I-85 n to...	NC 87 at Moore St	New 2L urb art on new lo	1.7	No	0	2	3.4	5.6	2001
91-97	1990	Alamance	1	7	7	U-2500	NC 49 (Harden St, Bur	NC 87	SR 1716	Widen 2L to 5L	1.1	No	2	5	3.3	1.2	1991
91-97	1990	Alamance/Guil	1	7	7	I-923	I-40/85	US 29	NC 54	Widen 4L to 6L	21.9	Yes	4	6	87.6	122.8	1995
91-97	1990	Alamance/Orai	1	7	7	I-304	I/40/85	E of NC 54	W of SR 1134	Widen 4L to 6L	13.5	Yes	4	6	54	90.7	1997
		Caswell		7	7		No major projs compl in 90's										
City of G	2000	Guilford	1	7	7	GR-1	Vandalia Rd	US 220	Holden Rd	Widen 2L to 4L urb art	1.2	No	2	4	2.4	0.7	2000
City of G	1998	Guilford	1	7	7	GR-2	Dolly Madison Rd	Friendly Ave	W. Market St	Widen 2L to 4L urb art	1.04	No	2	4	2.08	0.6	1998
City of G	2001	Guilford	1	7	7	GR-3	Lake Brandt Rd	Old Battleground Rd	Lawndale Dr	Widen 2L to 4L urb art	1.26	No	2	4	2.52	0.6	2001
City of G	1998	Guilford	1	7	7	GR-4	Merritt Drive	Spring Garden St	I-40 Bridge	Widen 2L to 4L urb art	0.94	No	2	4	1.88	2.7	1998
City of G	1999	Guilford	1	7	7	GR-5	Wendover Ave, w of G	Clifton Rd	Big Tree Way	Widen 2L to 3L urb art	1.09	No	2	4	2.18	1.15	1999
City of G	1999	Guilford	1	7	7	GR-6	East-West Connector	Cotswold Terrace	Lawndale Dr	Widen 2L to 4L urb art	1.09	No	2	4	2.18	1.9	1999
City of G	1999	Guilford	1	7	7	GR-7	Lake Brandt Rd	Lawndale Dr	new city limits	Widen 2L to 4L urb art	0.63	No	2	4	1.26	0.5	1999
City of G	2000	Guilford	1	7	7	GR-8	Old Battleground Rd	Brandt Ridge Rd	City limits	Widen 2L to 4L urb art	0.5	No	2	4	1	0.3	2000
97-03	1996	Guilford	1	7	7	R-609D	US 311 Bypass	W. of H.P. Reservoir	2000' w of NC 68 in Gu	New 4L hwy on new loc	3.2	No	0	4	12.8	21.4	1997
97-03	1996	Guilford	1	7	7	R-609EA	US 311 Bypass	2000' w. of NC 68 in	NC 68 in Guilford Co	New 4L hwy on new loc +	0.412	No	0	4	1.648	12.2	2000
97-03	1996	Guilford	1	7	7	U-2012	NC 68 and SR 2085 (A	NA	NA	New Exit on NC 68 at Air	1	No	4	4	0	7.9	1999
91-97	1990	Guilford	1	7	7	U-202	Freeman Mill Rd, Gr	Lovette St	Hall St	Widen 2L to 4L urb art	0.7	No	2	4	1.4	3.3	1993
91-97	1990	Guilford	1	7	7	U-2413	Wendover Ave, w of G	Penny Rd (SR 1535)	Landmark/Center Dr. in	Widen 2L to 4L rur art	4.1	No	2	4	8.2	9.8	1995
97-03	1996	Guilford	1	7	7	U-2536	Intermediate Loop, Hig	US 311 N of H.P.	Montlieu Ave	New 4L urb art on new lo	2.2	No	0	4	8.8	14.9	2001
97-03	1996	Guilford	1	7	7	U-3429	Vickery Chapel Rd (SR	I-85 Business, n. to...	Wiley Davis Rd	Widen 2L to 4L urb art	0.3	No	2	4	0.6	0.95	2001
97-03	1996	Guilford	1	7	7	U-3476	SR 1486, Main St in Ja	SR 1485	Wade St	Teague Dr	Widen 2L to 4L urb art	0.7	No	2	4	1.4	1.3	1997
91-97	1990	Guilford	1	7	7	U-510	Bryan Bvld Ext	New Garden Rd	SR 2176 (Benjamin Pk	New 4L hwy on new loc	3.3	No	0	4	13.2	26.1	1993
91-97	1990	Guilford	1	7	7	U-60	US 220, Greensboro	Vandalia St	Wilmore St n of I-40	New 4L hwy on new loc	1.8	No	0	4	7.2	26.7	1996
91-97	1990	Guilford	1	7	7	U-605	Bryan Bvld Ext	New Garden Rd	Airport Rd	New 4L hy on new loc	2.9	No	0	4	11.6	23.8	1998
91-97	1990	Guilford	1	7	7	U-800	West Market St	NC 68	Jamestown Rd	Widen 2L to 4L urb art	4	No	2	4	8	9	1995

Source	FFY	158	158	Div	Comm	TJ Numb	Route/City	From	To	Work Desc	Length	Syst	Bef	After	Add LM	Cost ($m)	Year
91-97	1990	Orange	1	7	5	U-2002	Main, Greensboro and	Old Fayetteville Rd	Carboro Bypass	Widen 2L to 4L urb art	3.5	No	2	4	7	3.5	1991
91-97	1990	Orange	1	7	5	U-2003	NC 54 and US 15-501	Old Fayetteville Rd w	US 501 Bus n of Chape	Widen 2L to 4L urb art	7	No	2	4	14	26.7	1993
91-97	1990	Orange	1	7	5	U-2302	NC 86 in Chapel Hill	I 40	s to SR1777 (Homestea	Widen 2L to 4L urb art	1.5	No	2	4	3	7.8	2000
97-03	1996	Orange	1	7	5	U-3100	Hillsborough Rd (SR 1	Loraine St to Old Fay	Along SR 1107 to NC 5	Widen 2L to 3L urb art	1.9	No	2	3	1.9	4.4	2000
91-97	1990	Orange	1	7	5	U-624	NC 86 in Chapel Hill	US 15-501 Bypass	Manning Drive	Widen 2L to 3L urb art	1.5	No	2	3	4.5	5.7	1992
91-97	1990	Rockingham	1	7	7	R-2019	US 220	NC 68	NC 704	Widen 2L to 4L rur art	8.3	Yes	2	4	12.6	15	1992
91-97	1990	Rockingham	1	7	7	R-2232	US 220	S of US 220-NC 704	Va State Line	Widen 2L to 4L rur art	13.3	Yes	2	4	26.6	31.7	2000
91-97	1990	Rockingham	1	7	7	R-2401	NC 14	NC 29 Bus n of Reidsv	NC 700-770 in Eden	Widen 2L to 3L rur art	10	No	2	3	30	20.2	1995
97-03	1996	Rockingham	1	7	7	U-2418	Reidsville Southern Lo	US 29 Business, s to	NC 87	New 5L urb art on new lo	2.4	No	0	5	12	13.9	1999
91-97	1990	Chatham	1	8	6	R-2218	US 64	Siler City	6 mi east	Widen 2L to 4L rur art	15.78	Yes	2	4	39.55	25.4	2000
97-03	1996	Chatham	1	8	6	R-2219	US 64, Pittsboro Bypas	SR 1514 w of Pittsbo	4 lanes w of Jordan Lak	Widen 2L to 4L rur art	9.4	Yes	2	4	18.8	57.3	2001
97-03	1996	Chatham	1	8	6	R-3114	NC 87 Bypass, s of Pit	NC 87	NC 902	New 2L urb art on new lo	0.7	No	0	2	1.4	1.9	2000
91-97	1990	Chatham/Rand	1	8	6	R-68	US 421, Siler City Byp	Siler City	Staley	Widen 2L to 4L, fly facil	13.1	Yes	2	4	26.2	47.1	1997
91-97	1990	Chatham/Wake	1	8	6	R-2318	US 64	E. of Lake Jordan	US I-64 at Cary	Widen 2 to 4L rur art	11	Yes	2	4	22	39.6	1997
		Hoke		8	6		Joint proj with Cumberland								0		
91-97	1990	Lee	1	8	6	R-2238	NC 24-87	Swan (Harnett Co Lin	US 421 at Sanford	Widen 2L to 4L rur art	6	Yes	2	4	12	9.6	1999
97-03	1996	Lee	1	8	6	U-2921	US 421 in Sanford	SR 1107 (Fields St)	NC 42 (Main St)	Widen 2L to 3L urb art	1.8	No	2	3	5.4	3.4	1999
91-97	1990	Montgomery	1	8	6	R-2107	NC 24-27	Little River	Biscoe	Widen 2L to 4L rur art	4	Yes	2	4	8	5.7	1991
91-97	1990	Montgomery/R	1	8	6	R-523	US 220/I -73/I-74	S of Steed	S. of Ulah	New 4L fwy on new loc	13	Yes	2	4	26	48.6	1996
91-97	1990	Moore	1	8	6	R-2004	US 15-501	US 1 at Aberdeen	NC 2 at Pinehurst	Widen 2L to 3L urb art	4	No	2	3	12	5.6	1993
97-03	1996	Moore	1	8	6	U-2420	Morgantown Rd, South	US 15-501	US 1	Widen 2L to 4L urb art	2	No	2	4	4	3.3	1999
91-97	1990	Randolph	1	8	7	U-1558N	Presnell St Extn, Ashe	Farr St east to ...	US 64	New 4L urb art	2.1	No	0	4	8.4	4.8	1994
97-03	1996	Randolph	1	8	7	U-2538	US 311 s of High Point	I 85 s to...	w if SR 1919	Widen 2L to 3L urb art	2.7	No	2	3	8.1	8.2	1999
97-03	1006	Richmond	1	8	6	R-3401	US. Marston to Hoffman	s of SR 1004 at Mand	Sr 1004 in Hoffman	Widen 2L to 3L urb art	4.7	No	2	3	4.7	1.7	1997
91-97	1990	Richmond	1	8	6	R-512	US 74/I-73/I-74 Rock-H	US 74 E of Rock.	US 74 W. of Hamlet	New 4L fwy on new loc	13.1	Yes	0	4	52.4	70.7	2000
97-03	1996	Richmond	1	8	6	U-2217	US 220 in Rockingham	SR 1124		1/2 exit (2 addit ramps)	0.5	No	0	2	1	1.8	1998
97-03	1996	Richmond	1	8	6	U-2583	US 220 in Rockingham	SR 1974 (Forest St)	s to, US 74 Bypass	Widen 2L to 4L urb art	0.7	No	2	4	1.4	3.1	2001
91-97	1990	Scotland	1	8	6	R-613	US 401, Laurinburg Byp	S of SR 1105	US 401 Bus N of L	Widen 2L to 4L urb art	7.3	No	2	4	14.6	16.2	1997
97-03	1996	Davidson	1	9	7	R-2220	US 64	I 85Bus in Lexington	I 85	Widen 2L to 4L urb art	4	Yes	2	4	8	10.1	1998
91-97	1990	Davidson	1	9	7	R-74	NC 52	I 85 in Lexington	Welcome	New 4L fwy on new loc	12.8	Yes	2	4	25.2	67.9	1995
97-03	1996	Davidson	1	9	7	U-2569	NC 68 at I 85 Business			Widen 2L to 4L urb art, at	0.2	No	2	4	0.4	4.5	1999
91-97	1990	Davie	1	9	7	R-2243	US 601	US 64	I-40	Widen 2L to 3L urb art	1.7	No	2	3	1.7	4.1	1992
97-03	1996	Davie/Forsyth	1	9	7	I-911	I-40 in Davie and Fors	W of NC 801 (Exit 18	w of SR 1122 (s of US	Widen 4L to 6L and pvt ra	7.1	No	4	6	14.2	43.1	1999
91-97	1990	Forsyth	1	9	7	I-900	I-40	US 421 (exit 188)	Exit 206 E of Kernersvil	New 4L fwy on new loc	18.5	Yes	0	4	74	184.9	1993
93-99	1992	Forsyth	1	9	7	R-2709	NC 150 Peters Crk Pk	Clemmonsville Rd	Davidson Co Line	Widen 2L to 4L rur art	2.7	No	2	4	5.4	7.2	2002
91-97	1990	Forsyth	1	9	7	R-511	NC 66	SR2611	I-40 in Kernersville	Widen 2L to 4L urb art	2.9	No	2	4	5.8	4.2	1993
93-99	1992	Forsyth	1	9	7	U-2115	Bethabara Bypass	NC 67 Reynolda Rd	Univ Pkwy (SR 4000)	New 4L urb art on new lo	2.2	No	0	4	8.8	4.5	1995
91-97	1990	Forsyth	1	9	7	U-2311	US 158, Winston-Sale	SR 1120	SR 1101	Widen 2L to 4L	5	No	2	4	10	11.4	1995
91-97	1990	Forsyth	1	9	7	U-2513	SR1102 (Lewisville-Cl	US 158, north to...	SR 1891 (N of I-40)	Widen 2L to 4L rur art	1.6	No	2	4	3.2	1.9	1994
91-97	1990	Forsyth	1	9	7	U-2575	Peace Haven - Polo Cl	Whitaker Rd	Faircloth St	Widen 2L to 4L urb art	0.8	No	2	4	1.6	2	1992
92-98	1993	Forsyth	1	9	7	U-2826	M L King Dr Ext	MLK Dr	Eighth St	New 4L urb art on new lo	0.4	No	0	4	1.6	3.2	1998
94-00	1993	Forsyth	1	9	7	U-3120	Hanes Mill Rd Extn	Univ Pkwy (SR 4000)	NC 8 Germantown Rd	New 4L urb art on new lo	1	No	0	4	4	2	1996
98-04	1997	Forsyth	1	9	7	U-3829	US 421	Jonestown Rd	Peacehaven Rd	Widen 4L to 6L fry	0.6	Yes	4	6	1.2	3.4	2001
91-97	1990	Forsyth	1	9	7	U-526	Clemmonsville Rd	US 52	I-40	Widen 2L to 4L urb art	0.9	No	2	4	1.8	3.6	1992
97-03	1996	Rowan	1	9	10	I-2511	I 85 widening	US 29 (China Grove	Jake Alexander Blvd in	Widen 4L to 6L (part of jo	4.5	No	4	6	18	90	2001
91-97	1990	Rowan	1	9	10	U-2113	Jake Alexander Blvd	US 70, s to...	just n of I-85	Widen 2L to 4L urb art	2.8	No	2	4	5.6	9.7	1995
91-97	1990	Rowan	1	9	10	U-2564	US 70, Salisbury	SR 1724 (Hurley Sch	US 601	Widen 2L to 4L urb art	1	No	2	4	2	1	1991
91-97	1990	Rowan	1	9	10	U-613	Jake Alexander Blvd	I-85 s to...	US 52/Stokes Ferry Rd	New 4L urb art on new lo	1.4	No	0	4	5.6	8.3	1998
		Stokes		9	7		No major projs compl in 1990s										
		Anson		10	10		No major projs compl in 1990s										
91-97	1990	Cabarrus	1	10	10	I-2303	I-85	at I 85 and SR 2126	Dale Earnhart Blvd.	New Exit 60 on I85	0	Yes	4	4	0	1.2	1993
94-00	1993	Cabarrus	1	10	10	R-2315	Speedway Blvd	Delta Rd	NC 29 at Sidney	New 4L rural art+exit on	3.4	No	0	4	13.6	10.6	1997
97-03	1996	Cabarrus	1	10	10	U-3115	US 29	Charlotte Outer Belt	Rocky River, just n of S	Widen 4L to 6L urb arterl	3.52	No	4	6	7.04	11.9	1999

Source	FFY	TIP	TIP	Div	Comm	TJ Number	Route/City	From	To	Work Desc	Length	Sys#	Bef	After	Add LM	Cost ($m)	Year
91-97	1990	Cabarrus	1	10	10	U-530	NC 136 in Concord	NC 73	US 601 s of Conc.	New 2L on new location	2	No	0	2	4	5.1	1998
91-97	1990	Cabarrus/Meck	1	10	10	R-2215	NC 49	UNC Charlotte	Town of Harrisburg	Widen 2L to 4L rur art	4.2	No	2	4	8.4	12.1	1998
91-97	1990	Cabarrus/Meck	1	10	10	R-815	NC 24-27	NC 51	US 601	Widen 2L to 4L rur art	6.6	Yes	2	4	13.2	21.9	2000
91-97	1990	Cabarrus/Stanl	1	10	10	R-2104	NC 24-27	US 601	Town of Locust	Widen 2L to 4L rur art	2.8	Yes	2	4	5.6	8.2	1996
91-97	1990	Mecklenburg	1	10	10	I-2401	I-77	I-85	SC state Line	Widen 4L to 6/8L frwy	13.24	Yes	4	6	26.48	52.3	1997
91-97	1990	Mecklenburg	1	10	10	I-301	I-85	Catawba River	NC 24-49 Junction	Widen 4L to 8L frwy	15.8	Yes	4	8	63.2	166.8	1994
City of C	1990	Mecklenburg	1	10	10	MECK-1	Harris Blvd	NC 49	Plaza Rd	New 4L urb art on new lo	2.5	No	0	4	10	11	1991
City of C	1987	Mecklenburg	1	10	10	Meck-10	Park Rd	Frederick Place	Sharon Rd	Widen 2L to 4L urb art	1	No	2	4	2	7.1	1994
City of C	1988	Mecklenburg	1	10	10	Meck-11	Shamrock Dr	Eastway Dr	Sharon Amity Rd	Widen 2L to 4L urb art	1.2	No	2	4	2.4	11.1	1994
City of C	1988	Mecklenburg	1	10	10	MECK-1	Milton Rd	The Plaza	Sharon Amity Rd	Widen 2L to 4L urb art	1	No	2	4	2	2	1994
City of C	1988	Mecklenburg	1	10	10	MECK-1	Colony Rd Ext	Sharon View Rd	Carmel Rd	New 4L urb art on new lo	1	No	0	4	4	3.8	1992
City of C	1998	Mecklenburg	1	10	10	MECK-1	Colony Rd Ext	Carmel Rd	Rea Rd	New 2L urb art on new lo	2	No	0	2	4	10	2000
Private	1998	Mecklenburg	1	10	10	MECK-1	Ballantyne Commons	Lancaster HY	Elm Lane	New 4L urb art on new lo	2	No	0	4	8	8	1998
97-03	1998	Mecklenburg	1	10	10	U-3426	Ballantyne Commons	Elm Lane	Providence Rd West	Widen 2L to 4L urb art	0.6	No	2	4	1.2	1.3	1998
City of C	1998	Mecklenburg	1	10	10	MECK-2	Park Rd	Sharon Rd, s. to...	Johnson Rd (n. of NC 5	Widen 2L to 6L urb art	2	No	2	6	8	17.6	1994
City of C	1998	Mecklenburg	1	10	10	MECK-3	Quail Hollow Rd	Sharon Rd, s. to...	Carmel Rd	Widen 2L to 4L urb art	1.5	No	2	4	3	1.52	1992
City of C	1998	Mecklenburg	1	10	10	MECK-4	Carmel Rd	Quail Hollow Rd, s. to	NC 51	Widen 2L to 4L urb art	1.5	No	2	4	3	12.8	1998
City of C	1998	Mecklenburg	1	10	10	MECK-5	Providence Rd	NC 51, s. to...	I-485	Widen 2L to 4L urb art	1.6	No	2	4	3.2	10	1998
City of C	1993	Mecklenburg	1	10	10	MECK-6	Sardis Rd	Rama Rd	Sardis Rd North	Widen 2L to 4L urb art	1.3	No	2	4	2.6	7	1998
City of C	1998	Mecklenburg	1	10	10	MECK-7	Westinghouse Blvd	Downs Rd	South Blvd	Widen 2L to 4L urb art	1	No	2	4	2	8.3	1994
City of C	1987	Mecklenburg	1	10	10	MECK-8	Monroe Rd	Conference Dr	Village Lake Dr	Widen 2L to 4L urb art	1.1	No	2	4	2.2	4	1994
City of C	1987	Mecklenburg	1	10	10	MECK-9	Beatties Ford Rd	I-85	Capps Hill Mine Rd	Widen 2L to 4L urb art	1	No	2	4	2	9.7	1993
91-97	1990	Mecklenburg	1	10	10	R-2012	NC 51 Matthews Bypa	NC 51 e of US 74	NC 51 w of US 74	New 4L rur art on new loc	3.3	No	0	4	13.2	26.5	1998
91-97	1990	Mecklenburg	1	10	10	R-203	NC 24-27	SR 3128 (Lawyers Rd	NC 51	Widen 2L to 4L urb art	5.9	Yes	2	4	11.8	20.4	1993
91-97	1990	Mecklenburg	1	10	10	R-211	I-485	I-77	US 74	New 4L frwy on new loca	16.6	Yes	0	4	66.4	205.2	1998
91-97	1990	Mecklenburg	1	10	10	R-2242	US 521	I-485 Outer Loop	SC state Line	Widen 2L to 4L urb art	3.4	No	2	4	6.8	10.4	1994
91-97	1990	Mecklenburg	1	10	10	R-2555	(Old) NC 73 Catawba	SR 2144 (s of new 73	SR 2195 (just w of I-77	Widen 2L to 3 L urb art	3.7	No	2	3	3.7	4.6	1993
91-97	1990	Mecklenburg	1	10	10	R-2624	I-77 and Sam Furr Rd	New Exit		New Exit+ upgrade Sam	1	No	2	4	2	5.8	1994
91-97	1990	Mecklenburg	1	10	10	R-58	NC 16	Mt Holly-Huntersville	NC 16 N of Lucia	New 4L rur art on new loc	9.7	No	2	4	19.4	31.7	1992
91-97	1990	Mecklenburg	1	10	10	J-2005	Harris Blvd	Plaza Rd	NC 24-27	Widen 2L to 4L urb art	4.1	No	2	4	8.2	13	1994
91-97	1990	Mecklenburg	1	10	10	J-209	US 74 Independence B	I-277	Eastway Dr (NC 4)	Widen 4L frwy to 6L frw	3.9	Yes	4	6	7.8	86.7	1998
91-97	1990	Mecklenburg	1	10	10	J-2303	Mallard Crk Church Rd	Mallard Crk Rd	I-85	Widen 2L to 4L urb art	1.5	No	2	4	3	4	1991
91-97	1990	Mecklenburg	1	10	10	J-2507	Mallard Crk Rd	Mallard Crk Church R	Harris Blvd	Widen 2L to 4L urb art	1.5	No	2	4	3	4.3	1995
91-97	1990	Mecklenburg	1	10	10	J-2508	Mallard Crk Church Rd	I-85	NC 29	Widen 2L to 4L urb art	1	No	2	4	2	4.9	1998
91-97	1990	Mecklenburg	1	10	10	J-2706	Westinghouse Blvd	Carpet St (w of I-77)	Downs Rd (w 0.5 mi)	Widen 2L to 4L urb art	0.5	No	2	4	1	3.3	1998
97-03	1998	Mecklenburg	1	10	10	J-2806	Westinghouse Blvd	W of NC 49	W of I-77	Widen 2L to 4L urb art	0.7	No	2	4	1.4	4	1998
97-03	1998	Mecklenburg	1	10	10	J-2910	Monroe Rd	Ex multi-lanes s of Ra	John St s of NC 51	Widen 2L to 4L urb art	0.7	No	2	4	1.4	3.7	1999
91-97	1990	Mecklenburg	1	10	10	U-809	Harris Blvd	I-77	I-85	Widen 2L to 4L urb art	5.5	No	2	4	11	12.1	1994
97-03	1998	Mecklenburg/U	1	10	10	U-2506	Rea Rd Extension	NC 16	I-485	New 4L urb art on new lo	5.3	No	0	4	21.2	14.7	2000
97-03	1998	Stanly	1	10	10	R-2530A	NC 24-27 in Albemarle	St Martin Rd w of Alb	Mt Vernon Dr w of US 5	Widen 2L to 4L urb art	1.6	Yes	2	4	3.2	4.5	2001
97-03	1998	Stanly	1	10	10	U-2400	Northeast Connector, A	US 52 n of Alb.	NC 24-27 e of Alb	New 2L rur art on new loc	3.2	No	0	2	6.4	8.7	1999
97-03	1998	Union	1	10	10	U-3444	Olive Branch Rd, Mars	US 74	SR 1735 (Union St)	New 2L urb art on new lo	0.3	No	0	2	0.6	0.8	1997
97-03	1998	Alleghany	1	11	7	R-3117	Sparta Western Loop	Grandview Dr s of Sp	US 21 w of Sparta	New 2L rur art on new loc	1.4	No	0	2	2.8	3.9	1998
		Ashe		11	7		No major proje comp in 90s								0		
		Avery		11	7		No major proje comp in 90s								0		
97-03	1998	Caldwell	1	11	9	R-2237	US321 (part done)	N of NC 268	Multi-lanes n of Blowing	widen 2L to 4L rur art	7	Yes	2	4	14	26.2	2001
91-97	1990	Caldwell	1	11	9	R-2626	Connector, US 64, Len	US 64	Abington Rd (SR 1310)	New 2L rur art on new loc	1.3	No	0	2	2.6	2.9	2000
91-97	1990	Caldwell	1	11	9	U-2309	SW Loop Extension no	Creekway Drive	US 321 North	Widen 2L to 4L urb art	2.6	No	2	4	5.2	13.2	1997
91-97	1990	Caldwell	1	11	9	U-91	Southwest Loop, Lenoi	NC 18 Bus w of Lenoi	US 321 s of Lenoir	New 4L urb art on new lo	4.5	No	0	4	18	30.8	1991
97-03	1998	Surrey	1	11	7	R-2236	CC Camp Rd, Elkin	I-77	US 21 Bypass e of Elki	Widen 2L to 4L urb art	1.4	No	2	4	2.8	1.8	2001
97-03	1998	Surrey	1	11	7	R-2917	US 601 s of Mt Airy	NC 752	SR 1399 (Edgewood D	Widen 2L to 4L urb art	1.3	No	2	4	2.6	3.2	2000
91-97	1990	Surrey	1	11	7	R-98	US 52/I-77 Connector	I-77	US 52 s. of Mt Airy	New 4L frwy on new loca	10	Yes	0	4	40	84.3	1999
97-03	1998	Watauga	1	11	8	R-529	US 421 e of Boone	NC 194 in Boone	2 mi e of US 221	Widen 2L to 4L rur art	11.9	Yes	2	4	23.8	78.9	2001

Source	FFY	158	158	Div	Comm	D Numb	Route/City	From	To	Work Desc	Length	Syst	Bef	After	Add LM	Cost ($m)	Year
97-03	1996	Watauga	1	11	8	U-2302	US 221 in Boone	US 321	US 421	Widen 2L to 4L urb art	0.9	No	2	4	1.8	9.6	1998
97-03	1996	Watauga	1	11	8	U-3406	US 321 in Boone	SR 1152 (Rivers St)	n. of relocated Rivers S	Widen 2L to 4L urb art	0.2	No	2	4	0.4	1.1	1999
91-97	1990	Wilkes	1	11	7	B-1431B	NC 18-268, Wilkesboro	D St	E St	Widen 2L to 6L+ repl Bra	0.2	No	2	6	0.3	4.1	1992
91-97	1990	Wilkes	1	11	7	R-2239	US 421	4 mi e of Wilkesboro	11 mi e of Wilkesboro	Widen 2L to 4L rur art	7	Yes	2	4	14	30.78	2000
91-97	1990	Wilkes	1	11	7	U-815	NC 268	SR 1200	US 421 Bypass	Widen 2L to 4L	1.4	No	2	4	2.8	4.4	1991
97-03	1996	Wilkes/Surrey	1	11	7	R-2604	NC 268 Bypass, Elkin	NC 268 w of Elkin	US 21 Bypass e of Elki	New 4L rur art on new loc	3.2	No	0	4	12.8	22.1	2002
91-97	1990	Yadkin	1	11	7	R-2120	US 421	I-77	W of Yadkin River	Widen 2L to 4L	15.9	Yes	2	4	31.8	63	2002
91-97	1990	Alexander	1	12	9	R-1016	US 64/NC 90	W of SR 1515	Iredell Co Line	New 2L on 4L ROW	7.8	No	0	2	15.6	27.9	1998
91-97	1990	Catawba	1	12	9	U-2215	US 321, Newton	NC 10	US 64-70	Widen 2l to 4L, urb art	2.7	No	2	4	5.4	4.4	1994
97-03	1996	Catawba	1	12	9	U-2306	Lenoir Rhyne Bvld Ext	Tate Bvld, n to...	8th St NE	Widen 2L to 4L urb art	0.7	No	2	4	1.4	9.4	1999
91-97	1990	Catawba	1	12	9	U-2533	Robinson Rd, Hickory	SR 1170	US 70-321	Widen 2l to 5L, urb art	0.4	No	2	5	1.2	0.1	1991
91-97	1990	Catawba	1	12	9	U-2819	New rd, s Hickory	Robinson Rd (SR 115	Startown Rd (SR 1005	New 2L rur art on new loc	1.2	No	0	2	2.4	1.5	1997
91-97	1990	Catawba	1	12	9	U-72	NC 127, Hickory	2nd Ave NE	SR 1400	Widen 3 L to 4L, urb art	4.6	No	2	4	9.2	19.5	1993
91-97	1990	Cleveland	1	12	10	R-519	NC 150, S. Shelby	NC 150	S. Dekalb St	New 4L urb art on new lo	1.9	No	0	4	7.6	2.8	1994
97-03	1996	Cleveland	1	12	10	U-2221	NC 180, e Shelby	NC 226 e of Shelby	NC 150 n of Shelby	Widen 2L to 4L urb art	4.9	No	2	4	9.8	16.2	2000
Gastonia	1993	Gaston	1	12	10	GAST-1	Hoffman Rd	Robinwood Rd	Gaston Day Schl Rd	Widen 2L to 4L urb art	1.3	No	2	4	2.6	1.7	1995
Gastonia	1997	Gaston	1	12	10	GAST-2	Hoffman Rd Extension	Gaston Day Schl Rd	Hudson Bvld	New 4L urb art on new lo	0.7	No	0	4	2.8	4.2	1999
Gastonia	1996	Gaston	1	12	10	GAST-3	Tilman Rd Connector	Hoffman Rd	NC 279 New Hope Rd	New 4L urb art on new lo	0.7	No	0	4	2.8	1.3	1998
Gastonia	1994	Gaston	1	12	10	GAST-4	Robinwood Rd	NC 274 Union Rd	NC 279 New Hope Rd	Widen 2L to 4L urb art	3.1	No	2	4	6.2	11.2	1998
Gastonia	1992	Gaston	1	12	10	GAST-5	NC 274 Union Rd	Robinwood Rd	Niblock Rd	Widen 2L to 4L urb art	2	No	2	4	4	3.1	1995
91-97	1990	Gaston	1	12	10	I-2003	Lowell Exit of I-85			New Exit at Lowell/Main	1	Yes	0	2	2	5.7	1994
91-97	1990	Gaston	1	12	10	I-302	I-85	NC 296/US 74 e of Kin	NC 273	Widen fwy from 4L to 6L	17.5	Yes	4	6	35	62.8	2000
91-97	1990	Gaston	1	12	10	U-2104	NC 7, Gastonia	Modena St	I-85	Widen 2L to 4L, urb art	0.7	No	2	4	1.4	1.6	1992
91-97	1990	Gaston	1	12	10	U-215	Hudson Bvld, Gastonia	US 321	New Hope Rd	New 4L urb art on new lo	4.5	No	0	4	18	12.3	1998
91-97	1990	Gaston/Lincoln	1	12	10	R-617A	NC 150, Cherryville	NC 279 at Cherryville	Crouse in Lincoln Co	Widen 2l to 4L rur art	6	No	2	4	12	15	1997
91-97	1990	Gaston/Lincoln	1	12	10	R-212	US 321	NC 275 in Dallas	NC 27 at Lincolnton	New 4L fwy on new loc	12.5	Yes	0	4	50	52.9	1994
91-97	1990	Iredell	1	12	10	R-1017	US 64/NC 90	Alexander Co line	I-40	New 2L rur art on new loc	7.7	No	2	4	15.4	15.5	1995
91-97	1990	Iredell	1	12	10	R-2226	NC 150, Mooresville	I-77	NC 152	Widen 2L to 4L urb art	1.9	No	2	4	3.8	4.2	1998
91-97	1990	Iredell	1	12	10	U-2213	NC 150, Mooresville	NC 152	NC 115	Widen 2L to 4L urb art	1.3	No	2	4	2.6	3.5	1992
97-03	1996	Iredell	1	12	10	U-2421	US 70 e of Statesville	SR 2352 (Barkley Rd	SR 2318 (Fanjoy Rd)	Widen 2L to 4L urb art	1.6	No	2	4	3.2	4.8	2000
91-97	1990	Lincoln/Catawb	1	12	10	R-55	US 321	Lincolnton	Hickory	New 4L Freeway on new	17.9	Yes	0	4	71.6	56.1	1998
91-97	1990	Buncombe	1	13	11	I-100	I-40 at Sweeten creek	New Exit 51 on I-40		New Exit 51	1	Yes	0	2	2	9	1999
97-03	1996	Buncombe	1	13	11	R-2306	US 74A	I-40 e. to...	SR 3198 (Fairview)	Widen 2L to 4L rur art	6.7	No	2	4	13.4	31.1	2001
91-97	1990	Buncombe	1	13	11	R-401	NC 280	Mills River	I-26	Widen 2L to 4/5L urb art	5.3	No	2	4	10.6	21.5	1993
91-97	1990	Buncombe	1	13	11	U-1001	Broadway St, Asheville	I-240 in Asheville	N. to US 19-23-70	Widen 2L to 4L urb art	1.7	No	2	4	3.4	7.6	1997
91-97	1990	Buncombe	1	13	11	U-2000	NC 63 (Leicester Hy, A	SR 1554	Asheville City Limits	Widen 2l to 4L urb art	3	No	2	4	6	9.3	1994
91-97	1990	Buncombe	1	13	11	U-2402	Airport Road	I-26	US 25	Widen 2l to 4L urb art	1.9	No	2	4	3.8	9	1998
91-97	1990	Buncombe	1	13	11	U-529	NC 63 (Leicester Hy, A	US 19-23	N. 1.5 miles	Widen 2L to 4L urb art	1.5	No	2	4	3	5.9	1991
91-97	1990	Buncombe	1	13	11	U-90	US 25	Blue Ridge Pkwy	I-40	Widen 2L to 5L urb art	2.9	No	2	5	8.7	16.4	1993
97-03	1996	Buncombe/Hen	1	13	11	R-2213	US 25	SR 1361 in Hendere	US 25A s of Arden	Widen 2L to 5L urb art	1.7	No	2	5	5.1	6.4	2001
91-97	1990	Buncombe-Ma	1	13	11	A-10	US 19-23	I-240 in Asheville	Tennessee State Line	New 4L fwy on new loc	30	Yes	2	4	60	265.1	2001
91-97	1990	Burke	1	13	9	U-2550	NC 18, Morganton	US 70 Bypass Flemin	I-40	Widen 2L to 5L urb art	1.8	No	2	5	5.4	12.2	1999
91-97	1990	Madison	1	13	11	R-1012	US 25-70	Hot Springs	Tennessee State Line	New 2L rur art on new loc	5.8	No	2	2	0	13.5	1995
91-97	1990	McDowell	1	13	9	R-2020	US 221/NC 226	SR 1434 n of Marion	NC 226 at Woodlawn	Widen 2L to 5L rur art	4.1	Yes	2	5	12.3	11.6	1997
91-97	1990	McDowell	1	13	9	R-204	US 221/NC226, Marion	SR 1154 s of I-40	SR 1434 N of Marion	New 4L rur art on new loc	4	Yes	2	4	8	32.6	1995
91-97	1990	Mitchell	1	13	8	R-2119	NC 226, Spruce Pine B	US 19	Mingus	New 4L rur art on new loc	1.5	No	0	5	7.5	13.5	1998
97-03	1996	Rutherford	1	13	10	U-2711	Oak St, Forest City	US 74 Bypass	US 221A (S. Broadway)	Widen 2L to 5L urb, + ex	1.6	No	2	5	4.8	5.3	2001
91-97	1990	Rutherford/Pol	1	13	10	R-99	US 74	Columbus	Forest City	New 4L fwy on new loc	18.3	Yes	0	4	73.2	78.5	1998
		Yancy		13	8		No major projs comp in 90s								0		
97-03	1996	Cherokee	1	14	12	R-2110	NC 60 (SP)	GA state line	UC 64-74	Widen 2L to 5L rur art	4.8	No	2	5	14.4	20.2	1999
97-03	1996	Clay	1	14	12	R-2703	US 64 Bypass, Hayesv	NC 64 Business (SR	NC 69	Widen 2L to 5L urb art	1.5	No	2	5	4.5	1.8	2000
		Graham		14	12		No major projs comp in 90s								0		
91-97	1990	Haywood	1	14	11	I-2103	I-40 at Newfound Road (SR 1004)			New Exit (Milepost 33)	1	Yes	2	2	0	4.9	1995

Source	FFY	158	158	Div	Comm	D Numb	Route/City	From	To	Work Desc	Length	Syst	Bef	After	Add LM	Cost ($m)	Year
91-97	1990	Haywood	1	14	11	I-3100	I-40, milepost 34.5-36.5	MP 34.5, w of SR 150	MP 36.5, w of Buncomb	Widen 4L to 5L by adding	2	No	4	5	2	2.9	2001
91-97	1990	Haywood	1	14	11	R-2023	US 276	US 23-74 Bypass	US 19-276	Widen 2L to 4L urb art	1.5	No	2	4	3	5.7	1993
91-97	1990	Haywood	1	14	11	R-2102	US 19-23	Maggie Valley	Dellwood	Widen 2L to 4L urb art	2	No	2	4	4	5.4	1995
	1996	Haywood	1	14	11	R-3328	Access Rd, Beaverdam	SR 1613 (Beaverdam	SR 1004 (Newfound R	New 2L rur art on new loc	1	No	0	2	2	2.4	1998
91-97	1990	Haywood	1	14	11	U-823	NC 215, Canton	US 19-23	I-40	Widen 2L to 4L urb art	1.4	No	2	4	2.8	6.4	1992
91-97	1990	Henderson	1	14	11	R-402	NC 280	US 64 at Brevard	NC 191 at Mills River	Widen 2L to 4L rur art	11.4	No	2	4	22.8	25.4	1993
91-97	1990	Henderson	1	14	11	U-2106	US 25, Hendersonville	NC 191 n to...	SR 1528	Widen 2L to 5L urb art	2.5	No	2	5	7.5	21	1998
97-03	1996	Jackson	1	14	11	R-2224	NC 107	Cullowhee, n. to...	s of East Laporte	2L to 3L, selected climbin	14.1	No	2	3	14.1	3	2000
97-03	1996	Jackson/Trans	1	14	11	R-2409	US 64	NC 107 at Cashiers	NC 178 at Rosman, Tra	2L to 3L, selected climbin	20.2	No	2	3	20.2	3.95	2000
91-97	1990	Macon	1	14	12	R-2303	US 23-441	GA state line	SR 1652 s of Franklin	Widen 2l to 4L rur art	9	Yes	2	4	18	20.7	1998
91-97	1990	Macon	1	14	12	R-504	US 23-441	SR 1649 near Union	SR 1652 s of Franklin	Widen 2L to 5L urb art	2.4	Yes	2	5	7.2	3.6	1994
91-97	1990	Macon	1	14	12	U-621	US 441 Business in Fr	Int of Palmer and Ma	US 23-441 Bypass	Widen 2L to 4L urb art	1.1	No	2	4	2.2	6.4	1991
		Polk		14	11		Joint proj with Rutherford Co								0		
91-97	1990	Swain	1	14	12	A-5	US 19-74-NC28	NC 28	W of Little Tennessee R	Widen 2L to 4L rur art	2.3	Yes	2	4	4.6	21.7	1992
		Transylvania		14	11		Joint projects with Henderson and Jackson								0		

Contact Names

The following individuals provided information concerning specific projects in their respective regions:

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Glossary

This brief glossary is intended to assist readers in understanding some of the terms and abbreviations in this report.

- **ADT (average daily traffic)-**An estimate, based on a short 2-4 hour count, of the daily traffic count using a section of road in both directions. Typical freeway traffic volumes are 20,000-80,000 vehicles per day, 4-lane urban arterials 20,000-45,000 vehicles per day.

- **ADT per lane-** The average daily traffic divided by the through lanes, in both directions. A rough measure of congestion.

- **Arterial-** A functional street class referring to higher-volume 2-lane and 4-lane roads that provide regional connections. Generally at-grade design, with no or few grade separations for cross-streets.

- **Aggregate studies**-Studies using data that has been added up, such as census data for communities.

- **Capacity**- The maximum amount of traffic that can pass a point in a given time, under prevailing geometric and traffic conditions. Typical freeway lane capacity is 2400 vehicles per lane per hour, arterials 1400.

- **Classification tree**- A 'hand-and finger'-shaped diagram that shows how data is split into groups; the software for creating such a diagram.

- **Commuting-** Travel to work. The Census defines commuting according to the most frequent work destination during the Census week, April 1, 2000.

- **Connectivity-**The degree to which road networks are smoothly connected, within each functional class.

- **Control group**-A group of observations that are observed but NOT subjected to treatment.

- **Demographic data** – Data describing the characteristics of residents of a tract or county, such as income, race, travel time, or commuting patterns.

- **Dependent variable** – In statistical regression or classification, the key variable of interest, assumed to depend on variation in the other ("independent") variables. In this study, the dependent variable is Population Change 1990-2000.

- **Destination choice-**Locations selected by travelers that represent the end of their trips.

- **Elasticity-**The sensitivity of a variable to changes in another variable, expressed in percent.

- **Ex-urban**- outside the urban area, beyond the suburban commuting zone.

- **FHWA** – Federal Highway Administration, the federal agency responsible for the national highway program.

- **Freeway**- A functional class and road design characterized by separated directions, separated grades, high speeds, and long sight distances.

- **GIS (geographic information system)**-A computer-based mapping system that allows storage and analysis of geographic data according to location.

- **Induced travel**-Travel though to be created solely by the access provided by the road system, rather than the characteristics or needs of the traveler.

- **Inflated income**- per-capita income from prior years, brought up to the present by adjusting for interim inflation.

- **Lane(s)-**The number of individual travel ways providing through movement.

- **Lane-mile-**The length of a section of road, times its through lanes. A measure of network capacity and investment size.

- **MPO (Metropolitan Planning Organization)-**Federally-mandated agency responsible for urban transportation planning in metropolitan regions greater than 50,000 population. North Carolina has 17 MPOs.

- **NCDOT**- North Carolina Department of Transportation, the primary agency responsible for major road projects in North Carolina.

- **Per-capita income-**Total earned and unearned income in a geography, divided by the resident population. A measure of geographic wealth.

- **Quasi-experiment-**A study designed to determine causality by comparing the data for groups treated with a improvement or service, with the data for those not treated.

- **Regression-**A statistical method for relating the variation in one statistic to the variation in other statistics.

- **R-Square (RSQ)-**A measure of the strength of a regression model; the percent of variation in the statistic of interest that is explained by variation in the other statistics.

- **Route choice-**The paths (sequence of streets) that individual drivers take to reach their destinations.

- **Smart growth**-A body of literature and belief system that asserts that urban growth can be made more efficient and less wasteful by increasing density of development and improving street and land use designs.

- **Sprawl**- A pejorative term referring to the pattern of population and non-residential land use in haphazard fashion, usually at the edges of regions; the change in this pattern over time.

- **Trip-**a one-way movement by a person or vehicle between an origin and a destination.

- **t-statistic-**A criterion for evaluating the strength of terms in a regression model.

- **TEA 21 (Transportation Equity Act for the 21st Century)-**The federal transportation funding Act, passed in 1998, providing revenues to states and localities for surface transportation improvements.

- **TIP (Transportation Improvement Program)-A** 7-year program of specific projects, by location and time, that each State intends to construct. All federally-funded projects must be on the TIP, although some locally-funded projects are not on it. Updated every 2 years.

- **Tract**- A small area, defined by the Census, about the size of 8-10 city blocks, used for summarizing and tracking data over time.

- **Urbanized area-**A region consisting of a central city and the immediate built up areas around it.

- **VMT (Vehicle-miles of travel)-**The number of miles traveled by all vehicles using a defined street system or geography over a defined period of time; the total miles driven by all vehicles in a region.

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[3] Transportation Infrastructure Act, 1989. NC Legislature.

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[76] Cervera E and Hartgen DT, op.cit.
[77] Linear regression models also have their limitations, particularly:

1. **Inferences of causality direction.** Regression models assume that the 'independent' variables are known perfectly and direct the changes in the 'dependent' variable, thus inferring causality when generally there is no direct causality present. Analysts are trained to account for this hidden assumption in interpreting regression results.
2. **Dependence on empirical (measurable) relationships:** Regression models of course assume that the data in the equations can be obtained and measured empirically. In fact, variables such as traffic, population change, density, and even area are estimates with unknown measurement error.
3. **Misspecification of variables.** Regression models generally attribute all change in the dependent variable to either the independent variables or to the error term. If the models do not contain enough variables, they may be mis-specified, that is they do not have the underlying data to develop reasonable model relationships.
4. **3. Independence of the observations**. Regression models assume that the observations in the data are independent of each other. But spatially adjacent or nearby census tracts are typically spatially correlated, that is adjacent tracts tend to have similar values for many common statistics. In tests of spatial autocorrelation for the 1551 tracts in North Carolina, we found the following correlations (Moran's I, a measure of spatial autocorrelation) between observations:

Population change:	0.34, +-0.03
1990 Population density	0.63, +-0.03
2000 Per capita income:	0.53, +-0.03
1990 Per capita income:	0.54, +-0.03
Percent non-white population, 2000	0.65, +-0.03
Miles of Widened Urban Arterial	0.12, +-0.03
Miles of Widened Rural Arterial	0.25, +-0.03

These findings, showing substantial spatial correlations for our key variables, mean that the 1551 observations are not wholly independent from each other, and therefore estimates of the strength of the models are high. A set of truly independent observations would therefore likely show weaker results.

4. Linearity of functional form. Regression models assume that the relationship between the 'dependent' variable and the 'independent' variables is linear, that is as the independent variables increase or decrease the dependent variable increases or decreases proportionally. The coefficients (b's) express the specific slope of the relationship. However, in spatial models the data are often not linear, but hump-shaped or u-shaped. To account for this possibility, we used the tool Knowledgeseeker to tease out non-linear relationships. We did find a few, which are noted in the text, but the results did not substantially change our findings.

5. Autocorrelation between variables. Regression models assume that the independent variables are not themselves inter-correlated, but in spatial data that is almost always the case. To account for this, we used a 'backwards stepwise' variable selection procedure, eliminating variables with weak coefficients until only the strongest variables remained. Although this procedure does not totally eliminate the problem, it reduces the concern.

In summary, we recognized the limitations of these tools, but since this form is widely used and we used it here because of its popularity in the modeling literature and ease of access, and took steps to account for the primary concerns.

[78] A road improvement's speculative effect (SPEC) is defined as (Year of Completion – 1990)*Length, and is a measure of how much "pull" it would have on earlier (the later the project, and the bigger the project, the more it pulls) A road improvement's spurring effect (SPUR) is defined as (2000-Year of Completion)*Length, and is a measure of the "push" that a road could have on development that comes later in the decade.

[79] TransCAD does not contain a stepwise regression routine, in which variables are entered in order of their importance. To approximate this, we used a 'backwards elimination' procedure, starting with all variables and eliminating those of least importance until a 'best' line was obtained.

[80] Angloss Corporation, KnowledgeSeeker for Windows Version 3.0, 430 King Street West # 201, Toronto Ontario, Canada M5V1J5, 1994.

[81] At an average family size of 2.51(Charlotte region, a one-mile square tract with 500 developable acres could hold about 1250 persons on 1-acre lots, or 2500 persons on half-acre lots. The average density of the inner cores of Charlotte-area cities, 1971, corresponds to about 0.7-acre lots.
[82] In the author's analysis of Ohio cities (Hartgen, 2003, op.cit.), a new exit on I-75 north of Cincinnati was found to have a similar effect; otherwise the impacts of new exits in Ohio was considerably less.
[83] Hartgen and Stuart, 1991, op.cit.