TECHNICAL ASSISTANCE REPORT

EXPECTED CHANGES IN TRANSPORTATION DEMAND IN VIRGINIA BY 2025

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(A Cooperative Organization Sponsored Jointly by the
Virginia Department of Transportation and
the University of Virginia)

Charlottesville, Virginia

June 2003
VTRC 03-TAR5

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ACKNOWLEDGMENTS

Several persons provided insights for the preparation of this report: J. Gillespie (Virginia Transportation Research Council) highlighted the value of understanding technological trends and reviewed initial drafts; S. Brich (Virginia Transportation Research Council), C. Burnette (Virginia Department of Aviation), G. Conner (Virginia Department of Rail and Public Transportation), J. Florin (Virginia Port Authority), and B. Lambert (Federal Highway Administration) provided useful and detailed freight suggestions; R. Gould, K. Graham, K. Lantz, R. McDonald, K. Spence, D. Wells (all from the Virginia Department of Transportation), A. O'Leary (Virginia Transportation Research Council), and G. Robey (Virginia Department of Rail and Public Transportation) gave review comments and information on passenger travel; R. Tambellini (Virginia Department of Transportation) provided forecasts for Virginia vehicle miles traveled; J. Lambert (University of Virginia) offered presentation suggestions; J. Knapp (Weldon Cooper Center for Public Service at the University of Virginia) and N. Terleckyj (NPA Data Services, Inc.) suggested data sources; L. Evans (Virginia Transportation Research Council) edited the document; and R. Combs (Virginia Transportation Research Council) assisted with figures. The inclusion of these names and agencies does not, however, imply agreement with the contents of this paper.

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LIST OF ABBREVIATIONS AND ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
BEA	U.S. Bureau of Economic Analysis
BTS	Bureau of Transportation Statistics
CFS	Bureau of Transportation Statistics' Commodity Flow Survey
FAF	Freight Analysis Framework
FHWA	Federal Highway Administration
GDP	Gross Domestic Product
ITS	Intelligent Transportation Systems
MSA	Metropolitan Statistical Area
MPO	Metropolitan Planning Organization
NAFTA	North American Free Trade Agreement
NHTS	National Household Transportation Survey
NPA	NPA Data Services, Inc.
NPTS	National Personal Transportation Survey
PDC	Planning District Commission
RADCO	Rappahannock Area Development Commission
TAZ	Transportation Analysis Zones
TEA-21	Transportation Equity Act for the 21st Century
VEC	Virginia Employment Commission
VMT	Vehicles miles traveled

EXECUTIVE SUMMARY

Background

The VTRANS 2025 Technical Committee, composed of representatives from the Virginia Association of Planning District Commissions, the Virginia Port Authority, the Virginia Department of Aviation, the Virginia Department of Rail and Public Transportation, and the Virginia Department of Transportation, asked the Virginia Transportation Research Council to identify trends that may influence transportation demand by 2025. These trends include *socioeconomic projections*, such as changes in population, employment, and income, *policy-related* projections pertaining to technology and legislation, and aggregate *freight* demand. The Committee also asked how transportation demand was expected to change by 2025, for both passenger travel and freight travel. *The answer is that demand for both freight and passenger travel is expected to grow*.

Transportation is a "derived" rather than a "source" demand because the need to travel is a result of people wanting to move themselves or goods. A road that has undergone 5% annual growth in traffic for a decade may or may not have that level of growth in its eleventh year; the derived demand of transportation depends on sources such as jobs, shopping opportunities, and other causes of travel. Accordingly, to forecast travel demand, the socioeconomic phenomena that inspire this demand, such as population and employment growth, changes in household size, and increases in personal income should be forecast. These socioeconomic projections yield a rough indication of how much aggregate travel will be needed in future years.

Yet any industry is affected by changes in public policy. Accordingly, it is appropriate to study legislative, financial, and technological trends that may ultimately affect federal and state transportation policies. Generally, socioeconomic trends and technological innovations have influenced behavior to a greater degree than have public policy initiatives, even though state and national polices can affect how transportation demand is fulfilled.

The resultant demand for freight and passenger transportation may then be assessed in several ways. For freight, the value, tonnage, and ton-miles shipped by rail, truck, and air, as well as growth at Virginia's ports, are relevant indicators. From a passenger perspective, the mode chosen, the distance traveled, and the travel times encountered are some ways to measure passenger travel.

To support Virginia's initiatives to design a multimodal transportation plan for the year 2025, this report summarizes how transportation demand is expected to change over the next two decades. Four broad areas affecting transportation demand are explored: socioeconomic changes, public policy changes, freight trends, and changes in how the transportation network is used. Accordingly, socioeconomic, policy, and freight influences on travel demand and resultant measures of freight and passenger use are discussed here. Sources include the U.S. Census Bureau, the U.S. Department of Transportation, the Virginia Employment Commission, the Weldon Cooper Center for Public Service at the University of Virginia, NPA Data Services, Inc., and literature references identified in the Transportation Research Information Service. Specific citations are given in the body of the report.

Population

- *The Commonwealth's population is forecast to increase from 7.1 million in 2000 to between 8.5 and 9.3 million in 2025,, with the forecast depending on the data source (U.S. Census Bureau or NPA Data Services, Inc.), as shown in Figure 1.* More than three quarters of this new growth will occur in just four planning district commissions (PDCs): Rappahannock Area Development Commission (RADCO), Richmond Regional, Hampton Roads, and Northern Virginia.

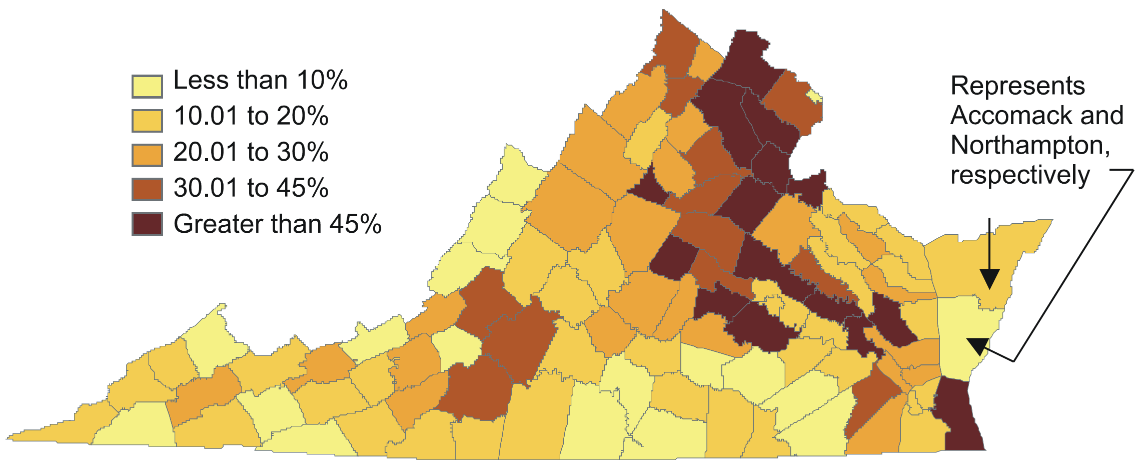

Figure 1. Projected Percentage Increase for Virginia County/City Populations from 2000 to 2025

- *Areas that have been characterized as rural or suburban will also see significant increases.* The Rappahannock-Rapidan, Middle Peninsula, Thomas Jefferson, and the Northern Shenandoah Valley PDCs should see population increases between 30% and 40% by 2025.

- *Mirroring national trends, Virginia residents are growing older.* Virginians aged 65 and over accounted for slightly under 12% of the population in 2000, and this figure is expected to rise to about 18% in 2025.

- *Population densities are expected to increase statewide, from an average of 179 persons per square mile in 2000 to 235 persons per square mile in 2025.* The extreme variability in population density throughout the state, however, ranging from Highland County (six persons per square mile in 2000) to the City of Alexandria (8,452 persons per square mile in 2000), limits the utility of this average value.

- *Some population densities are expected to grow substantially:* the counties of Prince William, Stafford, Loudoun, and Spotsylvania, for example, are projected to see an increase in density by more than 60% between 2000 and 2025. Some counties currently considered rural or suburban, such as Greene, Fluvanna, Powhatan, and Gloucester, are projected to see density increases on the order of 50% during the same time period. Population densities may affect total transport demand, the type of transportation services that are feasible, and potential for future development.

- *Large disparities in population density within a given region are not necessarily a guarantee that less dense jurisdictions will develop more rapidly than denser jurisdictions.* It can be said, however, that from examining population density alone, development pressures will potentially be quite strong over the next 25 years in at least a few regions: Northern Virginia, Richmond Regional, Hampton Roads, Thomas Jefferson, and RADCO PDCs. As pointed out by the Weldon Cooper Center for Public Service at the University of Virginia, the fact that most nonmetropolitan counties are bordered by a metropolitan area indicates the potential for such counties to grow.

The Economy

- *Personal income on a per capita basis is expected to grow by almost 50% from 2000 to 2025 in constant 1996 dollars, with the per capita personal incomes growing faster, in general, in the poorer PDCs, than in the richer PDCs.* By 2025, the Northern Virginia PDC will still be the highest per capita PDC, but the personal income in the other PDCs will be closer to that of Northern Virginia than they were in 2000.

- *Virginia's employment opportunities should grow from 4.4 million jobs in 2000 to 6.3 million jobs in 2025, with the highest rates of growth in the service (almost 59%) and wholesale/retail trade sectors (48%).* The proportion of employment held by the three largest PDCs will increase from 65% to 68% over the next 25 years. The PDC with the highest projected growth (RADCO, 68%) is adjacent to the Northern Virginia PDC.

- *Smaller PDCs will also see employment growth;* notably, Thomas Jefferson and the Middle Peninsula are expecting employment growth rates between 40% and 50% over the next 25 years.

Households

- *The average number of persons per household has been dropping for the past few decades and is expected to drop further from about 2.6 persons in 2000 to 2.4 persons in 2025.* Historically, smaller households have a larger number of automobile trips per person.

- *Disparities in home prices exist not just across the Commonwealth but also, in some locations, across jurisdictions that are in the same region.* This price disparity may be a contributing factor to what the literature describes as a shortage of housing in at least one region of the Commonwealth—Northern Virginia—that is expected to worsen over the next two decades. The literature further suggests that particular counties in Northern Virginia should reach "build out" projections before 2025: this would mean that either economic growth would be constrained, employees would commute from farther-out locations, or the definition of *build out* would change.

Public Policy

- *For the foreseeable future, increasing emphasis will be placed on operating transportation infrastructure efficiently in conjunction with construction and maintenance as opposed to performing only construction and maintenance.* This emphasis on operations may include moving people and goods more efficiently but may also include providing information that makes congestion more tolerable. An example is more accurate estimates of delay that will at least allow passengers to plan for a longer trip rather than be surprised en route. Shippers and passengers may have different information requirements.

- *Nontraditional sources of transportation revenue are expected to play an increasingly important role.* Examples are high-occupancy toll lanes, private sector financing, and other alternatives to the gas tax as the use of alternative-fueled vehicles grows, fuel efficiency grows, and road maintenance costs increase.

- *By 2015 or 2025 (depending on the source) the United States will have about 260 million vehicles, up from 221 million in 2000.* Although the increase is not dramatic, this sheer volume of vehicles represents a temptingly large market for firms that can provide vehicle-based communications services if a profitable business model can be developed. The incentive to develop an approach to providing profitable real-time traveler information for passenger and freight users should remain, despite previous failures of implementing such an approach on a universal scale.

- *Growth-control legislation is being used in at least one Northern Virginia jurisdiction and depending on its success or failure, additional efforts by counties to influence growth through zoning or planning may be replicated elsewhere in Virginia.* Traditionally, because Virginia is a Dillon's Rule state, localities have been restricted as to how growth can be managed; however, changes in the *Code of Virginia* open up, but do not prove, the possibility that localities may now have more flexibility to manage growth.

- *Telecommuters represent about 10% of U.S. adults. It is unclear whether that figure will remain constant (one school of thought is that face-to-face interaction will remain essential) or increase (another school of thought is that telecommuting will enable even longer home-to-work commuting distances than at present).* It is also plausible that telecommuting will not simply reduce travel but will, at least to some extent, shift travel demand to different times of day and to different trip purposes.

Freight

- *The traffic in the Port of Hampton Roads is projected to increase substantially, with containerized cargo projected to grow at 4.3% annually at least through 2025 provided the port makes necessary capacity improvements.* Without these improvements, the port will be at capacity between 2010 and 2017. Because about 75% of the containerized cargo arrives at the port by truck, truck traffic is projected to increase.

- *Freight tonnage in the southeastern region of the United States, a 16-state set that includes Virginia and Maryland, is expected to grow by 71% from 2000 to 2020, a rate of increase that outpaces population.* Each mode of freight in Virginia is also expected to grow significantly during a similar period (from 1998 to 2020): truck tonnage will grow by 81%, rail tonnage will grow by 41%, and air tonnage will grow by about 300%.

- *Another way of characterizing freight growth is that from 2000 to 2020 the value of freight originating or terminating in Virginia will more than double for rail, more than triple for truck, and more than quadruple for air.*

- *The market share of freight shipped for air, truck, and rail in terms of tonnage and value will also change during the next quarter century.* In Virginia, rail occupied about 30% of total tonnage in 1998; this figure will drop to 26% in 2020. In contrast, the share for trucking will increase from 63% to 68%. The market share of air freight is also increasing, more so in terms of value: air freight will occupy 12% of the value of the market for freight shipped in 2020, up from about 9% in 1998.

- *Noting its relevance as a freight corridor, the American Association of State Highway and Transportation Officials (AASHTO) expects I-81 to operate at levels of service E or F "throughout the entire state of Virginia" by 2020, assuming a "base case" scenario where the modal freight distribution in 2020 is the same as it is in 2000.* Accordingly, AASHTO suggests that nationally, an $83 billion investment in rail improvements would yield $1 trillion in benefits; most of the benefits would be seen by users and shippers.

- *The literature makes a strong economic argument for judging freight transportation investments from an intermodal perspective.* The first supporting reason is the interconnectedness of the modes; e.g., heavy highway congestion inhibits not just trucking performance but also performance at marine and airport terminals since these rely on trucks, at least in part, to bring goods to them. The second supporting reason pertains to economic competition between Virginia and other states. The literature gives examples of how shippers can use information about the transportation network, in terms of both real-time information (to maintain more efficient inventory levels and distribution systems) and overall performance (to choose locations for distribution centers or warehouses).

Passenger Travel

- *Nationally, passenger travel is expected to increase over the next 25 years.* National forecasts are that total passenger miles (e.g., the sum of passenger miles for all modes) will increase by 68% as a result of population increases and per-person travel increases. In Virginia, vehicle miles traveled (VMT) are projected to grow by 68% between 2000 and 2025.

- *For the past two decades automobile occupancies have dropped and VMT have risen, and there is no indication that these trends will reverse course.* The literature does suggest that as the automobile ownership market becomes saturated, VMT will not rise as fast, but that point will not be reached until 2015 or 2025. Nationally, the number of automobiles per person is expected to drop slightly from 0.80 in 2000 to 0.78 in 2025.

- *Although the proportion of Virginia households with no automobiles is dropping, the number of households with no vehicles increased slightly from 1990 to 2000; at present about 200,000 Virginia households do not have a vehicle.* The fact that some of these households are in rural counties with fewer transportation options suggests a potential genuine travel need.

- *National trend data suggest that public transportation use has stopped declining in terms of total ridership.* About 80% of Virginians drive alone to work, a number consistent with the national average of 85%.

- *These average ridership data mask diversity by county, and this diversity reflects not just the willingness to use public transportation but also the availability thereof.* About half of all Arlington residents drive alone to work, in contrast to 9 of 10 Colonial Heights residents. Usage of public transportation varies by county: the statewide average of 3.6% includes heavy users (e.g., Alexandria residents at 16%) and infrequent users (such as Caroline and Loudoun Counties at 1.3% and 1.5%, respectively). Although rural or smaller MPO areas tend to have lower percentages of commuters using public transportation than urban areas, some, such as Mathews County, Northampton County, and the City of Winchester, have use rates of about 2%.

- *Average commuting times increased over the past 10 years and range from an average of 21 minutes in Roanoke to 32 minutes in Northern Virginia.* Locations with the longest average commutes in excess of 37 minutes include rural areas (e.g., Buckingham County) and moderately suburban areas (e.g., Stafford County). Areas of the state with commute times below the statewide jurisdictional average of 27 minutes included small urban or MPO areas (e.g., Lexington, Staunton, and Albemarle) and the centralized portions of large urban areas (e.g., City of Richmond and City of Norfolk.)

- *Although it may be argued that commute trips are only a fraction of the total daily trips passengers make, the commute trip data are a useful snapshot of travel patterns for passengers as a whole.* Data from the National Household Transportation Survey (NHTS) suggest that Virginia passengers and drivers averaged 74 minutes in a vehicle daily (for all trips). Although NHTS cautions that its data set is too small to be reliable for a single state, the state average appears credible given the national average of 66 minutes.

- *Although it may be stated generally that passenger mode choice is sensitive to income, travel time, cost, comfort, and convenience, the literature warns that the import of these factors varies substantially by situation.*

Accuracy of These Predictions

A century of passenger transportation use suggests predictions over a long horizon are not equally accurate for all trends. As suggested from the case study described in this report, a forecaster looking 25 years ahead at any point between 1900 and 1975 could probably have predicted about half of these trends accurately at the national scale. Predictions for socioeconomic factors, such as population, ethnicity, employment, income, and household sizes, are generally feasible, albeit imperfect, provided the geographical area is adequately large (e.g., a PDC or larger).

Predictions for policy trends based on technological innovation, social change, or legislative environments, however, are much more difficult. The themes in this paper most heavily affected by these policies, such as modal split for passenger travel, modal split for freight travel, land use legislation, potential improvements in technologies that would help transportation operations, and public willingness to support additional transportation infrastructure, fall into that latter category. Unfortunately, predictions therein are most susceptible to error; fortunately, they may represent the areas of greatest opportunity.

Implications of This Increasing Transportation Demand

To support the work of the VTRANS 2025 Technical Committee, this report outlines how transportation demand may change by 2025 depending on socioeconomic and policy trends. Yet because VTRANS has an opportunity to consider transportation challenges from a multiagency and multimodal perspective, it is appropriate to identify transportation improvement concepts that fall within that purview. Accordingly, three emergent themes from the trends identified in this report merit discussion:

1. *A strong economic case is made for investing in freight improvements from an intermodal perspective.* Freight actions such as additional highway investments in the vicinity of airport or seaport terminals, additional rail investments in the I-81 corridor, or upgrading of short line railroads—all of which may reduce or mitigate the effects of truck traffic—suggest that allocation of resources and coordination across modal boundaries can yield greater benefits than would otherwise occur were each mode considered separately.

2. *A strong efficiency case is made for relating transportation investments to realistic land development forecasts.* The trite phrase "coordinating transportation and land use" has been tirelessly repeated such that yet another study citing the benefits thereof is not required. Specific transportation and land planning actions, however, could possibly help Virginia meet passenger travel demand challenges, such as (1) land use planning that spans a greater geographical scope than is currently the case for some PDCs, (2) linking transportation and land use planning at a tighter scale (e.g., solving the problem that results from parents choosing to drive rather than use transit because day care centers are not accessible by transit), and (3) using a more consistent

transportation and land development approach to manage the number of traffic signals deployed on an arterial roadway serving through and local traffic.

3. *A plausible theme is that there will be an interest in improving transportation operations, including stronger coordination among the different modes, as a complement to physical infrastructure expansions*. Supporting reasons include (1) an emphasis on travel time reliability as opposed to only speed of travel, (2) transportation revenue growth rates that are not as high as they were in the past, and (3) the appeal of automobiles as a large potential market for private sector information providers who can devise a successful profit-driven approach. Certainly, however, the extent to which operations improvements augment more traditional infrastructure investments remains to be seen.

A Potential Suggestion for Addressing This Increase in Travel Demand

Given the VTRANS charge of considering investments from a multimodal perspective, the three themes presented previously are reasonable considerations for further discussion. For example, regarding the increasing age of the population, possible actions are (1) to make land use changes that reduce the dependence on the automobile, (2) to provide transportation services in addition to the automobile, (3) to make driving easier for older drivers, or (4) to do nothing.[1,2] Any combination thereof is possible, and the question is whether economies of scale can be achieved by coordinating agency and modal efforts to address mobility needs for older travelers. If the answer is "yes," then in this case VTRANS should identify appropriate transportation improvements that necessitate such interagency and intermodal coordination. If the answer is "no," then VTRANS should move on and instead identify other problems that do benefit from a coordinated response as opposed to each agency, or mode, acting in isolation. This older traveler challenge is just one example, and the remainder of this document looks at the specific factors that are expected to influence transportation demand by 2025.

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EXPECTED CHANGES IN TRANSPORTATION DEMAND IN VIRGINIA BY 2025

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INTRODUCTION

During the next 20 years, demographic shifts in population, employment, housing, and age will affect transportation demand in Virginia. Changes in technology that influence telecommuting and the feasibility of various transportation modes also affect how transportation services are provided. This paper outlines key trends that demographers are expecting and data sources that staff for Virginia's statewide multimodal advisory committee may wish to consult as a multimodal needs assessment process is developed.

PURPOSE, SCOPE, AND OVERVIEW

Staff from the different modal agencies in Virginia—the Virginia Department of Aviation, the Virginia Department of Rail and Public Transportation, the Virginia Department of Transportation, and the Virginia Port Authority—requested that the Virginia Transportation Research Council identify key socioeconomic trends that are likely to affect transportation demand in 2025. Because the request was also designed to support Virginia's 2025 Statewide Multimodal Plan (VTRANS), staff asked that the paper identify the following factors that may influence travel demand:

1. historical and projected socioeconomic trends such as population, employment, and personal income

2. relevant changes in public policy, legislation, and technology

3. freight projections and changes in market share for the various modal freight movements

4. passenger travel trends including mode choice and automobile ownership.

The steering committee raised specific questions within each of these four areas, such as:

- How will the age of Virginia's population change by 2025?

- Why is it not possible to forecast all trends for all Virginia locations equally well to year 2025?

- What will be the value of freight shipped by the various modes of air, rail, and truck?

- To what extent do ethnicity and income determine passenger modal split?

Because competing viewpoints were held for some questions, portions of the report are quite detailed in an effort to resolve such questions.

The paper considers trends and forecasts across four main areas—each of which corresponds to one of the previous objectives: socioeconomic trends, public policy changes, multistate freight requirements, and measures of transportation use. Socioeconomic trends—population growth, income and employment changes, and household size and location—are a reasonable starting point for any long-term plan since these phenomena affect how the state will evolve and at the statewide level are somewhat stable over time. Public policy changes in the areas of national legislation, consumer needs, and transportation technology may also significantly alter how transportation services are delivered. Multistate freight requirements also influence transportation demand because freight movements can use Virginia's transportation network or may bypass the Commonwealth altogether. These three categories—socioeconomic changes, policy changes, and freight changes— may be thought of as sources of transportation demand. The way the transportation system responds to these sources of transportation demand is described herein as measures of transportation use, reflected by passenger vehicle miles traveled (VMT), mode choice for passengers and freight, tons of freight shipped, and travel time.

Although these four areas are presented as discrete sections for ease of illustration in Figure 2, they are related; e.g., rising incomes are generally associated with increased travel.

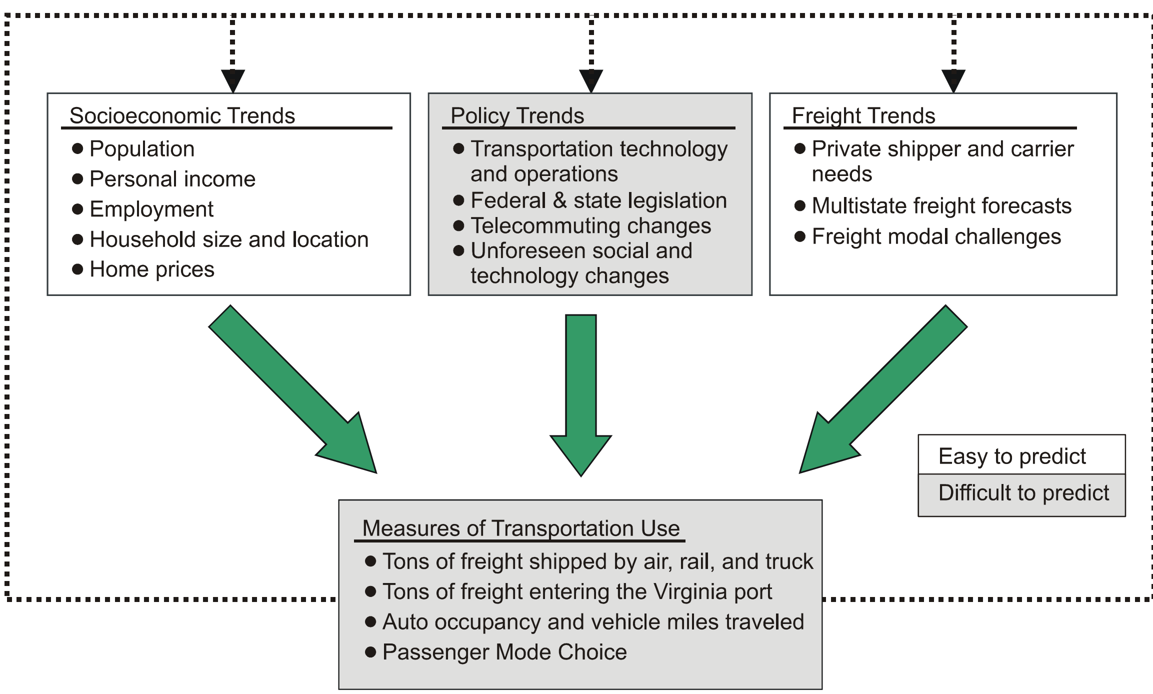


Figure 2. Sources of Transportation Demand Feeding Measures of Transportation Use

Further, they affect each other; e.g., rising home prices in a "close-in" suburban county may cause further residents to locate further away from their jobs, thereby increasing passenger VMT. Yet this resultant congestion may in turn cause prospective homebuyers to place a premium on the close-in suburban homes. Thus the dashed arrows in Figure 2 signify such potential relationships.

DATA SOURCES, DATA QUALITY, AND INTEGRITY OF PROJECTIONS

The data obtained herein derive from fairly common sources—the U.S. Census Bureau, the Weldon Cooper Center for Public Service at the University of Virginia, the Virginia Employment Commission (VEC), the Bureau of Transportation Statistics (BTS), and the literature accessible through the Transportation Research Information Service. Data were also purchased from NPA Data Services, Inc. (NPA), which offers a Virginia State Service Dataset. Two additional data sources may prove helpful in the near future as they are refined: the BTS TranStats Intermodal Transportation Database (noteworthy because of accessible customer service representatives who can be reached by telephone or email) and the Federal Highway Administration's (FHWA's) anticipated updates to the National Household Transportation Survey (NHTS) (which replaces the 1995 National Personal Transportation Survey [NPTS]).[3,4]

For passenger and freight statistics, data quality varies by source, geography, and horizon year:

- *Passenger* details such as travel time profiles and mode choice at the city and county level exist for journey to work trips, but for other trip purposes, comprehensive, updated detailed data are lacking. Geography also affects data quality; e.g., 2020 forecasts for employment are available for jurisdictions within the Hampton Roads PDC as these have been made available by PDC staff, but not every PDC necessarily has complete 2020 forecasts.[5] Projection year and geographical scope vary as well. The NPA dataset contains projections to year 2030 for 98 areas in the Commonwealth. In some cases, the area reflects a specific county, and in other cases the NPA area is a combination of city and county (e.g., the NPA data show York County, the City of Newport News, and the City of Hampton together.) The U.S. Census Bureau maintains projections for the state as a whole to year 2025, but these projections were done in 1995, with updates scheduled for 2003, and do not show counties and cities separately. The VEC currently has projections to year 2008 by individual county and city, with additional projections planned for 2003.

- *Freight* transportation data have historically been difficult to acquire owing to the proprietary nature of commodity flows and shipper characteristics.[30] A primary source of freight data was FHWA's *Freight Analysis Framework* project, which provides state-specific projections and in turn is based on more than a dozen data sources, such as the Federal Railroad Administration Rail Waybill Sample, Reebie Associates' truck data, water freight data from the U.S. Army Corps of Engineers, and motor carrier financial data.[6,7] These freight projections were supplemented with other data sources such as the BTS' Commodity Flow Survey (CFS), freight projections by the American Association of State Highway Transportation Officials (AASHTO), and work commissioned by the Virginia Port Authority as necessary. For example, the CFS was useful for obtaining a snapshot of freight movements in ton-miles; however, because the CFS does not by itself address NAFTA (North American Free Trade Agreement) movements; this information should be supplemented with Freight Analysis Framework data that do, in fact, consider NAFTA movements.

The main reason for obtaining data from disparate sources was to obtain as complete a picture as possible regarding trends by 2025 at the level of detail desired by the VTRANS Steering Committee. In many cases, there was only one source of data available. For example, although Census 2025 population forecasts are available for the entire state of Virginia, census forecasts were not available at the time the study was undertaken for specific geographic regions within Virginia. Thus, other data sources were necessary. For cases where multiple data sources are available (e.g., VEC and NPA data have 2010 projections for Virginia), no attempt was made in this effort to decide which estimate is more accurate. To do so would require detailed consideration of (1) the organization's track record for making previous predictions, (2) the methodology used for making forecasts, and (3) the assumptions on which the forecasts were predicated. To address such considerations imperfectly, however, in a timely manner, the researcher sought to do either of the following in the instances of overlapping data sets: (1) to use data that were *consistently* defined by geography and time (e.g., NPA data were used in some cases because the Virginia regions were thus consistently defined between 2000 and 2025) or (2) to identify trends that are common to multiple data sets (e.g., the U.S. Census and NPA both project an increase in the proportion of persons age 65 and over) for the year 2025 relative to the year 2000.

A logical question is whether it is desirable to make such a projection to year 2025, even assuming such predictions are feasible. One viewpoint is that even longer horizons are necessary, because 20 to 30 years is a relatively short time frame for transportation infrastructure impacts on land use to take effect.[8] A second viewpoint is that it is more important for planning horizons to be consistent; e.g., the FHWA has noted that given the shorter term air quality planning horizons of 5 to 10 years and the longer term transportation planning horizons of 20 years, some stakeholders have suggested lengthening the former and others have suggested shortening the latter.[9,10] The lack of standard planning horizons in Florida, for example, is specifically cited as being a complication in the comparison of long-range transportation plans.[11] It has also been pointed out that the freight planning horizon is shorter than the passenger planning horizon.[12]

Another logical concern is the feasibility of forecasting any trend for a specific location 25 years into the future. Generally, more faith may be held in trends that are (1) less susceptible to sudden change, (2) relatively large in geographical scope and/or based on a relatively large data set, and (3) projected over a shorter rather than a longer horizon. For example, 2010 population forecasts for the Commonwealth are more reliable than 2025 home price forecasts for the City of Charlottesville for several reasons:

1. Population trends have historically grown at a relatively steady rate without sudden increases or decreases, whereas home prices can suddenly drop because of market conditions, changes in school quality, or changes in an area's employment outlook.

2. Virginia is much larger than Charlottesville; the likelihood of a spurious trend emerging is much greater for a small city than it is for an entire state.

3. The likelihood of an unforeseen change occurring is greater over the next 25 years than over the next 10 years.

Accordingly, although forecasts for specific county/city combinations such as those shown in Appendix A can be obtained, this report argues that it is more credible to discuss projections at a larger geographic scale, such as that of a PDC.

A fourth factor that influences the ability to make predictions appears to be that trends driven by market or socioeconomic mechanisms are easier to predict than those driven by legislative fiat. For example, the continued decline in agriculture-related employment can be easily forecast, since the increased efficiency of farming techniques and the higher economic benefits of land for other purposes than agriculture are trends that are also expected to continue based on market principles. In contrast, projections of land use trends based on local zoning ordinances or local plans are less reliable, since plans and ordinances are subject to change and at least receive pressure from market forces, popular will, or political interests. (Within the context of this paper, the phrase *land use* denoted how parcels of land are developed for agricultural, residential, and commercial development; the degree to which these parcels are mixed; and population density.)

Within the scope of predicting each trend, specific caveats exist that suggest failure to look at details can obscure critical trends. For example, in a study of Hampton Roads, Case found substantial population loss—about 100,000 residents in suburban neighborhoods and core cities—when examining data at the transportation analysis zone level.[13] (Transportation analysis zones, or TAZs, vary in size in order to represent a section of homogeneous land uses, but a typical size is one quarter of a square mile; for planning purposes, for example, the Charlottesville metropolitan area is divided into about 250 such zones; larger areas such as Hampton Roads may contain thousands such zones.) The practical implication of the study was that since populations are forecast first by county and second by TAZ within such counties, a failure to predict loss in particular TAZs means that growth is not predicted in other TAZs within the same county. In Case's case, this may lead to "more future development pressure on rural areas than expected."[13] The implication of Case's study findings is that for particular types of trends, errors in forecasting may systematically undercount a particular item, which in his particular study was rural population growth. (As another example, predictions for the Virginia Port activity beyond 2010 should be credible but only if the Virginia Port Authority carries out planned capacity expansions to accommodate additional freight activity that is expected to exceed existing capacity.)

SOCIOECONOMIC TRENDS AFFECTING TRANSPORTATION DEMAND

Population, employment, housing, and density are interrelated; in a sense, one cannot discuss one without considering the others. Of the trends discussed in this paper, population seems to be the most predictable provided the geographical area is sufficiently large.

Population Trends, Forecasts, and Implications

Historically, population has grown slower than transportation demand; however, population growth is a useful indicator of whether travel demand will decease, increase, or remain constant. For the state as a whole, recent decennial growth rates have been around 15%, whereas future decennial growth rates are expected to be between 8% and 11% depending on the source of the projections and the decade. The Weldon Cooper Center for Public Service, the VEC, the U.S. Census Bureau, and NPA provide Virginia-specific population projections.[14,15]

As shown in Figure 3, Virginia's statewide population is expected to increase from a 2000 value of about 7.1 million to a 2025 value between 8.5 and 9.3 million. This discrepancy of 10% in the statewide total for 2025 may be attributed to either different forecasting methodologies or the date of the U.S. Census forecasts, which were done in 1995 and are expected to be updated later in 2003. (The U.S. Census projections are in line with the VEC projections; however, since the VEC projections were done in 1999, it is reasonable to assume that the VEC projections could have made use of the 1995 U.S. Census projections available at the time the VEC forecasts were performed.) Thus the utility of Figure 3 is its display of disparity in forecasts from different but credible sources, as opposed to portraying the "most" accurate forecast.

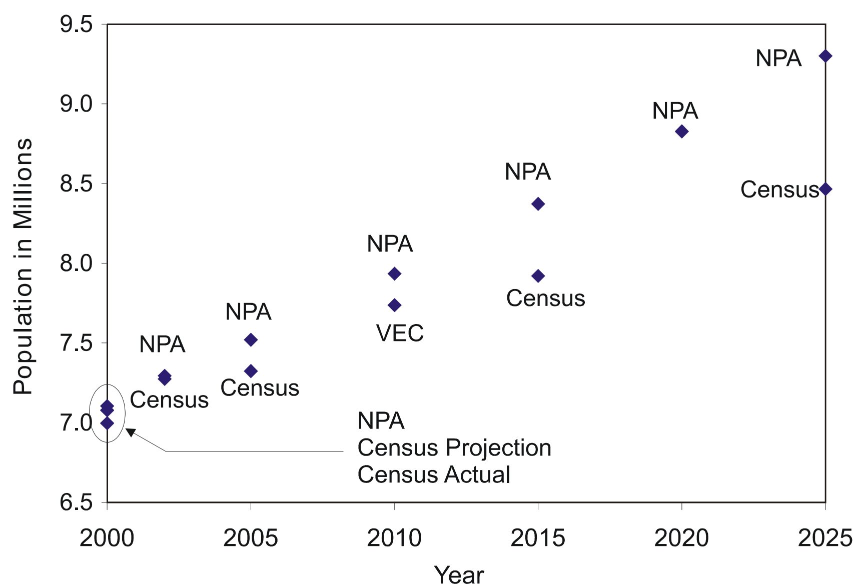


Figure 3. Virginia Population Projections to 2025 (U.S. Census, NPA, and VEC)

Geography's Influence on Population Growth

This increase from the Commonwealth's 2000 population of 7.1 million to the VEC-projected 2010 population of 7.7 million is not evenly distributed by geography. One way to describe geographic variation is through the use of forecasts for PDCs. PDCs are not a perfect way of reporting population because a few counties are members of two PDCs. For example, Gloucester County is a member of the Hampton Roads PDC and the Middle Peninsula PDC. With a projected 2025 population of about 50,000, Gloucester County would have a slight impact on the Hampton Roads PDC forecast but a larger impact on the Middle Peninsula PDC forecast. PDCs are quite useful, however, because they are sufficiently large to be less susceptible to unforeseen changes in population yet small enough such that these predictions are meaningful. Figure 4 shows how Virginia is divided by PDC and by employment region.

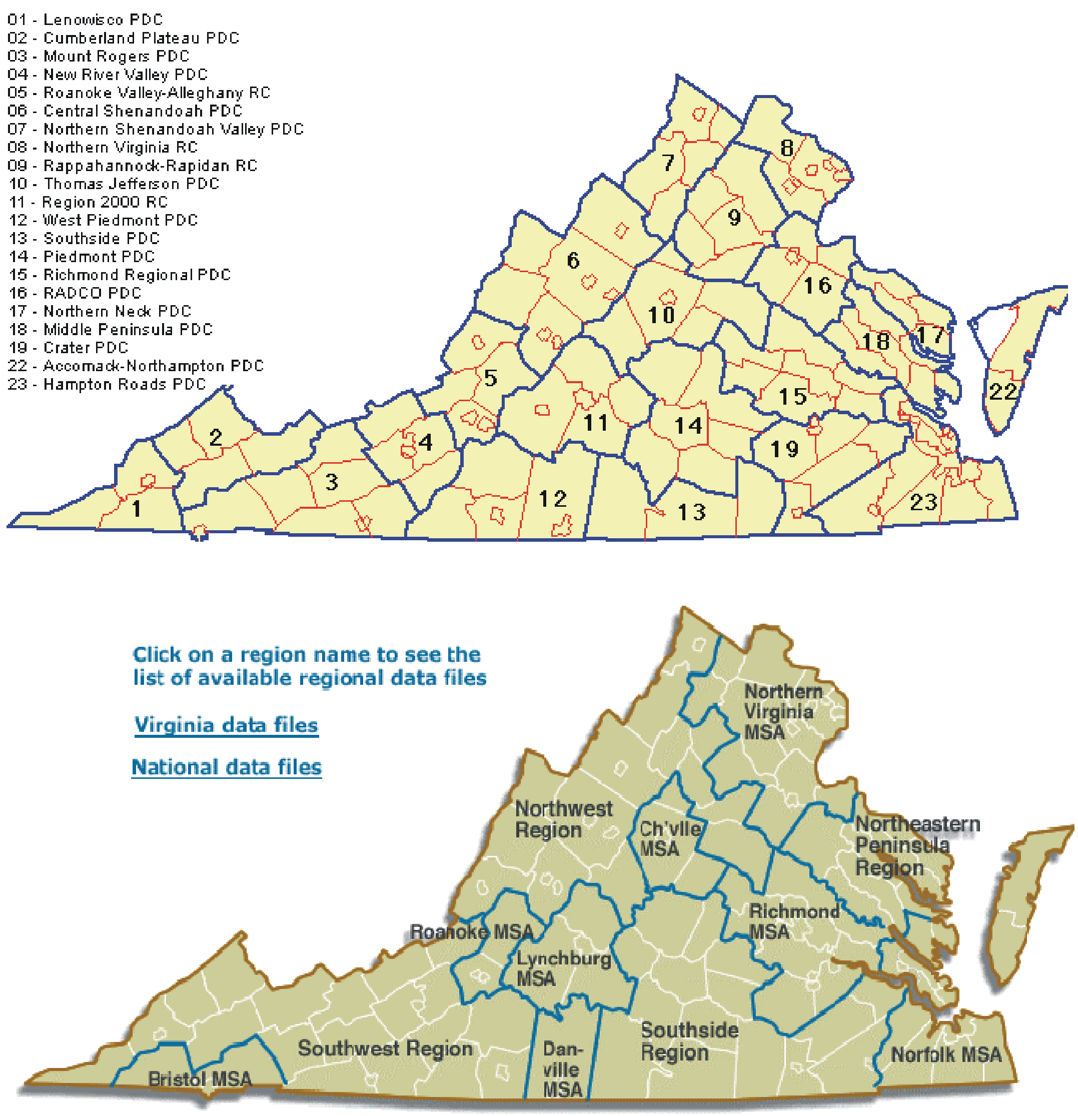


Figure 4. Virginia's PDCs and Regions. Courtesy of the Weldon Cooper Center for Public Service at the University of Virginia and the Virginia Employment Commission, respectively.

Figure 5 suggests that more than three quarters of this growth to year 2010 will occur in areas represented by four planning district commissions: Northern Virginia PDC, Hampton Roads PDC, Richmond Regional PDC, and the Rappahannock Area Development Commission (RADCO). This characterization does not mean the remaining 17 PDCs will see little growth, because several smaller PDCs are projected to grow substantially *relative to their 2000 population*. Four additional PDCs are forecast to experience double-digit growth between 2000 and 2010: Middle Peninsula PDC (16%), Northern Shenandoah/Lord Fairfax PDC (15%), Rappahannock-Rapidan PDC (10%), and Thomas Jefferson PDC (13%).[16,17]

Figure 6 shows the corresponding population increases for 2025 based on NPA data. The projected changes in trends between the 2010 and 2025 forecasts, such as the Middle Peninsula's rise in 2010 and then the very slight decrease in 2025, are not meaningful: these differences likely reflect differences in forecasting methods or how PDCs are defined as opposed to

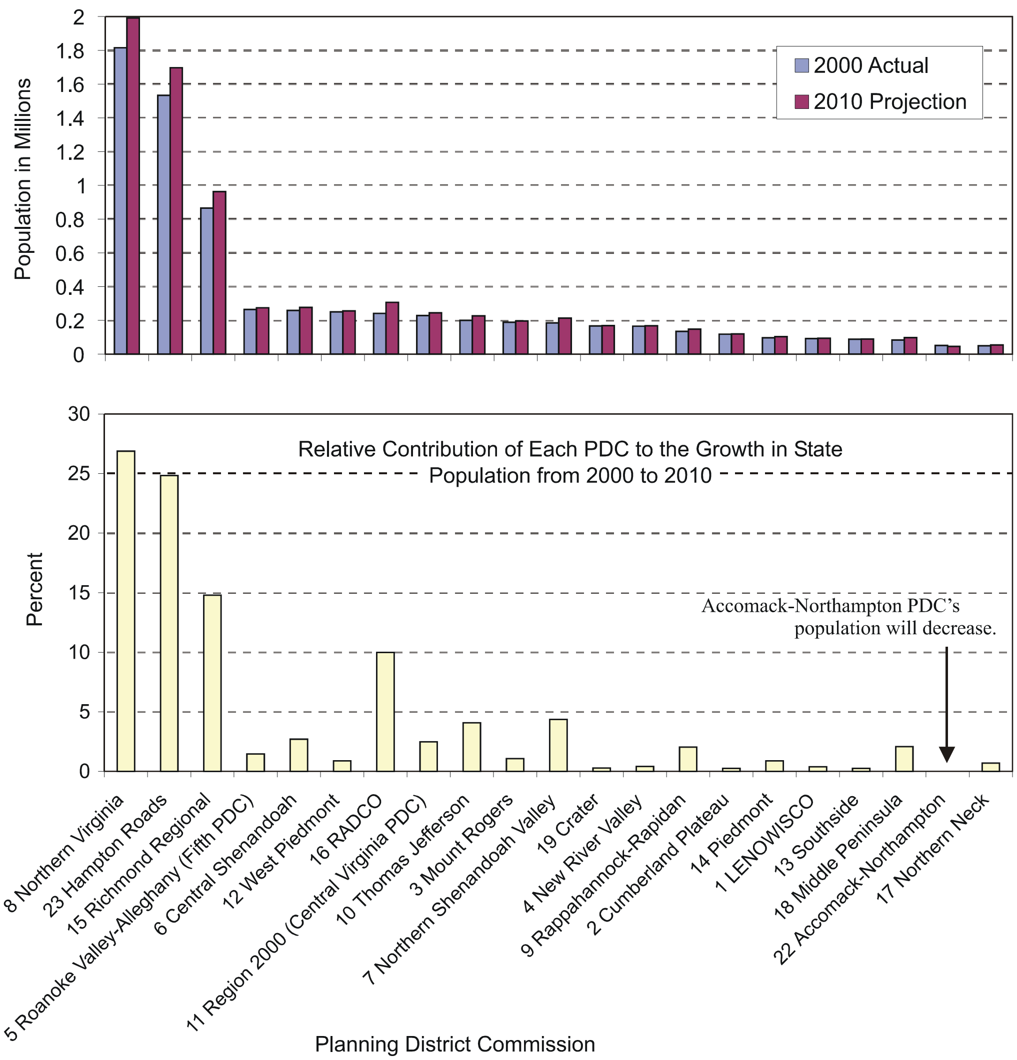


Figure 5. 2010 Population Projections by PDC (based on VEC Forecasts)

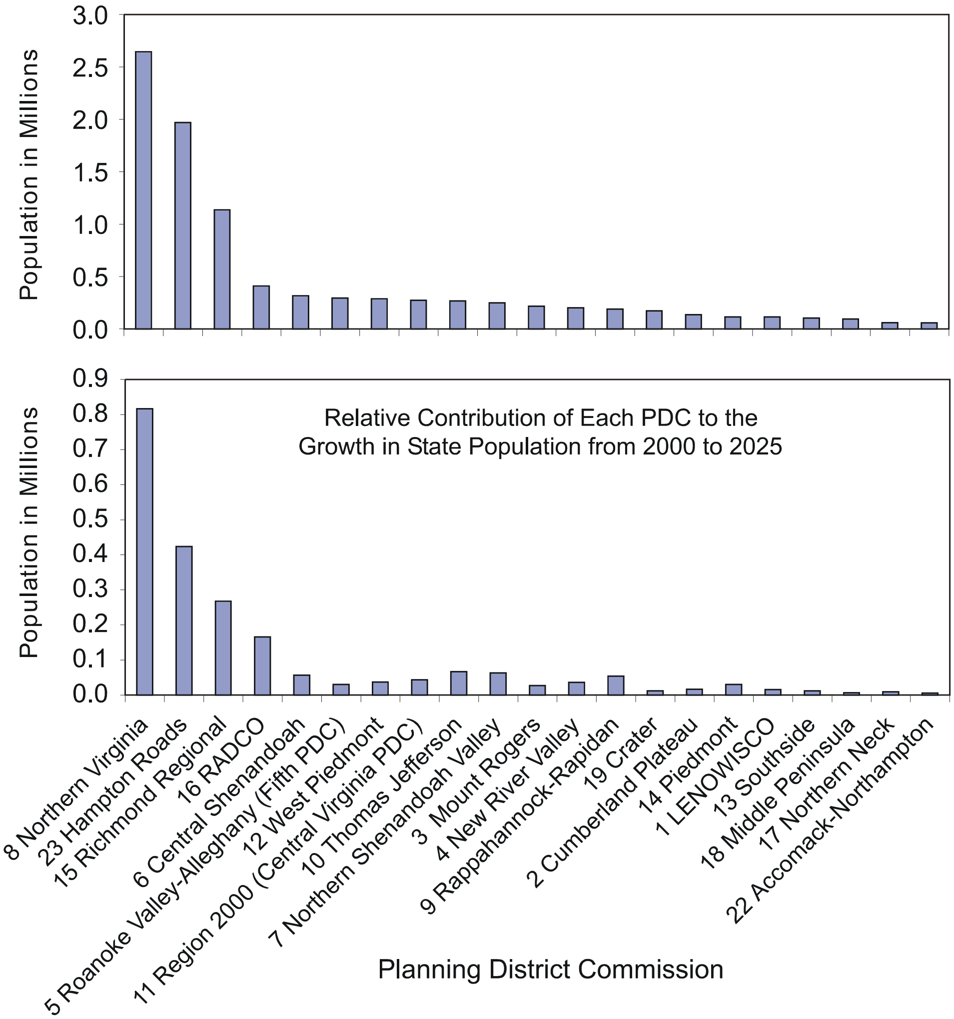


Figure 6. 2025 Population Projections by PDC (based on NPA Forecasts)

differences in reality. The combined figures are useful, however, where they suggest consistent trends, such as the continued rise of RADCO's population to be the fourth largest PDC in 2025. In other words, the value of Figure 6 is the comparison in growth among the PDCs themselves as opposed to providing an exact population figure for each PDC. (Population estimates for 2025 are provided in Appendix A.)

The VEC and NPA projections suggest that the percentage of the state's population in the three most urbanized planning districts—Northern Virginia, Hampton Roads, and Richmond Regional—will increase from 59.5% in 2000 to 60.1% in 2010 and 61.8% in 2025. Since PDCs are an administrative boundary, however, they are not a perfect delineator between urbanized and rural areas. The Weldon Cooper Center reports that as of 2000, 67% of the state population would be in the *metro* areas of Northern Virginia, Hampton Roads, and Richmond.[16,17]

Figure 1 presented percentage growth for each city/county combination from 2000 to 2025, and Figure 7 presents similar information in the form of net population change. These 25-

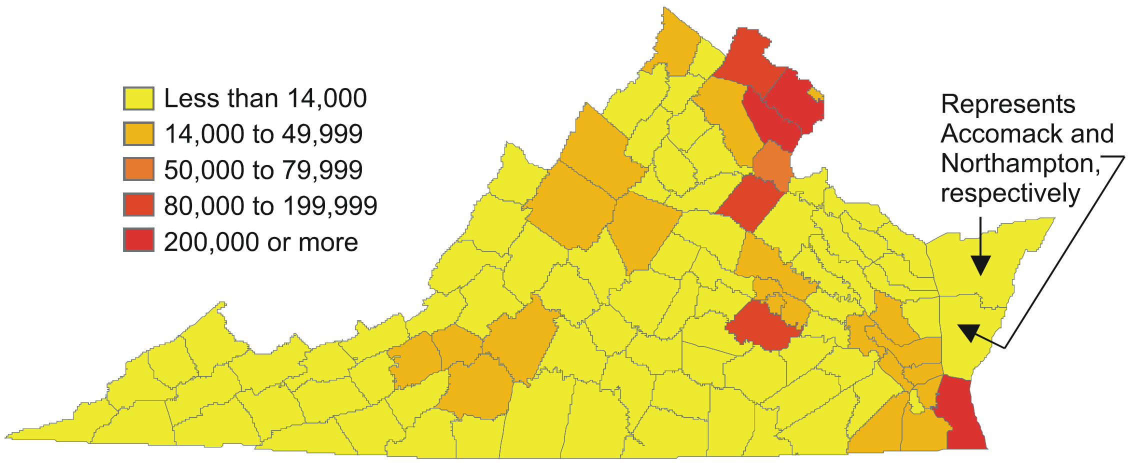


Figure 7. Change in Population from 2000 to 2025 (Forecast Data from NPA Data Services, Inc.)

year projections at the county level are tenuous at best, however, given the long horizon and the relatively small geographical area that spans the forecast. Figure 7 confirms that, as shown the first six figures, substantial growth is expected in the four urbanizing areas of the Commonwealth and in several smaller areas that may be characterized as rural/suburban in nature.

The NPA data contain only regional forecasts, but not individual jurisdiction forecasts, for three regions: (1) Hampton, Newport News, and York County; (2) Henrico County and the City of Richmond; and (3) Chesapeake, Norfolk, and Portsmouth. Thus 2025 forecasts for the individual jurisdictions within these three regions were unavailable, although 2025 forecasts for each region were available. To display the data in Figures 1 and 7 for these three regions, therefore, 2010 forecasts for the jurisdictions were used to estimate 2025 forecasts in a proportionate manner, using the 2025 regions as a control total. Thus for those three regions, the jurisdiction forecasts are reliant on 2010 projected proportions but the regional total is more credible. (For example, the NPA region of Hampton, Newport News, and York County has a 2010 projection of 411,000, with York County alone having a 2010 projection of 78,000, giving York 19% of the regional total. The region is expected to grow further to 481,500 in 2025; thus York's share in 2025 may be estimated as 19% of 481,500, or almost 91,500.)

Change in Age and Racial Distribution of Virginia Residents

According to U.S. Census projections, Virginia's population rank relative to other states should not change over the next two decades: Virginia was the 12th most populous state in 1995 and is expected to remain the 12th most populous state in 2025.[18] Yet in Virginia—and nationally—there are shifts in the age of this population: in Virginia, the percentage of the population under age 20 will decline from 27% in 1995 to 24.6% in 2025, whereas the percentage of the population aged 65 or over is expected to increase to 17.9% in 2025 from 11.1% in 1995, as shown in Table 1.

Table 1. Proportion of Population Aged 65 and Over as Projected by U.S. Census and VEC

Age Group	2000	2010	2025
Proportion between ages 65 and 74	6.2%	6.8%	10.3%
Proportion between ages 75 and 84	4.2%	4.0%	5.6%
Proportion between age 85 or over	1.3%	1.6%	2.0%
Total	11.7%	12.4%	17.9%

The U.S. Census Bureau points out that Virginia's "dependency ratio"—the number of persons under age 20 or over age 64 per 100 people compared with those aged 20 and 64—will rise from 61.7 (in 1995) to 73.9 (in 2025). This change mirrors shifts that are expected to occur nationally: Virginia had almost the lowest dependency ratio is 1995 (50th of 51) and is projected to have the same ranking in 2025. On the other hand, the proportion of school age children (e.g., persons between the ages of 5 and 17 inclusive) is expected to decline slightly from 18.1% in 2000 to 16.1% in 2025.[18,19] In real numbers, therefore, Virginia's dependency ratio will be driven by an increase in persons aged 65 or more.

Figure 8 shows a rightward shift by 2025, signifying the statewide growth in the *number* of persons aged 65 or over: in short, the number of persons aged 65 and over will increase from slightly more than 800,000 in 2000 to 1.5 million in 2025. (The NPA data suggest a slightly higher figure of 1.7 million in 2025, which, similar to the shaded value shown in Table 1, would be about 18% of the NPA 2025 forecast population.)

The *proportion* of persons aged 65 or more varies by PDC. Figure 9 compares these percentages between 2000 and 2025 with the proportion of the population aged 65 and over ranging from a projected low of 13% (Thomas Jefferson PDC) to a projected high of almost 28%

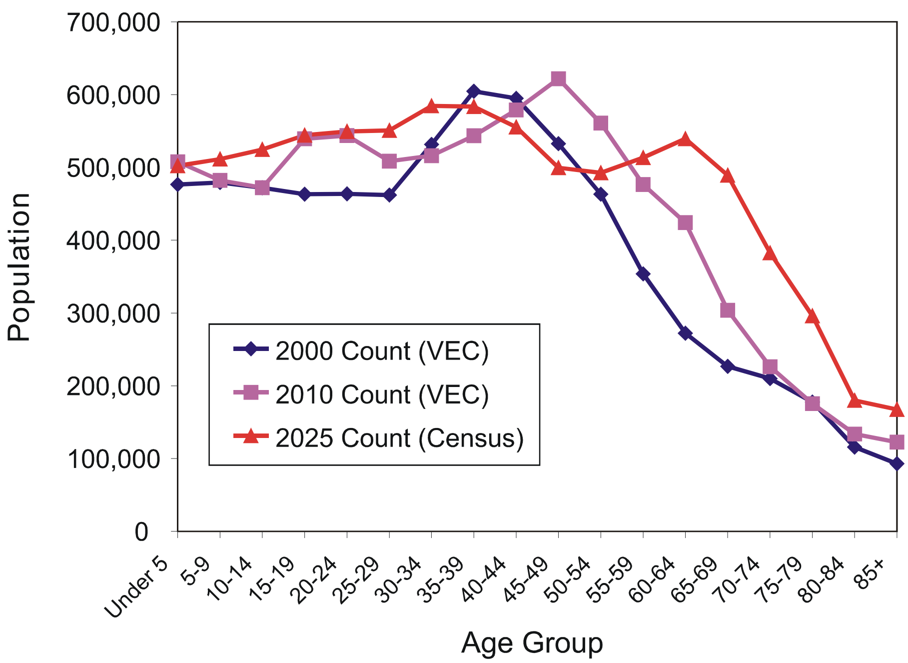


Figure 8. Expected Change in Population Aged 65 and Over by 2025 (U.S. Census and VEC)

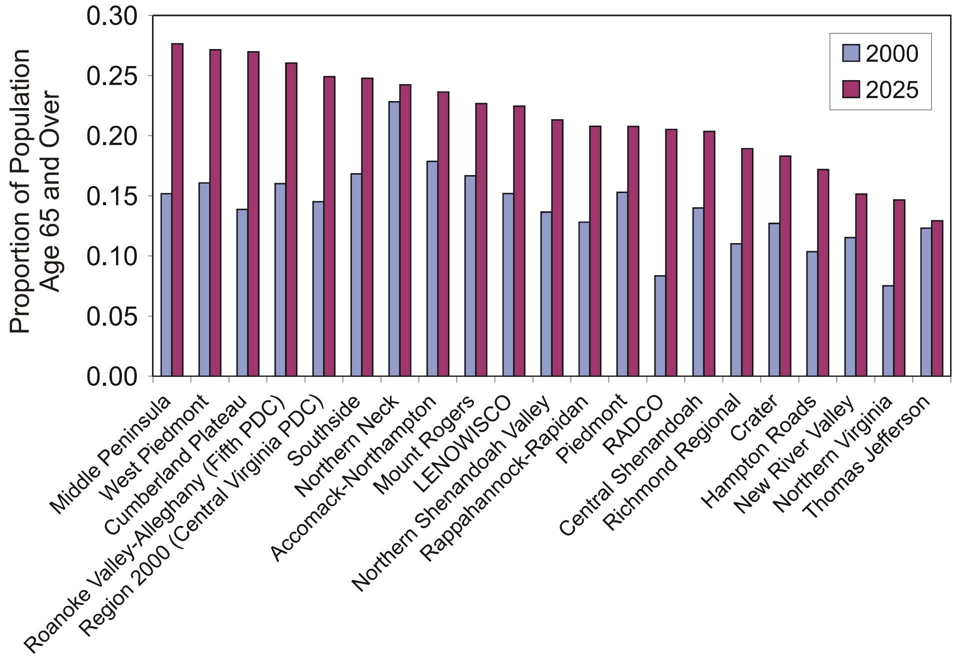


Figure 9. Proportion of Population Aged 65 and Over in Year 2025 (NPA)

(Middle Peninsula PDC). Not only is it apparent that the number of persons aged 65 and over will increase overall, but the disparity between the 2000 and 2025 trends also suggests that the increase will not be uniform throughout the Commonwealth. PDCs such as RADCO, Northern Virginia, and the Cumberland Plateau will double the proportion of persons over age 64, whereas a few other PDCs such as Northern Neck, New River Valley, and Thomas Jefferson will see smaller increases.

Changes in driving habits may also increase VMT for this older group. At the national level, Spain indicates that by 2030, 9% of the population will be 75 or older and a majority of this group will be women.[20] The author further noted that a key difference between the future and present is that these women will adopt "their fathers' travel profiles rather than their mothers'," such that in 2030 older women will drive three times more VMT and make twice as many trips on a daily basis as was the case for such women in 1997. To the extent that national changes in older women's driving habits are repeated in Virginia, it may be the case that changes in behavior of women aged 75 or older, such as an increase in VMT, are greater than the increase in population. U.S. Census data based on 1995 projections to 2025 expect this proportion of persons aged 75 or greater to be even larger, at about 7.6% of the population.[21] Clearly, therefore, an implication of this change in the age of the population is the resultant change in transportation service needs for persons who fall into the category of "older driver." Such changes might be (1) doing nothing, (2) making automobile travel more conducive for older drivers, (3) providing other mobility options such as demand responsive transit, (4) making land use changes that reduce automobile dependence, or (5) some combination thereof.

A related topic affected by an aging population and critical in its own right is mobility for persons with disabilities. Currently, almost 1.2 million Virginians (17% of the population) are classified as having a disability.[22] At present, age and disabilities are correlated: 17.5% of all persons between ages 21 and 64 have a disability, whereas this number is 42% for persons aged 65 and over. In 2025, therefore, a larger increase in persons aged 65 and over *may* portend an increase in the proportion of population with disabilities.

U.S. Census 2025 projections based on 1995 data for Virginia also suggest a change in the distribution of population by ethnicity. Although the proportion of the statewide population that is non-Hispanic American Indian, Eskimo, and Aleut is expected to remain constant at 0.2% for the 1995 and 2025 horizons, the proportions of Virginians that are of Hispanic origin, non-Hispanic Asian or Pacific Islander, or non-Hispanic African-American are all expected to increase. Figure 10a compares the relative Virginia population proportions for 1995 and 2025.[14] Figure 10b illustrates that age distributions are not evenly spread across all groups; e.g., persons of Hispanic origin occupy a greater proportion of the 0 to 15 age category than of the age 65 to 74 category.

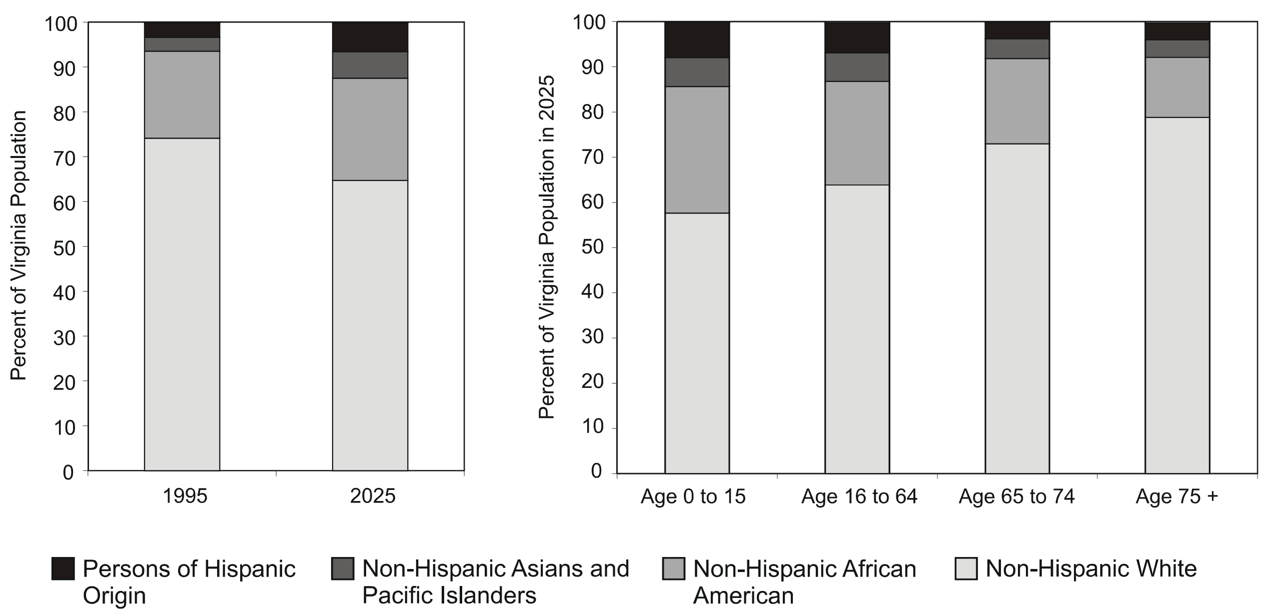


Figure 10. Proportion of Population by Ethnic Group and Age (U.S. Census)

Changes in Virginia's Population Density

One way to consider the potential for the population to expand is to look at comparative population densities; specifically, although Virginia has a statewide average population density of about 179 persons per square mile of land area, this density is not representative of the Commonwealth as a whole, given the extreme variation in densities of neighboring jurisdictions.[23] Only 52 of the Virginia's 135 jurisdictions exceed this value, with the City of Alexandria having the greatest population density of 8,452 persons per square mile of land area. The more densely populated areas are not limited to cities; e.g. Arlington County is the 2nd most densely populated area of the Commonwealth and Fairfax County is the 15th; both have higher densities than the cities of Virginia Beach, Williamsburg, Fredericksburg, and Roanoke. At the other end of the spectrum, Bath and Highland County have fewer than 10 persons per square mile. Table 2 shows the top 10 and bottom 10 jurisdictions in the Commonwealth ranked by population density. The population densities are meaningful in the sense that they suggest the potential for the development to expand, especially in areas adjacent to higher priced urban locations.

Although statewide differences in population density are not surprising, differences within a region are noteworthy, especially since disparity in densities is potentially a predictor of growth within the lower density areas. (Of course many factors influence growth in a county other than density, such as accessibility to employment, taxes, natural resources, and so forth. On the other hand, given that some counties adjacent to urbanized areas have tended to show high growth rates, density is a reasonable indicator of potential growth worth exploring, at least superficially.)

Figure 11 shows population densities for three regions that are expected to exhibit diverse growth patterns found in Virginia: (1) a region with a large population that should continue to grow steadily in the future, (2) a less populated region that is expected to grow quickly, and (3) a region that is expected to remain relatively rural. These regions are, respectively, the Virginia portion of the Norfolk-Newport News-Virginia Beach Metropolitan Statistical Area (MSA), the Roanoke MSA (which includes Roanoke City and County, Salem, and Botetourt County), and the Northeast region of Virginia (the nonmetropolitan area bordered by Accomack, Essex, Caroline, and Westmoreland counties). All three areas are located entirely within the Commonwealth. The size of the circle is proportional to the population density. For the Northeast region, the difference in densities from the most to the least densely settled area is not that great, ranging from 21 persons per square mile for King and Queen County to 87 persons per square mile for Lancaster County. Yet the density disparity is quite large for the other two regions shown—notably, the density of the City of Roanoke (over 2,000 persons per square mile) is almost 40 times that of Botetourt County (56 persons per square mile).

Table 2. Top and Bottom Virginia Jurisdictions, Ranked in Terms of Population Density, 2000

Rank	Jurisdiction	Persons per Square Mile	Rank	Jurisdiction	Persons per Square Mile
1	Alexandria City	8,452	126	Buckingham County	27
2	Arlington County	7,323	127	Charlotte County	26
3	Falls Church City	5,226	128	Rappahannock County	26
4	Charlottesville City	4,390	129	Sussex County	26
5	Norfolk City	4,363	130	Surry County	25
6	Manassas Park City	4,129	131	King and Queen County	21
7	Manassas City	3,537	132	Bland County	19
8	Fairfax City	3,407	133	Craig County	15
9	Richmond City	3,293	134	Bath County	10
10	Portsmouth City	3,033	135	Highland County	6

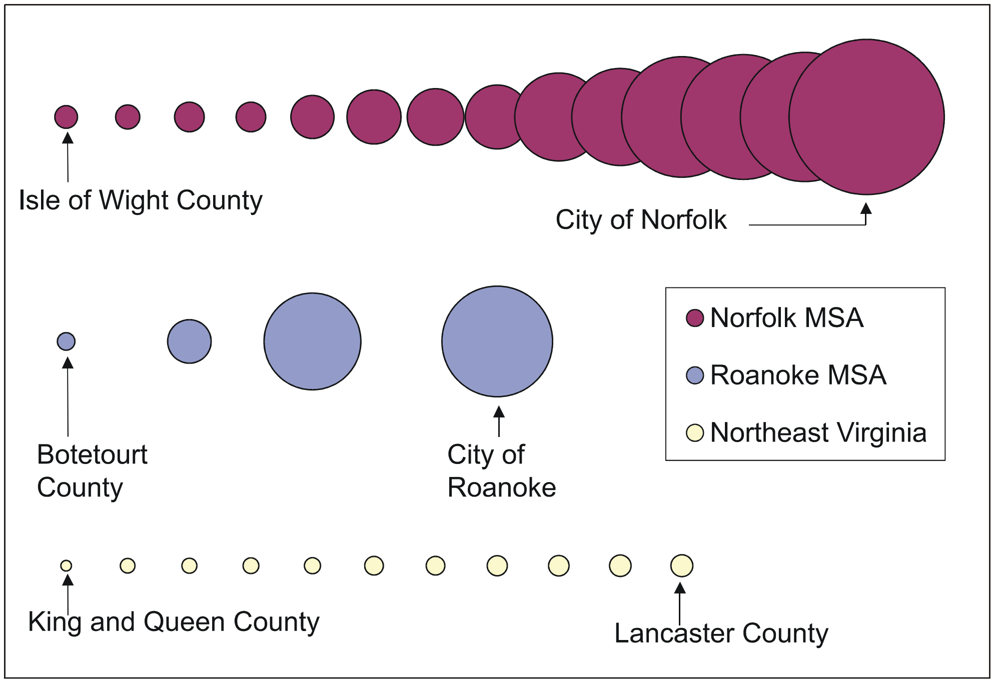


Figure 11. Relative Population Densities for Jurisdictions within Norfolk MSA, Roanoke MSA, and Northeast Virginia Regions, 2000 Data

A historical precedent has existed in the recent past decades for suburban metropolitan jurisdictions with lower densities to grow more rapidly than more urban jurisdictions with higher densities. For example, the closer-in Northern Virginia jurisdictions of Alexandria, Arlington, Fairfax City and Fairfax County, and Falls Church underwent population density increases between 9% and 18% from 1990 to 2000.[14,24] During the same time period, the further-out Northern Virginia jurisdictions of Loudoun, Manassas Park, Manassas, Prince William, Spotsylvania, and Stafford underwent population density increases in the range of 26% to 97%. Similarly, in the Richmond area, the City of Richmond actually lost population during that 10-year period, whereas suburban jurisdictions saw double-digit increases. In a similar vein, Martin pointed out that as of 2000, approximately 52% of the Commonwealth's residents lived in the suburbs. Martin further noted that although Virginia has 59 (of a total of 99) nonmetropolitan counties, 37 counties are bordered by a metropolitan locality. These border locations are potential future determinants of growth to the extent that they replicate a pattern from the 1990s where for the past 10 years, almost three quarters of the growth in rural counties took place in such counties that bordered a metropolitan locality.[25]

The 2025 forecasts for population density by jurisdiction are, therefore, somewhat speculative because it is difficult to predict movements within individual jurisdictions and some data are not available at the individual city level. It is more reliable, however, to examine changes in density within the relative PDCs. With those constraints in mind, Figure 12 highlights the 2000 and 2025 population densities by PDC, and once again it is apparent that high growth is projected in the more urbanizing portions of the Commonwealth. The Northern Virginia PDC will continue to be more dense than the rest of the Commonwealth, and the top four PDCs in terms of density will be Northern Virginia, Hampton Roads, Richmond Regional,

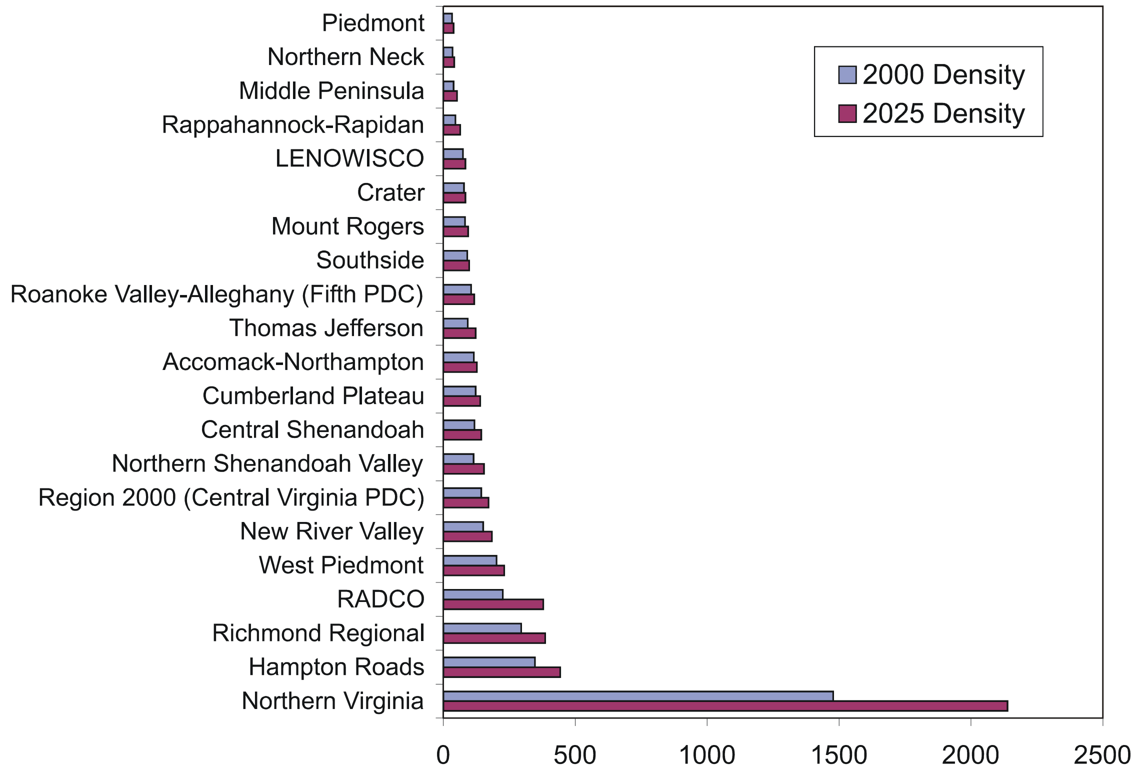


Figure 12. Projected 2025 Population Densities (NPA)

and RADCO. Another benchmark is to compare 2025 densities to those that are understood today: in 2025, RADCO and Richmond Regional will be more densely populated than Hampton Roads is at present. Note that the effects of population density are probably understated in Figure 12 since they do not describe the heavy population clusters that may be found in specific jurisdictions within a PDC.

Within some of the more urbanized PDCs, higher density growth on a percentage basis tends to be expected in the lower-density jurisdictions: e.g., in Northern Virginia, Arlington and Alexandria are expected to increase their population density by approximately 10% whereas Loudoun County should see its population density increase by 80%. A similar trend is expected in Richmond, where the City of Richmond and Henrico County will not see their density increase as much as that of outlying New Kent or Powhatan County. On the other hand, density in some jurisdictions is expected to repeat existing trends: e.g., in RADCO, Stafford and the Spotsylvania/Fredericksburg areas are expecting a 75% increase in population density compared with a 27% increase for Caroline County.

Thus, as stated previously, population density differences within a given region are a useful indicator for highlighting potential growth areas, but population density is in itself not a perfect growth predictor. This is to be expected, since it may well be the case that areas of lower population density are correlated with other factors that truly cause population change, such as quality of the school system, home prices, zoning requirements such as large lot sizes, and changes in the local employment outlook. (The growth shown in Figure 13 appears plausible

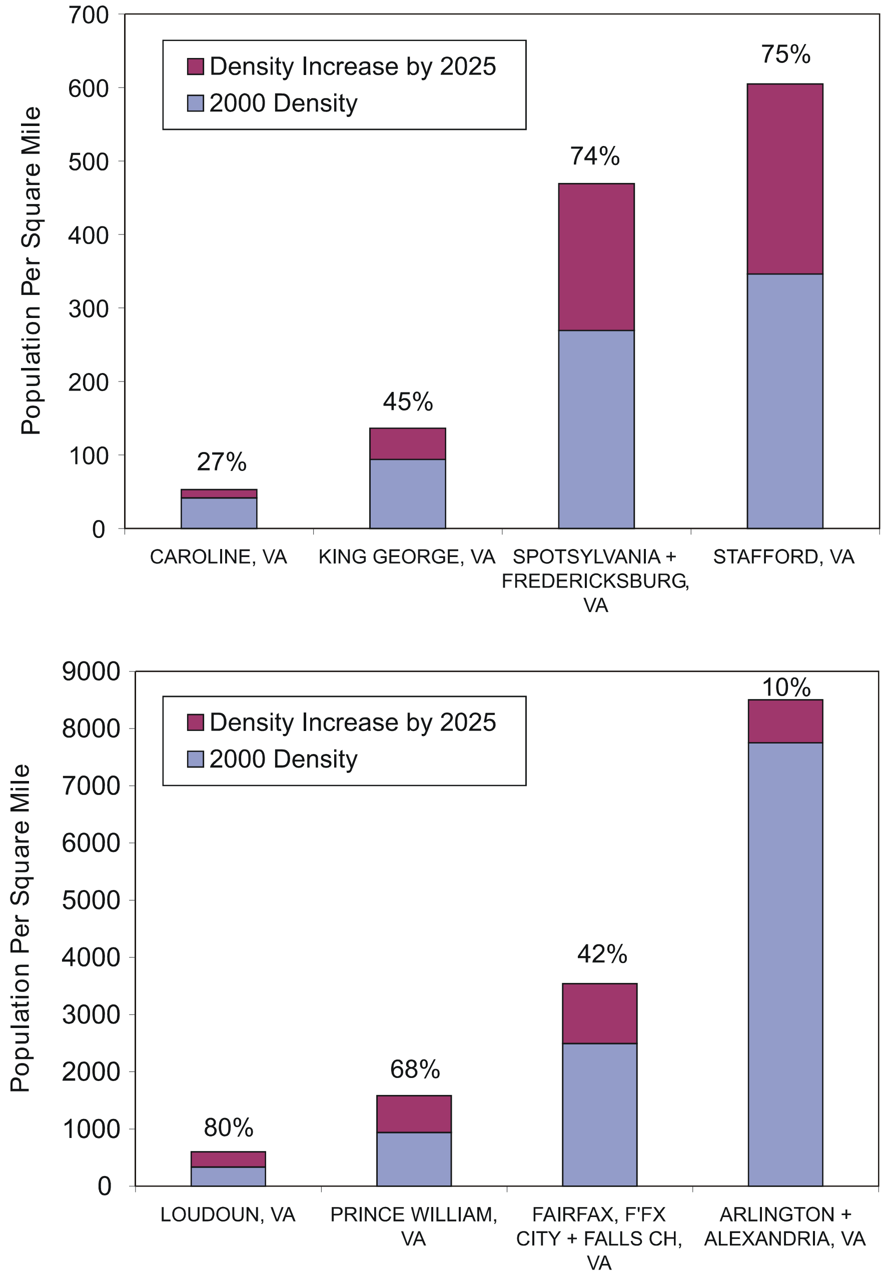


Figure 13. Projected 2025 Increase in Population Density for Northern Virginia and RADCO PDCs (NPA)

even given recent growth control measures that have been proposed for Loudoun County, as discussed later.)

In sum, six population trends are suggested based on available data and projections, and the first five population changes will plausibly cause freight and passenger travel demand to increase.

1. Virginia as a whole will keep growing at a steady rate, with most population growth in the urbanizing areas of Northern Virginia, Hampton Roads, and Richmond in terms of absolute numbers.

2. There will be substantial percentage increases in population in PDCs that historically have not been viewed as urban, such as RADCO (68%), Rappahannock-Rapidan (40%), and Middle Peninsula (36%). Even though these PDCs may have a small portion of the Commonwealth's total population, the increase in population therein should place substantial demands on the transportation infrastructure in those regions.

3. To the extent that the 1990s is a lesson for future expansions, Virginia's geography is such that a large number of rural counties border metropolitan areas and may be candidates for future growth.

4. The vast differences in population density even within a given region suggest that development pressure will continue to be placed on rural areas that border or are included within metropolitan areas.

5. The distribution of the population by age will change, such that persons over the age of 65 will make up a larger percentage of the population with the caveat that this age group may travel more than has previously been the case.

6. The ethnicity distribution of Virginia is expected to change, with a greater proportion of the Commonwealth's population being African-American, Asian, Hispanic, or Pacific Islander in 2025 than was the case in 2000.

Economic Trends and Forecasts

Economic indicators give clues regarding transportation needs since generally transportation demand increases as disposable income increases. In fact, research has shown that income is more important than gasoline prices in terms of influencing personal travel. The U.S. DOT's Volpe Center indicated that after controlling for other factors in the 1995 NPTS, a 10% increase in household income will increase personal motor vehicle travel by 3.5 to 3.7%.[26] In the United States, an expected increase in the per-capita Gross Domestic Product (GDP) of 50% from 2000 to 2025 "in real terms" may thus partly, but not entirely, explain why passenger VMT are expected to increase by about 36%.[33] The sensitivity of passenger travel to gasoline prices is not as strong; the reported finding is that a 10% increase in gasoline prices will reduce passenger travel by 1.9 to 3.2%.[26]

In order to examine current Virginia-specific data, one useful source is the U.S. Bureau of Economic Analysis (BEA), which maintains historical income data for states, counties, and regions. Since 1969, personal income, unadjusted for inflation, has grown at an average rate of 8.7% annually for the Commonwealth, which reflects rates as low as 5.2% (City of Norfolk) and as high as 13.1% (Loudoun County). The metropolitan areas have historically shown a higher rate of growth than the nonmetropolitan areas, with averages of 8.9% and 7.8%, respectively.[27]

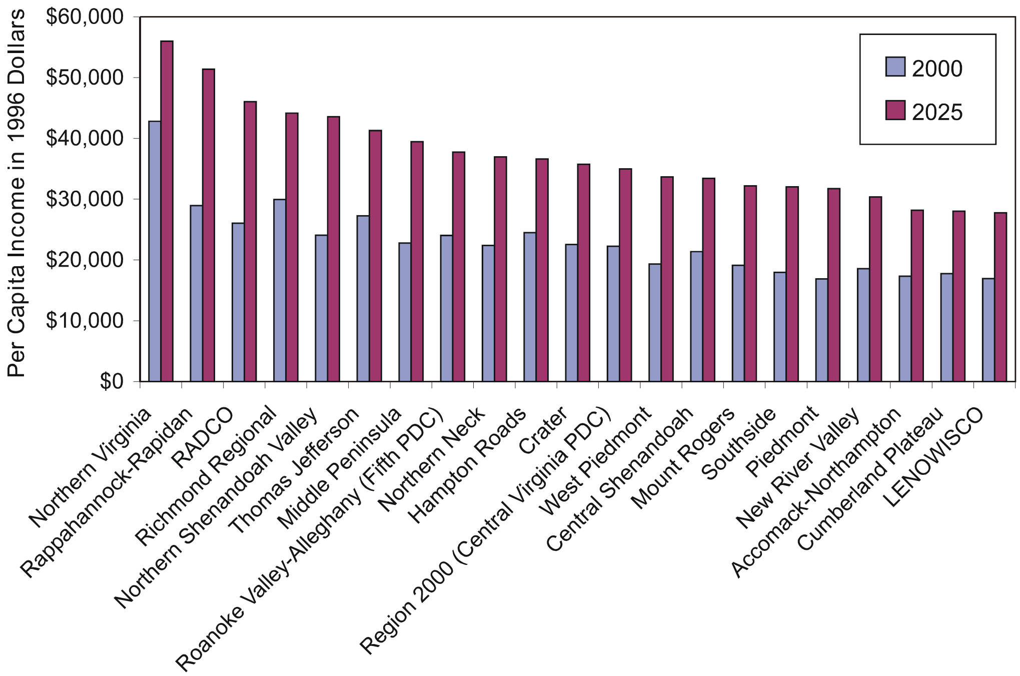
As of 2000, per capita personal income in 2000 dollars according to the BEA was $31,120 for the Commonwealth, reflecting a range from $16,604 (Lunenburg County) to $51,227 (the area of Fairfax County, Fairfax City, and Falls Church). The difference between metropolitan and nonmetropolitan areas is marked, with average per capita incomes of $33,887 and $21,220, respectively.

Between 2000 and 2025, NPA suggested that statewide personal income on a per capita basis will rise by almost 50% to over $43,000. (All NPA data are in units of 1996 dollars; e.g., the 2000 average according to NPA data was approximately $28,990 in 1996 dollars.) Some PDC per capita incomes are projected to rise faster than others; e.g., Rappahannock-Rapidan and RADCO would experience the largest *absolute* gains such that they become the second- and third-ranked PDCs in terms of per capita income, slightly behind Northern Virginia, as shown in Figure 14a. On a percentage basis, the PDCs with the largest forecast gains in income are generally those with lower per capita incomes; e.g., Piedmont, Northern Shenandoah, and Southside are expected to have per capita incomes rise between 78 and 88%. In contrast, Richmond Regional and Northern Virginia PDCs will also see their per capita income rise—but only by 47% and 31%, respectively.

Between 2000 and 2025, the gap between the richest and poorest PDC is expected to narrow slightly. In 2000, the poorest PDC had a per capita income that was only about 40% that of the richest PDC; by 2025, this figure should be about 50%. Figure 14b presents this pattern of the other PDCs catching up to the wealthiest PDC in a different manner. Instead of 20 of the 21 PDCs having between 40% and 68% of the Northern Virginia PDC per capita income (as was the case in 2000), these 20 PDCs will have between 50% and 92% of the Northern Virginia PDC per capita income in 2025. In other words, PDC per-capita incomes are expected to become more similar to that of the wealthiest PDC over the next quarter century.

Employment data will logically affect transportation since it is a derived demand because of employees needing to get to work, businesses procuring raw materials, and the related distribution of finished goods and services. Virginia's year 2000 employment was 4.4 million jobs, almost all of which are nonfarm positions: 3.6 million were in the private sector and 0.8 million were in the public sector.[28] The nonmetropolitan regions account for only about 18% of the total employment in the Commonwealth. The BEA divides Virginia into 105 areas, where each area represents one, two, or three jurisdictions. Table 3 shows the top 40 BEA areas in terms of employment, which account for almost 88% of all Commonwealth jobs. Urbanized cities and counties are equally represented.

The types of positions that are expected to open will also play a role in transportation demand, especially in terms of the types of transit services that become feasible. Nationally, it has been suggested that retail positions, with the flexible hours and dispersed locations, and service positions, with their associated smaller firms and reduced employee concentrations, will make traditional transit services less feasible.[30] (This statement does not mean that transit must be ineffective; rather it suggests that more creative forms of transit, such as paratransit or jitney service, merit serious consideration.)



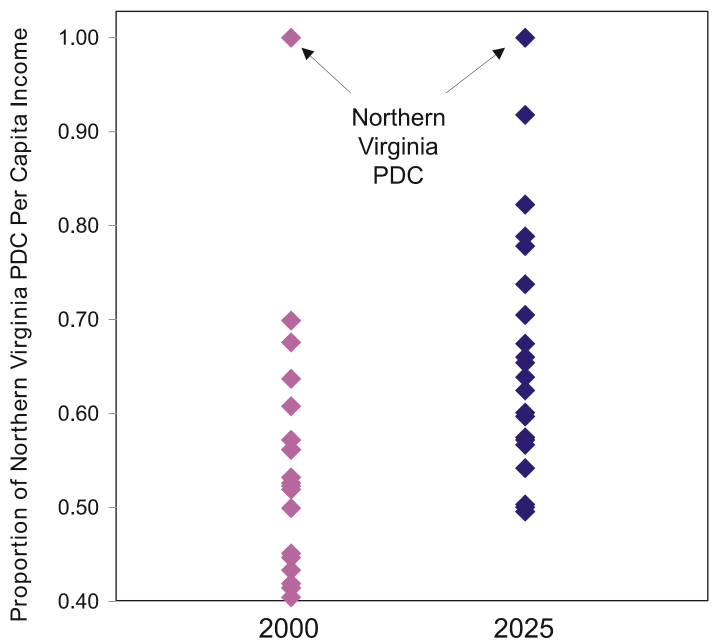


Figure 14. 2025 Per Capita Forecasts Based on NPA Data and Relative Scatter Among PDCs

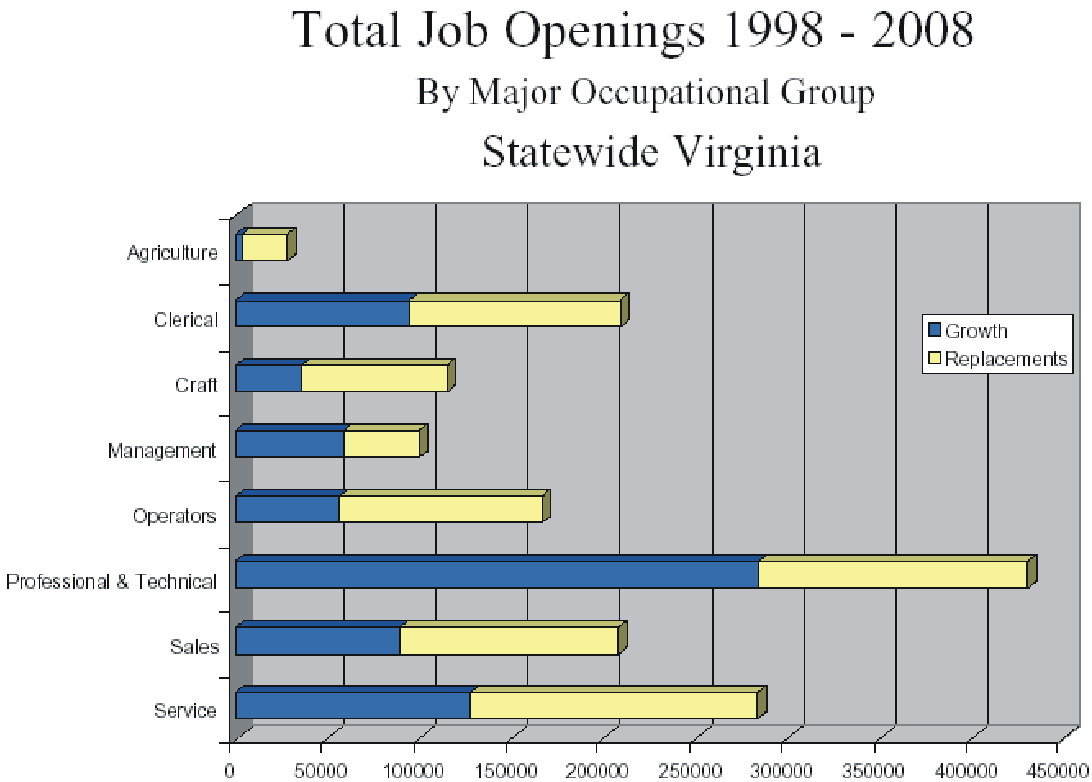
Table 3. Top Forty Areas in Virginia, Ranked by Number of Jobs in 2000

Jurisdiction	Employment	Jurisdiction	Employment
Fairfax, Fairfax City + Falls Church	749,552	Frederick + Winchester	58,071
Virginia Beach (Independent City)	236,744	Pittsylvania + Danville	57,465
Norfolk (Independent City)	225,619	Montgomery + Radford	55,588
Arlington	201,727	Portsmouth (Independent City)	52,973
Richmond (Independent City)	197,878	James City + Williamsburg	49,791
Henrico	194,613	Hanover	48,957
Prince William, Manassas + Manassas Park	140,700	Washington County + Bristol	43,352
Chesterfield	135,178	Dinwiddie, Colonial Heights + Petersburg	43,058
Alexandria (Independent City)	119,586	Henry + Martinsville	42,281
Newport News (Independent City)	118,679	Stafford	33,114
Loudoun	110,724	Prince George + Hopewell	28,852
Chesapeake (Independent City)	102,681	York + Poquoson	27,620
Albemarle + Charlottesville	100,612	Fauquier	26,772
Roanoke (Independent City)	90,083	Suffolk (Independent City)	26,127
Campbell + Lynchburg	87,261	Bedford + Bedford City	25,930
Hampton (Independent City)	83,410	Carroll + Galax	21,065
Roanoke + Salem	74,239	Wise + Norton	21,010
Rockingham + Harrisonburg	69,626	Tazewell	20,771
Augusta, Staunton + Waynesboro	62,241	Shenandoah	19,757
Spotsylvania + Fredericksburg	59,484	Pulaski*	19,625

*Because the BEA indicates only one "Pulaski" for Virginia, it is inferred that this includes both Pulaski County and the City of Pulaski.

The VEC projects employment growth in various positions statewide and for individual regions for the period 1998 to 2008.[29] (VEC forecasts are thus 5 years old, and VEC expects to update these forecasts in 2003.) Although detailed projections for a variety of specific positions can be obtained (e.g., an expected 14% increase in the number of motorcycle repairers), the summary statistics shown in Figure 15a suggest that the largest areas of growth will be in the professional/technical and service series whereas there will be virtually no growth in the agriculture sector (agricultural employment will be based on turnover in existing positions). In sum, Virginia appears to mirror national trends, with sales and service positions showing dramatic increases in Figure 15a.

Statewide, employment growth of 23% was forecast for the 1998 to the 2008 period, although growth will vary by region within the state as shown in Figure 15b, with the Northern Virginia MSA expecting to see 37% growth in employment over that 10-year period and the Danville MSA and adjacent Southwest Region expecting to see a 5% growth in employment. At a large enough geographic scale, population and employment forecasts would be expected to be correlated at the regional level; the unanswered question is the extent to which population and employment are expected to be in balance within a given jurisdiction.



Region	Employment Growth (Percent Increase)
Northern Virginia MSA	37
Charlottesville MSA	21
Northwest Region	17
Northeastern Peninsula Region	11
Richmond MSA	21
Norfolk MSA	20
Southside Region	7
Lynchburg MSA	12
Bristol MSA	10
Roanoke MSA	14
Southwest Region	5
Danville MSA	5

Figure 15. Expected Job Openings by (a) Occupational Group and (b) Region for 2008 (Figure 15a is courtesy of the Weldon Cooper Center for Public Service at the University of Virginia)

Looking ahead to year 2025 using NPA data (which were updated in 2002), similar trends are expected to continue: statewide, the service sector will show the greatest increase in terms of number of positions, and high employment growth in absolute numbers is expected in the urban PDCs of Northern Virginia, Hampton Roads, and Richmond Regional. Figure 16 also gives the expected percentage increase in employment for each PDC, with some of the greatest growth on a percentage basis occurring in RADCO, which is expected to increase employment by 63%. Large percentage increases are expected also for the Thomas Jefferson and Middle

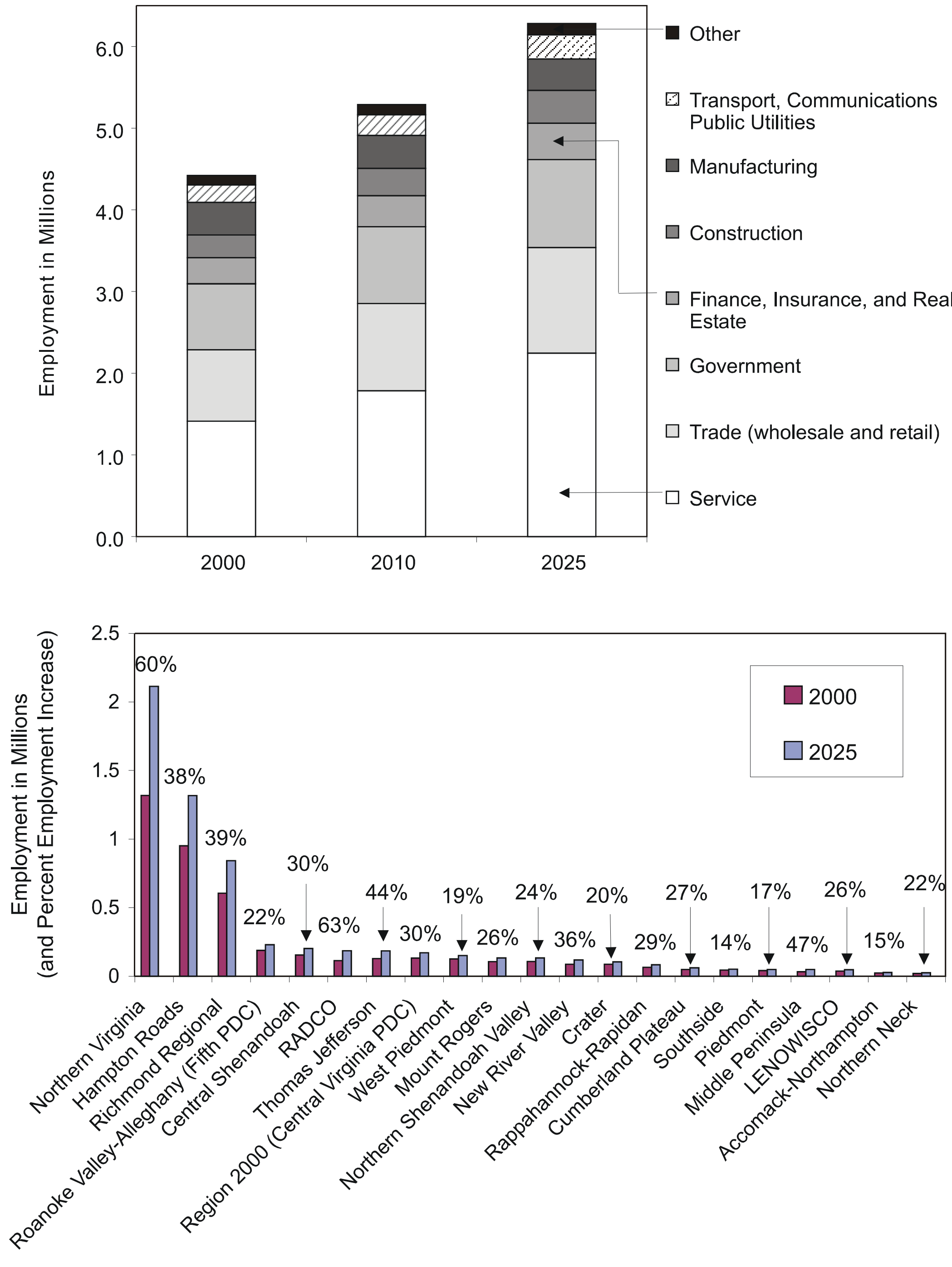


Figure 16. Expected 2025 Increase in Employment for PDCs and Statewide, Based on NPA Data

Peninsula PDCs. Another interpretation of Figure 16 is that the three urban PDCs of Northern Virginia, Hampton Roads, and Richmond Regional will increase their share of the Commonwealth's employment: in 2000, they had 65% of the Virginia total, and in 2025 they are expected to have 68% of Virginia's total employment.

In sum, economic data suggest five main implications for increasing travel demand, for both passenger and freight.

1. *Employment will continue to rise in several urban areas, but growth will be unevenly distributed by profession and geography.* Notably in the short term, other regions in addition to the four most urban areas (Northern Virginia, Richmond, Hampton Roads, and Roanoke) are expecting double-digit growth over the next 10 years, such as the Charlottesville MSA. Thus higher demand may be felt in these growing regions that are not viewed as urbanized but that are also clearly not rural-only.

2. *The proportion of employment held by the three largest PDCs will increase from 65% to 68% over the next 25 years; it* is possible, but not proven, that the employment growth in the PDC with the highest projected employment growth (RADCO, with 63%) may be the result of its proximity to the PDC with the second highest projected employment growth (Northern Virginia, with 60%).

3. *Growth in the service sector, with jobs having nontraditional hours, means that traditional transit services may not be well suited to accommodating this new demand, especially in areas with lower population densities.*

4. *To the extent that historical trends hold true, travel is relatively sensitive to personal income, and thus increasing incomes in real terms should increase the propensity to travel.* The almost 50% rise in per-capita personal incomes statewide over the next 25 years, forecast by NPA, suggests that demand for travel is poised to grow.

5. *The disparity in personal income by PDC should lessen between 2000 and 2025:* although all PDC per-capita incomes will grow, the incomes in PDCs with lower incomes in 2000 are projected to grow at a faster rate than in the PDCs with higher incomes.

Household Trends and Forecasts

There are at several ways in which housing data may be used for making transportation planning forecasts. Changes in household size and automobile ownership may denote a change in the number of vehicle trips per person, and the locations of households indicate where new transportation services may be needed. Further, the number of new households themselves may be a surrogate for the economic well-being of a region.

Changes in Household Size

Planning models have historically shown that smaller households tend to make more vehicle trips per person after controlling for other factors, such as the number of vehicles per household.[30] From 1967 to 2000, Virginia household sizes dropped from a statewide average of 3.44 to 2.55 persons per household.[31,15] Analysis of the NHTS data shown in Table 4 shows a relatively clear linkage between increasing automobile ownership (or decreasing household size)

Table 4. Vehicle Trips Per Person Versus Vehicle Ownership and Household Size, 2001 NHTS Data

Number of Persons per Household	Number of Automobiles per Household					Average (All Households)	Average without Zero-Vehicle Households
	0	1	2	3	4		
1	0.10	2.97	3.33	3.64	4.42	2.50	3.05
2	0.38	1.99	3.21	3.40	3.67	2.84	2.96
3	0.41	1.49	2.52	3.04	3.49	2.46	2.53
4	0.27	1.34	2.12	2.50	2.97	2.11	2.19
5	0.27	1.17	1.80	2.23	2.66	1.85	1.92
6	0.30	0.91	1.40	1.84	2.15	1.45	1.50
Average	0.25	2.01	2.50	2.78	3.07	2.35	2.48

and an increasing number of *vehicle* trips per person. (Anomalies are possible with any data set; in this case, because of some surprising results with zero-vehicle households, the average values were tabulated with and without the zero-vehicle households as shown in the rightmost columns of Table 4.) To the extent that Table 4 is accurate, the decrease in household size in Virginia would be accompanied by an increase in the number of vehicle trips per person.

In at least some areas, there is a correlation between household size and distance of the jurisdiction from the central business district; generally, larger households tend to be in areas that are further from the urban core. This trend, however, is not absolute and may be offset by the fact that in these outlying areas, a greater proportion of trips may be taken by automobile. Table 5 shows the 1990 household size for select Virginia jurisdictions in the Washington, D.C., metropolitan area and the greater Richmond area. The jurisdictions are listed in approximate distance from the central business district, and there is a trend toward larger household sizes. (Table 5 also shows quite a bit of variability within this trend, and thus it is likely that several factors in addition to distance from the core area explain household size, such as varying proportions of children.)

Looking ahead to 2025, NPA data suggest that household sizes will continue to drop but at a slower rate, from 2.62 persons per household in 2000 to 2.39 persons per household in 2025. Household sizes by PDC are shown in Table 6, with all PDCs showing an expected decline in the average number of persons per household. Figure 17 shows the historical trend of statewide persons per household. Three trends are evident. First, although the number of persons per household is projected to decrease, the rate of decrease is expected to drop; looking back, the most radical drop in household size occurred between 1965 and 1980, a period of time correlated with a rapid increase of women in the labor market.[62] Second, the relative position of the various regions around the Commonwealth, in terms of household size, is expected to remain constant: the Roanoke Valley had the lowest household size in 2000 and should continue to have the lowest household size in 2025. Third, the variability among PDCs in terms of household size should remain about the same: with about 0.5 person per household being the difference between the highest and lowest PDCs.

Table 5. Average Household Sizes for Select Virginia Jurisdictions, 2000 Data

Northern Virginia Area		Richmond Area	
Alexandria	2.04	Richmond	2.25
Arlington	2.12		
Fairfax County	2.75	Hanover	2.73
Fairfax City	2.60	Henrico	2.41
Falls Church	2.27		
Loudoun	2.80	Charles City	2.91
Manassas	2.88	Chesterfield	2.82
Manassas Park	3.09	Goochland	2.70
Prince William	3.04	New Kent	2.77
Spotsylvania	3.01	Powhatan	2.84
Stafford	3.05		

Increasing distance from urban core

Table 6. Forecast Persons per Household, 2025, NPA Data, in Order of Decreasing Household Size

PDC	2000	2025	PDC	2000	2025
RADCO	2.88	2.66	Middle Peninsula	2.55	2.36
Piedmont	2.75	2.54	Northern Shenandoah Valley	2.55	2.35
Crater	2.72	2.52	Region 2000 (Central Virginia PDC)	2.55	2.34
Hampton Roads*	2.74	2.52	Cumberland Plateau	2.50	2.31
Rappahannock-Rapidan	2.71	2.50	Accomack-Northampton	2.49	2.30
Northern Virginia	2.66	2.49	LENOWISCO (PDC for Lee, Wise, Scott Counties and City of Norton)	2.44	2.25
Central Shenandoah	2.64	2.44	Northern Neck	2.43	2.25
Richmond Regional	2.55	2.38	West Piedmont	2.43	2.24
Thomas Jefferson	2.57	2.38	Mount Rogers	2.41	2.22
New River Valley	2.57	2.38			
Southside	2.57	2.37	Roanoke Valley-Alleghany (5^{th} PDC)*	2.39	2.21

*The NPA data available for this study contained an error for the 1998, 1999, and 2000 employment and housing files for 2 of Virginia's 98 regions: (1) Roanoke City, Roanoke County, and Salem, and (2) York, Newport News, and Hampton. Accordingly, the 2001 NPA employment and household data for these two regions were substituted for the 2000 NPA data throughout the report. (NPA explained that this error resulted from the manner in which the files were given to NPA from other sources and indicated that steps are being taken to correct the error.)

What the data do not convey in Table 6 is the effect that geography should have on household size if trends suggested in Table 5 hold true. The reader may recall that Table 5 suggested a rough trend where households further from the city center tended to be larger. Because NPA forecasts aggregate individual cities and counties, it is not possible to compare directly Table 5 for year 2000 and 2025. It is possible, however, to look at some jurisdictions within PDCs as forecast for the year 2025 and for the concepts given in Table 6 to become moderately apparent: e.g., in the Richmond Regional PDC, the county of Powhatan (2.84 persons

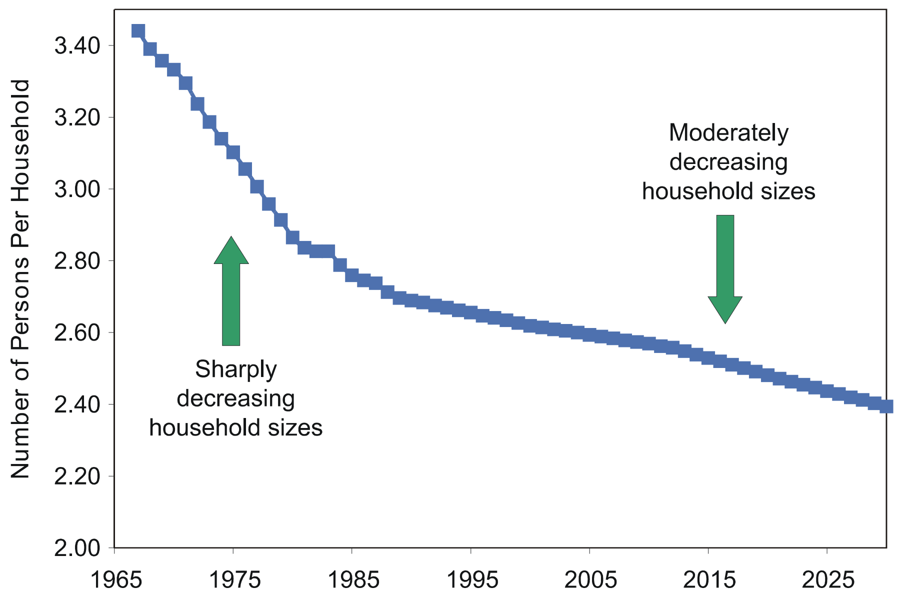


Figure 17. Trends in Persons per Household in Virginia, NPA Data, 1967-2030

per household forecast for 2025) has a larger household size than the combined area of the City of Richmond and Henrico County (2.2 persons per household forecast for 2025). Thus it can be inferred that differences within regions based on proximity to central business districts may be correlated to household size, at least as much so as the particular PDC.

Automobile Ownership

Despite the rate of historical growth in automobile ownership, automobile ownership rates should not continue to increase as quickly as they did in the past in the United States given that the market should eventually reach saturation. Dargay and Gately developed mathematical models for forecasting automobile ownership as a function of income, using data from 26 countries.[32] They found that although automobile ownership did increase with income, the sensitivity of automobile ownership to income—or its elasticity—was greatest when per-capita GDP was between $3,300 and $5,100 in 1985 dollars. With the U.S. incomes already in excess of that number, the authors forecast that U.S. automobile ownership will continue to rise, but not as rapidly as in the past, with the authors predicting that in *2015* the U.S. market will be saturated, with 190 million automobiles and 260 million total vehicles. Compared to 2001 estimates of 138 million automobiles and 230 million vehicles, this forecast translates into more vehicles and more VMT in the immediate future. Beyond that point of market saturation, however, there should be a rate of growth in automobiles that will be below that in the past.

Interestingly, unpublished sources cited by the BTS forecast 262 million total vehicles, but not until *2025*—a 10-year difference for the level projected by Dargay and Gately.[33] (U.S. DOT also points out that "saturated" vehicle ownership rates have not been attained for all demographic groups but instead will rise in African-American, Hispanic, and Asian households as wealth increases.[33])

Meyer and Miller also pointed out that one group whose automobile ownership rates should continue to increase significantly are "immigrants whose vehicle ownership will increase dramatically as their improved economic status enables them to own a vehicle."[30] Virginia is expected to gain more than 600,000 persons from international immigration by 2025, which would represent approximately 7% of the Commonwealth's U.S. Census–projected population at that time.[18] That amount would put Virginia as the eighth largest in the nation in terms of net population gain from international migration, although it is not clear if this population would have higher than average growth in automobile ownership.

Another component of automobile ownership is the set of households with no vehicles. Although the percentage of households without a vehicle statewide dropped from 8.8% to 7.6% from the 1990 to the 2000 census, such decreasing generalizations are deceptive for two reasons.[34] First, since the number of households increased, the net effect is that in Virginia, the number of households without a vehicle increased from 202,504 to 204,500 over that 10-year period. Second, there are rural jurisdictions where there appear to be fewer transportation options yet the proportion of non-vehicle households is higher. Figure 18 shows the percentage of households, by census tract, for which no vehicles are available.[94] For example, 11% of the households in Accomack County, 11.6% of the households in Brunswick County, and 10.1% of the households in Prince Edward County have no vehicles therein—and these are relatively rural counties with incomes below the median level for the state.[35]

The question was raised as to whether "vehicles available" might include vehicles licensed for farm use and thus affect the number of no-vehicle households in rural agricultural counties. The U.S. Census definition of "vehicles available" does not explicitly include or exclude vehicles available for farm use. The definition implies, however, that any vehicle that was used *only* for business purposes, of which farming would logically be considered, should not be included. The census definition states that "vehicles available" includes "passenger cars, vans, and pickup or panel trucks of 1-ton capacity or less kept at home and available for the use of household members . . . . Vehicles kept at home but used only for business purposes also are excluded."

Certainly there are many reasons for not having a vehicle; e.g., some jurisdictions have a larger proportion of no-vehicle households plausibly because the costs associated with owning a vehicle coupled with the availability of transportation options may reduce the necessity of vehicle ownership. Jurisdictions such as Arlington County and the City of Alexandria with 12.2% and 11.1% of households without vehicles, respectively, fit this description, especially given their high public transportation rates that will be shown in the Northern Virginia portions of Figure 36 later in this report.

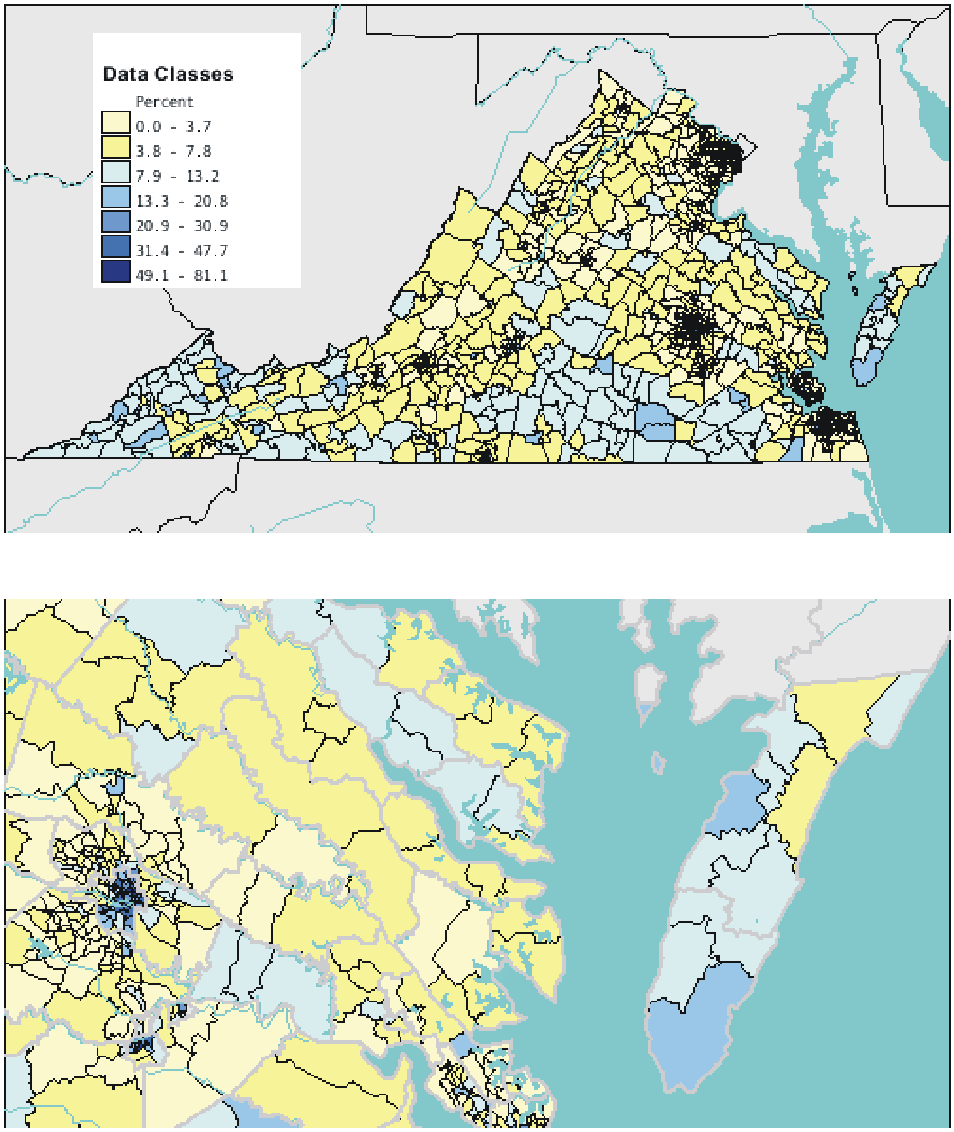


Figure 18. Percentage of Households with No Vehicles for (a) Virginia and (b) Virginia's Eastern Region

In sum, automobile ownership suggests two trends for Virginia. First, VMT will probably continue to increase, although some sources note that VMT will not continue to increase as fast as it has in the past, owing in part to the automobile ownership market becoming saturated at higher income levels. This does not mean that VMT will not continue to increase, however: populations are still growing, and VMT use should still be increasing in some demographic groups that historically have not had access to a vehicle. Second, a significant number of households—over 200,000—do not have an automobile, and although the proportion of no-vehicle households has decreased, the absolute number of such households has increased slightly.[36] On the surface, this trend appears worrisome in locations where other transportation options are lacking.

Changes in Household Location

Another way in which housing data may be used is as an estimation of transportation demand within a region. As the variation in housing prices increases within the various jurisdictions that comprise a metropolitan region, so may the incentive to travel within that region (to the extent that employment is concentrated heavily in a few key locations). A graphic produced by Martin as Figure 19 highlights the contrast in median home prices throughout the Commonwealth.[38] Certainly, the disparity *between* regions is not surprising, with counties and cities with lower median housing prices being located in the southern and western portions of the state.

The disparity *within* some regions may suggest the potential for continued or increased intra-regional transportation demand. For example, when all home prices above $1 million and below $10,000 are excluded, Central Virginia has Albemarle County with an average asking price of almost $173,000 compared to adjacent Buckingham County to the south with an average asking price of just under $49,000. In the southeastern portion of the Commonwealth, the difference between asking prices in the City of Virginia Beach and Accomack County was almost $50,000. (Similar results are obtained when using median housing values: the difference between Albemarle and Buckingham is $93,500 and the difference between Virginia Beach and Accomack is $47,500.) Discrepancies such as these within a region *may* contribute to increased transportation demand therein, as residents take advantage of low home prices in one municipality and work opportunities in another.[37]

(One view is that the trend of increased travel demand will result if employment is concentrated at a few high-priced places within the region. Residents then have an incentive to purchase a lower priced home at one location and commute to a work site at another location. An alternative view is that an ideal region has a mix of median housing prices such that prospective residents may find a place to live regardless of income. Interestingly, one way to realize this second theory is to define a region as being a very large area such that it encompasses jurisdictions with diverse median home prices.)

One caveat to concluding that disparity in housing costs will increase travel demand is that house prices reflect a variety of factors—schools, lot sizes, house sizes, date of construction, and other amenities. Thus it could have been the case that location is not the root cause of disparity in house prices: e.g., perhaps houses in Virginia Beach are bigger or better constructed than those in Accomack. Although much of these data are not readily available, it was possible to use the number of rooms, number of bedrooms, and year of construction to create a model based on Virginia's 135 jurisdictions that could predict 43% of the variability in asking price based on these three variables alone. This model forecast a difference of $35,000 in price between Accomack and Virginia Beach and a $39,000 difference in price between Albemarle and Buckingham. The results do not prove the extent to which location affects the other 53% of variability in home prices, but they do suggest the possibility that at least some other factor, in addition to construction year and dwelling size, affects house pricing. Further, the Albemarle-Buckingham or Accomack–Virginia Beach price differences forecast by the housing size and year model are substantially less than the differences observed, suggesting that something other than house construction quality itself is responsible for differences in price by location.

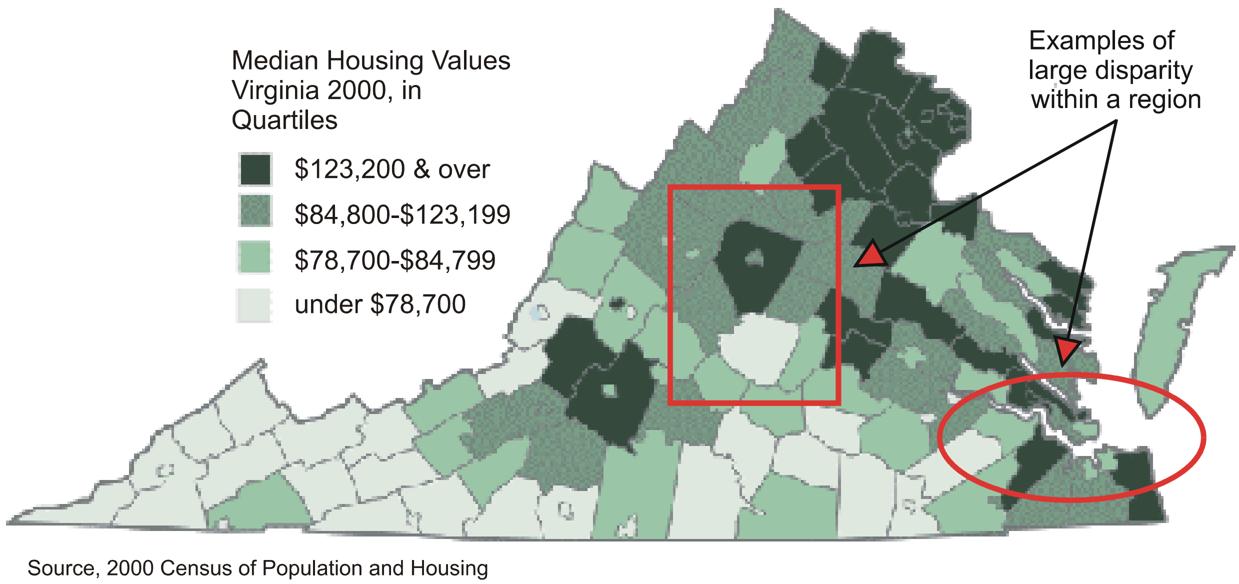


Figure 19. Median Housing Values in Virginia, 2000 (Base figure courtesy of the Weldon Cooper Center for Public Service at the University of Virginia; arrows added by VTRC)[38]

Housing locations may also be used to forecast economic impacts or intra-regional transportation demand, especially as jurisdictions express an interest in controlling residential population growth. In a recent comparison of housing demand and supply for the Washington, D.C., metropolitan area, McClain and Fuller noted that for the period from 1970 to 2000, in the Washington region, jobs increased by 1.72 million and households increased by 1.03 million—a ratio of 0.60 households per new job created.[39] Using a slightly lower ratio for future growth, the authors forecast that over the next 25 years the housing "deficit" for the Washington, D.C., area will quintuple from approximately 43,000 to over 218,000 units. The net effect is that the authors give several stark alternatives for what may occur: *if population growth is successfully controlled in the metropolitan jurisdictions*, then either economic potential may not be attained (as new jobs are not filled) or workers may be forced to commute from even further jurisdictions where growth controls are not in place. Conversely, *if population growth is not restricted in the metropolitan jurisdictions*, then close-in counties such as Fairfax, Loudoun, and Prince William will reach "build out" projections—the point at which all new land has been developed as per zoning ordinances—well before 2025. (As discussed later, the definition of *build out* depends on the zoning ordinances and/or legislation that are in place: growth can be restricted or unrestricted by enacting, modifying, or repealing such legislation.) Table 7 summarizes these potential outcomes.

Table 7. Oversimplified Summary of Growth Outcomes Based on Washington, D.C., Area Housing Deficit

Scenario	Economic Growth	Population Growth in Close-in Areas	Commuting Growth
Close-in population growth is restricted and economic growth stops	Stops	Stops	Stops
Close-in population growth is restricted and economic continues	Continues	Stops	Increases
Close-in population growth continues	Continues	Continues, thereby redefining "build out"	Stops

In sum, four major housing-related trends may conspire to increase transportation demand by 2025:

1. *Nationally and in Virginia, there has been a trend toward smaller household sizes, which is expected to continue through 2025, although the rate of decrease should be less than it has been in the past.* Smaller households may foretell higher per-capita automobile trip rates per person, since historically smaller households have shown higher vehicle trips per person than larger households. At the national level, automobile ownership rates should eventually start to level off, although not until 2015 or 2025.

2. *Predicted changes in household sizes by PDC are relatively similar*, suggesting that the generally downward trend in household size will not affect one PDC more or less than another to the extent that the forecasts used herein are reliable.

3. *Disparity in housing prices within some regions of the state can to some extent be logically expected to increase intra-regional travel as residents take advantage of employment opportunities in one location and homeownership opportunities in another.*

4. *The recent efforts of jurisdictions to control population growth through legislation may further exacerbate this trend if those efforts are successful and employment growth continues.*

POLICY TRENDS AFFECTING TRANSPORTATION DEMAND

It is tempting to view diverse components of the transportation industry as a single system whose performance can be optimized. Certainly, intermodal linkages, such as traveler information across modes, can be improved. The phrase "department of transportation" instead of "department of highways," coupled with efforts to coordinate initiatives within the various modes that comprise these departments, is further evidence of this interest in operations.[48] It has also been suggested that operating a multimodal infrastructure is as important as constructing that infrastructure.

Deen, however, noted that the transportation sector is fragmented in the sense that multiple providers and customers are spread across the public and private sectors; therefore, a single command and control transportation organizational structure is unlikely.[40] Instead, the implication is that improved operations will be accomplished as a series of individual initiatives that gradually place more emphasis on managing components of the system in lieu of solely expanding infrastructure. To understand better the transportation environment, therefore, it is appropriate to look at some of the legislative, industry, and consumer trends that may incrementally change how transportation services are provided.

Operations and Technology Trends

The operations and technology trends described can also be described as ways of using information technology and/or Intelligent Transportation Systems (ITS) to increase the efficiency of existing facilities.

- *Availability of advanced communications capabilities for transportation vehicles*. The commercial failure of services that provide drivers with real-time information can be held as an argument against the likelihood of profit-driven transportation information in the near future. However, Kulash noted that from a manufacturer's standpoint, a firm that can devise and implement a profitable information-based in-vehicle service would be rewarded with a tremendous market—over 200 million personal and commercial vehicles in the United States.[48] Given that advanced electronics are already becoming parts of conventional household devices, a strong incentive for competitors to attempt to deploy commercially viable vehicle-based information services on a large scale may be expected.

- *New emphasis on passenger operations to make congestion tolerable*. Even though metrics that reflect congestion—delay per person, average travel speed, total hours spent below a particular speed—can be quantified, Kulash noted that levels of congestion that are tolerated can change with geography and over time.[48] Part of this change stems from relative conditions—e.g., the familiar argument that in an urban area with heavy congestion, drivers in a particular location become somewhat accustomed to delays and thus more tolerant. Yet another part of this change may arise from technologies that allow persons to be more productive during congestion, such as cell phones, faxes, car stereos, and so forth. Still a third component of improving congestion tolerance is suggested in literature indicating that travel time reliability and/or prediction is of value to users, even if travel times are only slightly reduced.[41] An extension of this can be seen from the motorist's perspective and the commercial carrier's perspective: the motorist may at least be relieved to know the expected duration of a delay (as opposed only to seeing traffic slowed); the shipper may be better able to know the margin of inventory that needs to be maintained to meet just-in-time requirements.[42] In both examples, the extra information is helpful even though travel times are not necessarily shortened.

- *Renewed emphasis on freight operations*. At intermodal terminals, a critical delay component occurs at the port landside, where congestion affects freight traffic moving to or from highways, rail lines, and waterways. Further, the limited physical space for terminals and transfer points also hampers the growth of these non-highway modes. Thus there are initiatives to use information technology to manage the freight transfers, such as the FIRST (Freight Information Real-time System for Transport) demonstration project hosted by the Port Authority of New York and New Jersey, which aims to reduce unnecessary truck trips to the intermodal terminal (and thus eliminate truck queues extending several blocks) by providing timely, accurate cargo container information to carriers.[43]

- *Trip customization services*. Beyond demographic shifts, expectations of transportation consumers may or may not affect how transportation services are demanded. For example, the *Yankelovich Monitor*, a magazine that looks at consumer trends, indicates that persons currently between the ages of 16 and 24 expect customization of the services they use, an example cited in the *Monitor* being websites that "remember" their likes and dislikes.[44] (An existing transportation-related service is the ability that users have to customize the VDOT website, available at **www.virginiadot.org**, to their personal interests, such as upcoming projects and travel information for a specific geographic area.) Yet the same article also gives a challenge: this age group is less willing to reveal personal information, with less than 24% of those surveyed indicating they are willing to provide personal demographic data in return for a "customized shopping experience." Looking ahead to the next 20 years, given the expectation that ITS will play a key role in the provision of transportation services, it is reasonable that transportation consumers would strongly desire easily-customizable trip planning information, especially if they were intending to use more than one mode of transportation.

- *Telecommuting* has increased, although not necessarily in the manner that would have been expected. The U.S. DOT found in 1992 that 2 million workers were telecommuting, approximately 1 to 2 days a week; the same report forecast that by 2002, between 7.5 and 15 million workers would be telecommuting.[45] According to a report by Pratt for the U.S. Department of Labor, as of 1999 there were 19.6 million persons—about 10% of U.S. adults—who worked at home at least 1 day per month; this group averaged 9 days of work at home on a monthly basis.[46] The same author pointed out that measuring telecommuting and understanding barriers to telecommuting can be difficult, owing in part to the fact that "telecommuting at its most successful is informal."[47] The U.S. DOT noted that the physical means for telecommuting have existed for some time and suggests that further "market penetration" of telecommuters may be a result of the need to build better team relationships in light of complex systems; accordingly, the workplace necessitates more face-to-face contacts and hence less telecommuting.[33] In other words, such a view may be paraphrased as being that increasingly complex tasks require more in-person dialogue than has been required in the past. A different perspective, however, is that of Kulash, who suggests that telecommuting might "push the boundaries of suburbia still further out and . . . encourage satellite communities beyond the suburban fringes."[48] The question at this point, in short, is whether this trend will continue. Although the nature of the occupation affects telecommuting potential (e.g., a survey of Houston employers reported by Pratt shows significant telecommuting in the wholesale sector but little to none in the retail industry), about one third of survey respondents indicated "corporate culture" as a reason for not telecommuting.[47] Giuliano suggested that supervisory perceptions (e.g., employee oversight and loyalty) and employee perceptions (e.g., access to internal information and separating work from home) are more important than technological obstacles.[92] The literature also suggests that the effect of telecommuting may be more complex, including the concept that it may in some cases *stimulate* travel (e.g., when sales forces "telecommute" by visiting clients in person rather than staying at the office.)[46,49] In sum, even if an increase in telecommuting does occur and it reduces traditional work-based peak hour trips, there may still be increases in non-peak hour or nonwork trips.

National Legislative Trends

The manner in which transportation improvements are selected, as well as the types of improvements being considered for funding, may affect the transportation supply outlook in 2025. Although forecasts for 2025 in terms of how transportation organizations may function are not given here, an examination of near-term changes may yield clues regarding how transportation planning, including multimodal planning, will evolve.

- *A serious reconsideration of bus and rail opportunities*. In the short term, Orski noted that for the purposes of the upcoming 2003 transportation reauthorization there are several areas of agreement, including increased consideration of bus rapid transit and provision of intercity bus services to complement the restructuring of Amtrak. Recent developments in Virginia and nationally, although not enough by themselves to prove his thesis correct, certainly support his argument. Examples include the consideration of bus rapid transit as an alternative to the Metro expansion in the Washington, D.C., metropolitan area and the suggestion advanced by the Reconnecting America advocacy group that "quality bus" (along with high speed rail) can serve medium distance markets. The role of advocacy groups in influencing transportation is significant; e.g., a related group, the Surface Transportation Policy Project, has been credited with playing a large role in making the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) more of a multimodal transportation bill than a more highway-oriented bill comparable to the previous Surface Transportation Uniform and Relocation Assistance Act (STURAA) of 1987.[50]

- *Increased transportation financing from nongovernmental sources*. Orski noted that after the 2003 transportation reauthorization cycle is completed, there will be a pressing need to find an alternative to transportation financing other than revenue from the gasoline tax, owing to increased costs for highway maintenance and increased use of non-gasoline vehicles.[51] It is possible that the modest growth in user-fee based facilities from the 1990s—notably high-occupancy toll (HOT) lanes, such as SR 91 in California, or privately financed toll roads, such as the Dulles Greenway in Virginia, will be part of those alternative sources of financing.

- *Continued involvement of multiple players*. In one sense this trend is familiar: transportation industries have always had multiple stakeholders who logically attempt to influence transportation improvements: examples are citizens who may affect the highway location process through public hearings, jurisdictions that work with the VDOT resident engineer to influence secondary road improvements; metropolitan planning organization (MPO) representatives who create a regional transportation improvement program for VDOT to incorporate in its state transportation improvement program, and members of congress who exert influence over routes served by Amtrak. Yet attempts to develop and operate a multimodal system suggest a potentially even greater number of stakeholders. National examples of diverse groups involved in transportation policy that may or may not may not be relevant in Virginia include:

  — *regional planning authorities* whose ability to coordinate land use decisions among the member jurisdictions will drive the demand for transportation within a region at the metropolitan area. One example is the Georgia Regional Transportation Authority, which has authority for transportation and land use planning throughout the state.[52]

  — *local county and city governments*, who influence not only large scale housing and employment but also how transportation services are delivered. Examples are funding for local transit services and the design and operations of arterial roadways through interactions with the VDOT resident engineer.

  At the national level, there is an increasing involvement of other agencies in transportation decisions. This coordination issue, although challenging, also presents opportunities to improve efficiency; e.g., the U.S. General Accounting Office reports that better coordination between human services providers (who provide services for seniors and the disabled) and transit operators can lead to fewer one-way trips, equipment and personnel sharing, and clustering of passengers, thereby lowering costs.[53] (The office cites five case studies conducted by the Community Transportation Association of America that saw reduced costs *and* an increased number of trips per month that were the result of interagency coordination.)

Population-Related Legislative Trends in Virginia

At the national level, suburban growth is expected to continue in a pattern similar to that which has been occurring for the past half century.[30] Growth control initiatives have been proposed in Virginia and range from measures that directly influence zoning (e.g., increasing the acreage requirement per new home constructed) to plans meant to serve as blueprints for various agencies to follow. For example, a January 2003 ordinance approved by Loudoun County will reduce the number of new homes that can be constructed in Loudoun from about 180,000 to 100,000.[54] Given that Loudoun currently has 73,000 residences, the new zoning ordinance, if it survives legal challenges, will significantly influence the quantity and type of residential growth that county and adjacent counties will see.

(It is often repeated that Virginia is a "Dillon's Rule state," meaning that "a locality has only the explicit powers that are authorized by the state legislature."[55] Hence although the *Code of Virginia* permits localities to maintain a zoning ordinance, until 1997, Title 15.1 of the *Code* prevented cities and counties from working together to coordinate zoning except in cases where transportation districts had been created. In 1997, Title 15.1 was repealed and Title 15.2 was enacted, which gave local governments the ability to "work together in all areas of common power." The degree of this power, however, is not yet clear and thus will depend on legal actions and/or legislation.[55] In short, the extent to which Virginia localities can manage growth through land use planning given the passage of Title 15.1 will be determined by the courts. At this time, therefore, a reflexive statement that Virginia's Dillon Rule status thereby guarantees land use coordination as being infeasible is simply not accurate.)

Given these efforts in Northern Virginia by counties to control growth, it is reasonable to think that counties in other locations of the Commonwealth may plan to enact comparable legislation if (1) these counties encounter similar growth pressures and (2) these counties see the existing growth control measures in Loudoun or elsewhere as successful. Although Figure 12 shows that the other PDCs in the Commonwealth are not expected to be as densely populated in 2025 as Northern Virginia is in 2000, the significant population increases in some locations coupled with some counties desire to influence growth suggest that legislation remains an option counties will consider. It is also plausible that counties could implement growth-influencing planning initiatives in lieu of or in addition to such legislation. For example, Albemarle County's comprehensive land use plan designates "preferred development zones," which encourage higher housing densities than are in existing residential developments (in addition to other design aspects such as mixing residential and commercial uses and open public spaces).[56] The extent to which this encouragement becomes reality is not yet known.

In sum, the long-term response of individual jurisdictions to this growth, the extent to which metropolitan areas will coordinate their response, and the extent to which intraregional density discrepancy alone really will encourage future growth are unclear at this time. It is unclear whether local jurisdictions will successfully enact or maintain legislation that uses zoning to affect growth and, if so, whether such legislation will affect development in the way originally intended by the legislation.

To What Extent Can Policy Trends Be Predicted?

Forecasts for 2025 socioeconomic measures such as population, income, and employment are readily available. Within the realm of policy, however, it is generally not possible to forecast precise legislative, technological, and social trends a quarter century into the future, as reflected by the upper shaded area in Figure 2. A practical reason is that over a 25-year horizon, it is impossible to identify key social responses that may result from technological or organizational innovations, economic changes, or political events. Anecdotal examples of unforeseen disruptions include the 1990s' increase in business applications of the World Wide Web, the 1980s' personal computer revolution, the rapid rise in television set purchases between 1947 and 1952, and the number of persons educated under the G.I. Bill following World War II.

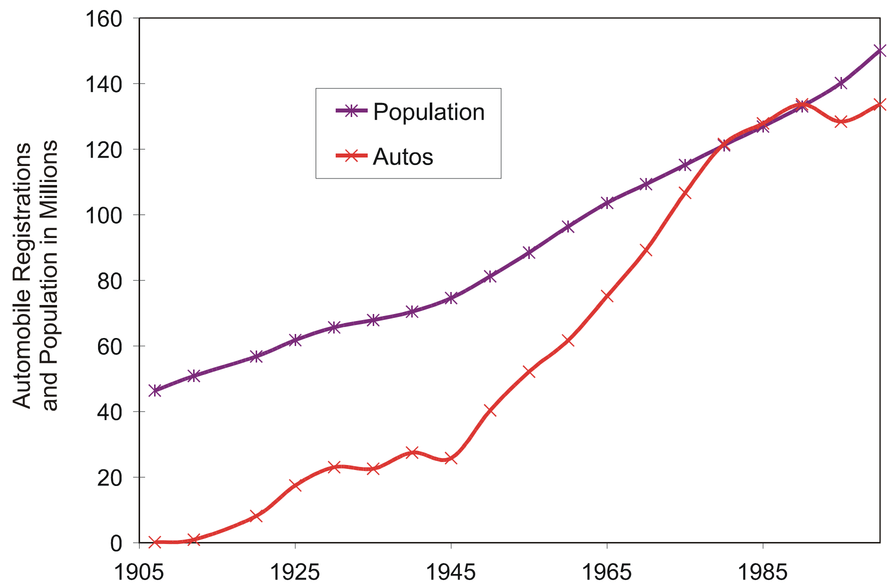
Two examples presented here suggest the difficulty of foreseeing fundamental policy shifts. The first example pertains to modal split for passenger travel, and the second example concerns the general rise in VMT. In short, these challenges pertain to predicting technological and social change—a much more difficult task than predicting population or employment.

Example 1: Historical Changes in Mode Choice

A century of data provides some perspective on forecasting social and technological developments related to transportation. Figure 20 shows national trends in population, light rail ridership, rapid rail ridership, bus ridership, and automobile registrations for almost 100 years in absolute numbers.[89,57,58,59] Looking backward, with the perspective of hindsight, Saltzman suggested that none of the trends is surprising: at the turn of the century and peaking around 1920, for example, streetcar ridership was strong, owing to technological change (electrifying horse railways) and land use change (dispersion of cities). The fact that public transportation ridership was lower in 1935 than in 1930, especially in light of increasing population (and no corresponding increase in automobile registrations), can be explained by an economic change (the Great Depression). Social change (World War II) explains the early 1940s' increase in all public transportation modes, whereas land use and economic changes (increasing incomes and greater dispersion of cities) are cited as reasons for the automobile's dominance thereafter; the less frequently mentioned shift from a 6-day to a 5-day workweek may also have contributed to transit's demise, since transit ridership historically benefited most from the commuter trip.[57] Since the 1970s, automobile ownership has still risen but transit has stopped declining in raw numbers because of several possible reasons including continued population increases, state and federal programs designed to increase public transportation, higher parking costs and congestion costs in some metropolitan areas, and greater environmental concerns.

It can be argued that the large changes in the trends shown in Figure 20 were driven heavily by social, economic, and demographic change as opposed to public policy initiatives only. That is, technological developments, such as innovation in rubber-tired vehicles that enabled the bus to take market share away from the streetcar in the 1920s, had more of an impact than public policy initiatives, such as encouraging the use of transit instead of automobiles in the 1990s.

(There are of course instances where public policy initiatives have had a marked influence, such as the combination of vehicle, roadway, and driver improvements that have decreased automobile passenger fatality rates during the past few decades. Further, public policy and technology are interdependent: it has been noted by some that the construction of the



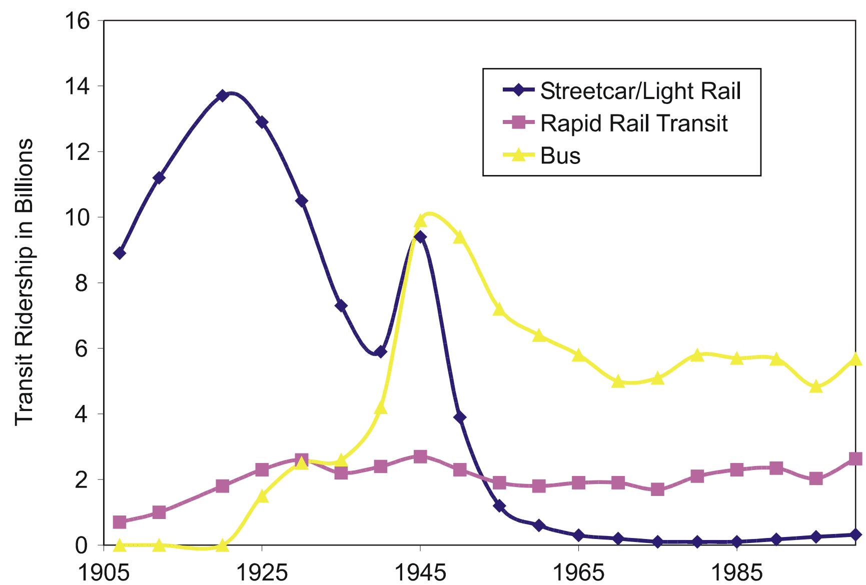


Figure 20. National Changes in Transit Ridership, Population, and Automobile Ownership, 1907-2000

interstate system—a public policy initiative—did much to increase automobile and truck usage. Put another way, the national legislation that enabled funding for the Interstate Highway System ultimately led to marked changes in travel behavior. Thus the preceding paragraph does not negate the importance of public policy initiatives but simply suggests that social and technological forces are indeed quite powerful.)

The resultant challenge is to forecast these changes: looking forward is much more difficult than looking backward. For example, Figure 21 shows the information from Figure 20 normalized to the year 1925 for each of the five trends. If someone in the year 1925 had been

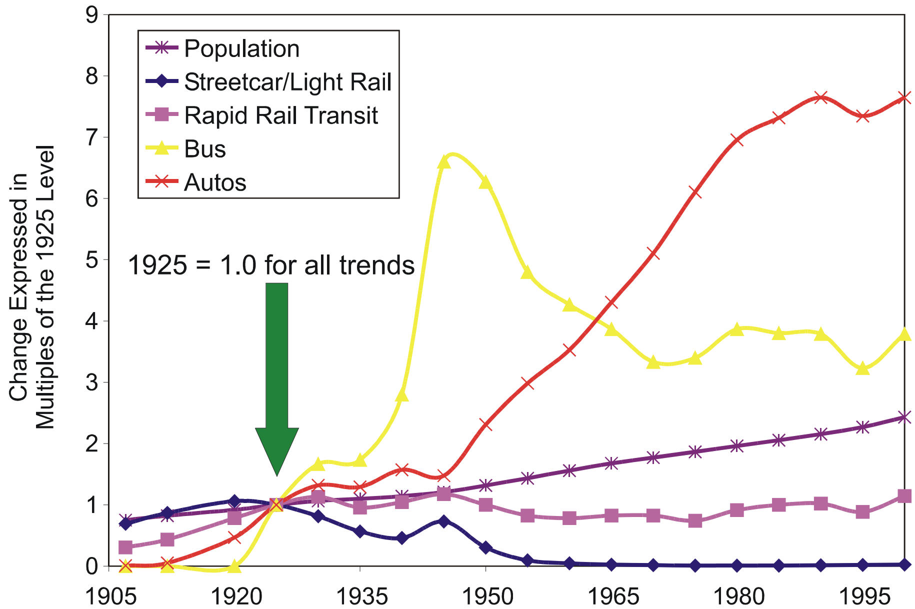


Figure 21. Change in Transit Ridership, Population, and Automobile Ownership Relative to 1925

looking ahead based on previous data, what might he or she have predicted over the next two decades? What trends would a national-level forecaster have identified correctly? What trends might have remained hidden?

With only the historical base from 1907 to 1925 to draw from, the 1925 forecaster probably would have predicted rapid growth in three of the four transportation modes: bus ridership, automobile ownership, and raid rail transit ridership, all outpacing population growth. The forecaster would still have expected population to rise but not as quickly as those three modes. An astute 1925 forecaster possibly would have expected streetcar ridership to drop given that signs of this decline were not crystal clear but could be inferred (e.g., from declining public perception of holding companies and the lack of investment in some cases since 1920), although less knowledgeable forecasters might have thought the drop in streetcar ridership since 1920 was merely an aberration.

Taking these five trends in turn, a good forecaster might likely have called half of them accurately, as shown in Figure 22. By 1950, the forecaster likely would have predicted population just about perfectly, with the past indications of national population trends being a good predictor of the present. High marks would also have been awarded for the bus ridership prediction in 1950: although the forecaster probably could not have foreseen the Great Depression, the dominance of bus over trolley combined with World War II rationing would have provided a respectable estimate of bus ridership, although the forecast would have been a bit lower than the actual value. For the automobile, the high value predicted for 1950 would eventually come true—but not until 1975. The electric trolley ridership prediction might also have been in the right direction but with a not very accurate value, such that the 1950 prediction would have been higher than it should have been. Finally, the rapid rail transit ridership would have proven the most difficult to predict—given the increased urbanization of the United States

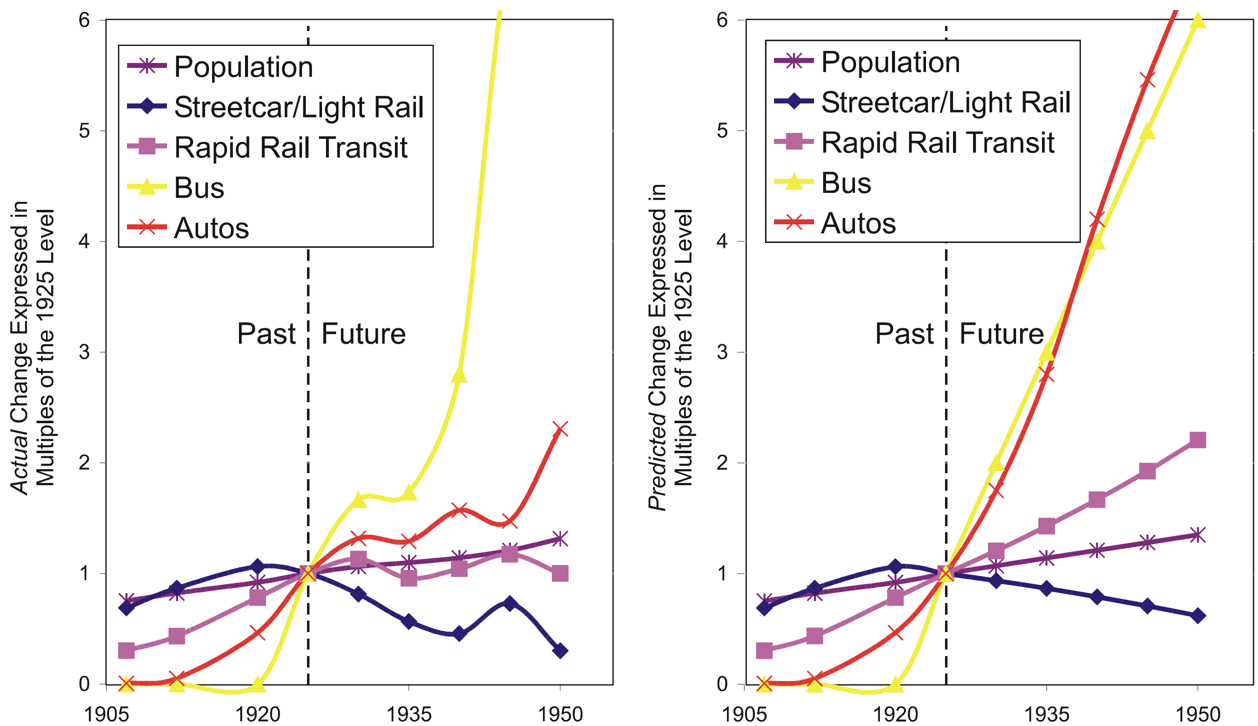


Figure 22. Comparison of Actual and Predicted Changes Assuming a 1925 Base Year

in 1925 combined with rapid rail trends leading up to 1925, growth by 1950 might reasonably have been predicted, not the decline that actually occurred.

In fact, returning to Figure 20, it is difficult to pick any 25-year horizon and be guaranteed a success of predicting all five trends accurately, using only data available up to that point in time, with a possible exception being the period from 1975 to 2000. This problem is exacerbated when unlike the national level estimates in Figure 20, smaller area forecasts must be made for counties or census tracts, where it is much easier to make forecasting errors. Realistically, of course, more complex forecasting models can be developed to keep estimates "in check;" e.g., the number of automobiles can be constrained to a reasonable proportion of the population but knowing in advance shifts such as the rapid rise in automobile ownership starting in 1945 is more difficult.

Looking ahead, how other technologies will develop may be questioned; e.g., will new technologies proceed in an exponential manner as described by wireless usage (see Figure 23a) or will growth be in a more steady, linear manner comparable to that of alternative fueled vehicles (see Figure 23b).[60,61] Perfect knowledge of how such trends will evolve would enable much more accurate assessments of long-term transportation demand.

In sum, several public policy trends were suggested at the beginning of this section, such as increased transportation revenue from nongovernmental sources, an emphasis on transportation operations as opposed to only construction of new infrastructure, and Virginia counties' interest in growth control legislation. The statement that these trends will become more critical by 2025 is reasonable to the extent that unforeseen technological and social

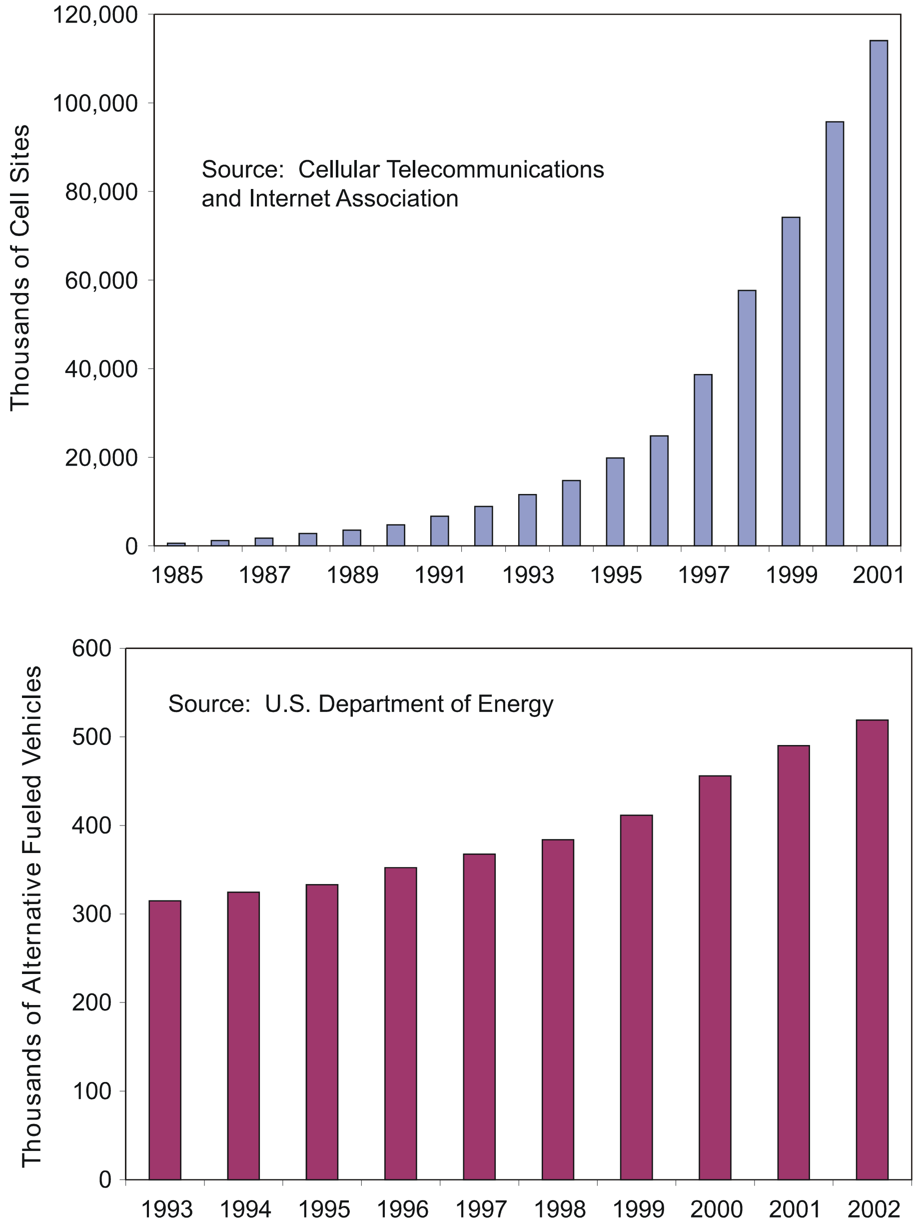


Figure 23. Recent Growth in Number of (a) Cellular Sites and (b) Alternative Fueled Vehicles in the United States

developments do not occur over the next quarter century. Yet the past 100 years suggest that such changes are likely to occur over a relatively long time frame; further, the effects of those changes have historically been more dramatic than the effects of public policy initiatives.

Example 2: Growth in Vehicle Miles Traveled

The BTS in 1997 suggested that the 95% growth in passenger miles from 1970 to 1995 was not explained solely by the 28% increase in population over the same period.[62] Instead, BTS noted that over that period, at least six key events occurred to increase travel:

1. The number of women working outside the home increased by 100%.

2. The number of households increased by 56%.

3. The number of automobiles increased by 79%.

4. Disposable household income increased by 48%.

5. The suburbs gained 17.5 million people whereas central cities lost half a million people.

6. The proportion of jobs in the suburbs rose from 37% to 42%.

BTS forecasts that passenger travel will continue to increase but not as rapidly as before. Reasons given for expecting the rate of increase in transportation demand to slow are that population growth is slowing to about 1% annually, the number of households is stabilizing, vehicle ownership is reaching saturation rather than continuing to increase rapidly, and women's entry into the labor force is matching that of men's. Yet BTS correctly noted several factors that may change travel demand from this picture of stability, including

- continued land use dispersion of residences and jobs
- increases in travel by the low-income population and women
- retirement decisions
- shifts in immigration
- shifts in teleworking.

BTS may be wise to use caution in their forecasts because the outcomes for these factors are not known. For example, it is not clear if the increases will continue, as the literature suggests that technologies alone are not a guarantee of workers choosing to telecommute. Further, if telecommuting does continue or expands, the precise influence on travel is not clear; it has been suggested that telecommuting could make suburban areas geographically greater.[45,48]

Lomax et al. suggested, with some degree of humor but some seriousness as well, that for a few thousand years travel times to work have remained stable. Humans have responded to advances in transportation technology by altering where they choose to live, yielding an average commute of 20 to 30 minutes.[42] The larger lesson is that the human response to travel conditions, whether they are positive or negative, constrains otherwise indefinite trends in passenger and freight travel. An extension of their argument could be that the dynamics of human behavior naturally prevent transportation conditions from becoming too extreme: when travel conditions worsen, people adapt to become less dependent on transportation, but when travel conditions improve, people rely more on transportation to take advantage of the resultant opportunities. Determining whether this theory holds is beyond the scope of this paper, although one can speculate that the lag time of this human response to travel conditions varies by trip purpose, such as being shorter for particular types of freight trips and longer for work-based passenger trips.

FREIGHT TRENDS AFFECTING TRANSPORTATION DEMAND

Freight movement is partly dependent on economic activity outside Virginia; thus, out-of-state shippers can choose to move freight along Virginia routes or other routes that bypass the Commonwealth. In that vein, it is appropriate to view freight transportation as a *source* of transportation demand, on par with population, employment, or federal legislation. This demand for shipping is eventually translated into a modal choice for freight in the form of water, air, rail, or truck. In that latter sense, freight transportation becomes a measure of *transportation usage*, reflected as tons, vehicle miles, or value in dollars moved along Virginia's rail network. Accordingly, the topic of freight may be discussed as a source of travel demand *and* a resultant measure of transportation use.

To understand freight as a source of transportation demand, it is worthwhile to consider three perspectives: the view of the private sector as it makes short- and long-run decisions in light of freight shipping capabilities; freight movement predictions for the multistate freight corridor of which Virginia is a member, and challenges faced by each freight mode. Together, these three perspectives suggest aggregate freight movement demands that will be placed on Virginia's freight transportation system. They do not, however, guarantee a specific mode split for freight.

Perspective of the Private Sector

In principle, passenger and freight transportation users have similar motivations: all other things being equal, both groups will tend to choose the mode that offers the lowest cost. Further, in both the passenger and freight realms, advocacy groups encourage public investment in some form in various transportation modes. Finally, the passenger industry and freight industry are dynamic: the quick response of airlines to using hub networks for passenger transportation following airline deregulation is complemented by logistics suppliers choosing among competing ports for freight transportation. There are, however, at least two theoretical differences in how passenger and freight decisions are made. First, unlike passengers, freight shipments are insensitive to the "quality" of the trip provided the freight is delivered at the right time, in good condition, at the lowest possible price. Second, whereas passenger travel decisions are the result of individual decisions for individual trips, freight decision making is more easily consolidated in the form of a shipper's or carrier's decision. Thus to some degree it can be argued that aggregate economics drives freight travel more so than passenger travel.

As an example, analysis done by AASHTO makes the case for investing in the nation's rail network. AASHTO applied the FHWA's Highway Economic Requirements System (HERS) model to determine the value rail service provides in terms of removing truck traffic from the nation's highways; the authors found that without any freight rail service whatsoever, the cumulative cost of shifting all freight from rail to truck would be $1.943 trillion during the period 2000 to 2020. Conversely, AASHTO makes a case for additional investment in rail to reduce the cost that truck traffic places on the nation's highways: AASHTO suggests that an "aggressive" investment of $83 billion in the rail system would yield over $1 trillion in benefits. Interestingly, direct highway needs are only a small portion of those benefits ($27 billion); the benefits largely accrue to users and shippers in the form of reduced costs ($600 billion and $400 billion, respectively).[63]

Shortened travel times are not necessarily the only or even most important benefit to shippers. For some firms, improved transport facilities would give them "enormous" opportunities to reorganize their freight program in terms of inventory size or location.[64] For those firms, the direct costs of congestion (e.g., longer travel times) are quite small relative to the opportunity costs of not being able to have a more efficient inventory structure.[64] The literature cites examples where firms have reduced operating costs as a result of better freight capabilities; e.g., Dell Computer "estimates that they save $30 per monitor by virtually eliminating inventory" as a result of their just-in-time approach.[65] A precedent exists for businesses to change their distribution procedures significantly beyond merely shortening inventory: Ford Motor Company, for example, *increased* the amount of freight they ship by rail by using a "mixing centers" concept where Ford purchased properties ranging from 300 to 700 acres; Ford then uses the centers to maximize "trainload and truckload" vehicle movements (from manufacturing plants to the centers and then from centers to dealers). The Ford example is noteworthy because, as described by the authors, a lower priced mode (rail) was used more efficiently (through the use of the mixing centers) to reduce time and costs.[65]

It is a trite, often-repeated, and true statement that transportation and land use are related, with each affecting the other, and complicated diagrams with bi-directional arrows such as those in Figure 2 are common. An equally important but lesser known example, however, is offered by Burnson: good transportation infrastructure can attract carriers and logistics companies who are looking to situate warehousing, transportation, or distribution facilities.[66] Interestingly, the perspectives offered by public and private sector interests quoted by Burnson as to what constitutes good transportation infrastructure include both physical facilities and services: adequate air cargo terminal space, a large number of well-maintained public roads, deepwater ports, rail services, and complete customs services that allow international goods to move quickly. Certainly other factors such as taxes and an educated workforce are also determinants in the location decision, but transportation capabilities have helped to attract companies. These private perspectives are relevant because they indicate that the quality of the transportation system can influence whether additional freight users locate to Virginia, which in turn affects freight demand and in turn affects the quality of the transportation system.

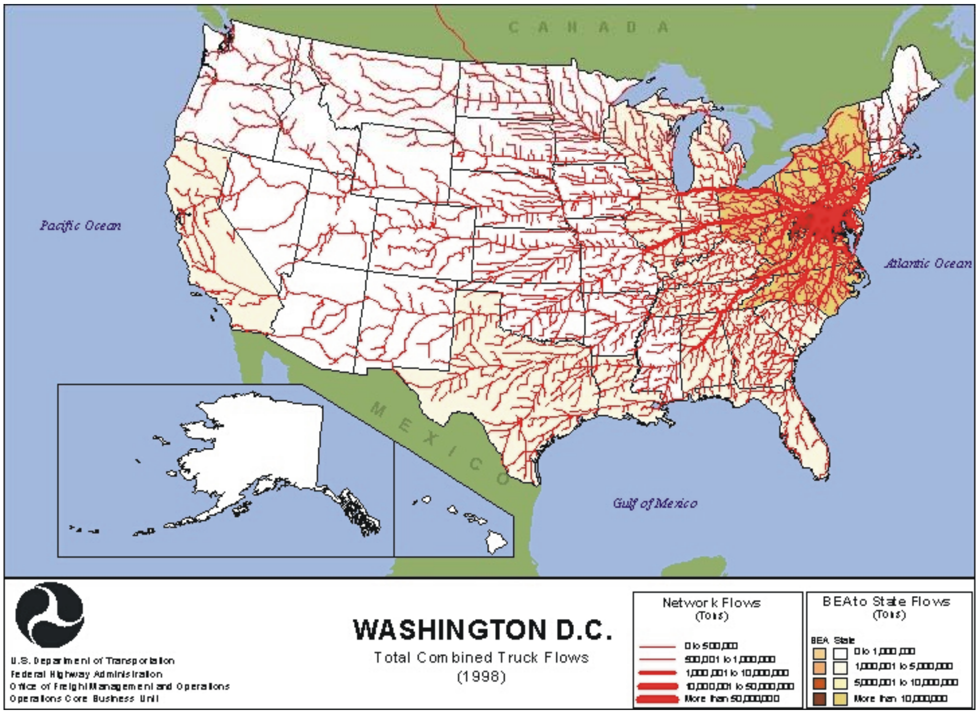
In sum, the literature suggests that significant benefits are accrued by freight shippers and carriers when freight transportation capabilities are enhanced. Certainly, as is the case with passenger transport, freight users benefit from shorter travel times. Yet two additional perspectives held by shippers are also relevant and in some cases may be more important than simply reducing travel times. First, if travel can at least be reliably predicted (even if congestion is not eliminated), then shippers or carriers can reduce inventory costs by maintaining the most efficient inventory and warehousing structure that the transportation system will allow without having to maintain a hedge inventory to account for travel time variability. Second, logistics suppliers' decision as to where to locate their facilities is based in part on the quality of the freight transportation system. Notably, the FAF indicates that shippers assign a value of $25 to $200 per hour of increased travel time and the cost of unexpected delay "for trucks is another 50% to 250% higher."[67]

Freight Movement Forecasts for the U.S. Southern Region

Mason noted that three factors—dispersion of the work force, importance of just-in-time delivery, and economic growth—will increase freight shipments such that the number of trucks will double on U.S. roadways and potentially quadruple in some metropolitan areas over the next 10-years.[68] According to FHWA's FAF, U.S. intermodal freight volumes are expected to double over the next two decades.[69] Both sources clearly suggest that freight movements will increase at a faster rate than population growth over the same period.

AASHTO forecasts that between 2000 and 2020, freight tonnage in the 16-state southern region of the United States, which includes Virginia, West Virginia, and Maryland, should grow by 71%.[63] Baseline forecasts for the northeast/southeast corridor mean that in Virginia, most of I-81 and I-95 will be operating at level of service F by 2020; this assumes a baseline case where rail maintains its market share and the highway network in place in 1998 remains in place in 2020.[63,67] Under this scenario, rail traffic (dominated by lumber, paper products, and clay) would occupy 26% of tonnage and ton-miles; the remaining 74% of tonnage and ton-miles would be by truck. Without additional investment in capacity in rail, rail would lose market share such that rail fright dropped by 45% and truck traffic increased by 4 billion VMT in 2020.

Figure 24 shows existing truck movements for Washington, D.C., and water transportation for Virginia; the two figures combined show that Virginia not only acts as a significant freight origin and destination but also accommodates a significant amount of through traffic, especially on its I-95, I-81, and I-85 corridors, and through the Port of Hampton Roads activity. With freight tonnage expected to grow by 71% in the southern region versus 58% in the northeast region from 2000 to 2020, the implications are that the Virginia corridors will see substantial increases in freight demand over the next two decades and this increase will be at a rate higher than that of population.[63] (It should be noted that an FHWA representative pointed out that NAFTA movements are indeed included in the FAF, but for the I-81 corridor, these are not the primary source of freight.[7])



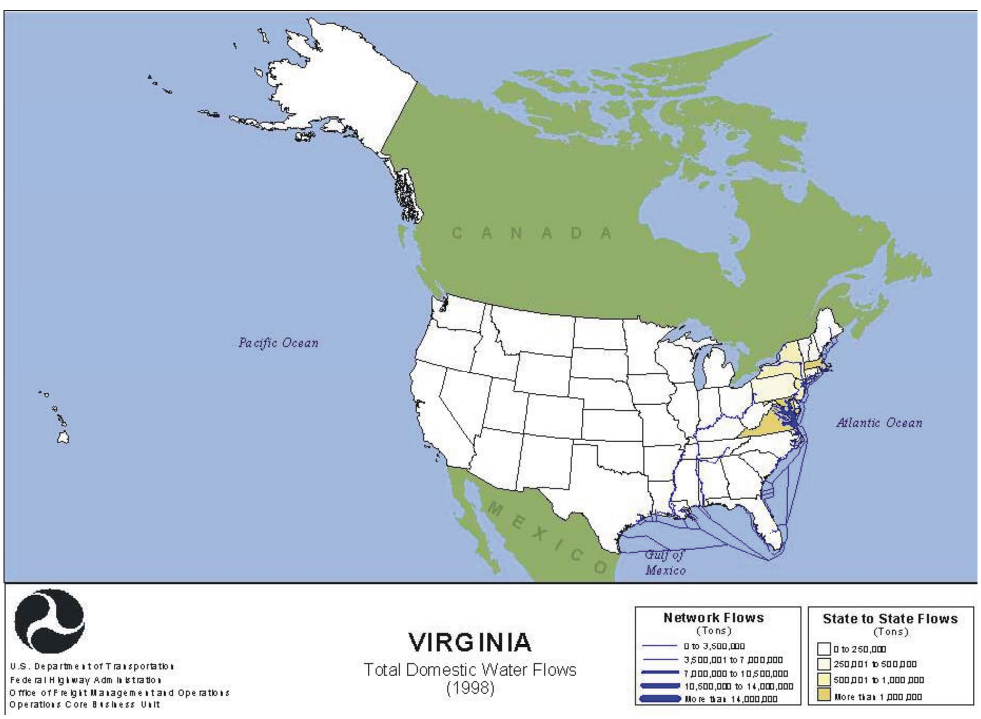


Figure 24. Freight Truck and Water Activity, Courtesy Freight Analysis Project, 1998

Challenges for Each Freight Mode

The literature also points out that the obstacles faced by each mode of freight are different.[63] Thus the extent to which a given mode will win market share over another mode is dependent on overcoming these obstacles. That is, whether most of the 71% freight tonnage increase cited for the southern region of the United States is carried by rail, truck, air, or water is dependent on the efficiency and cost of these modes, which in turn depends on transportation providers' ability to resolve problems that will be faced over the next two decades.

Modal-Specific Obstacles

- *Air freight* is typically not constrained by airside congestion since air cargo flights operate at off-peak periods; however, air freight is limited by two key factors: the ability of air cargo hubs to maintain warehouse space (since airports are located in congested areas where land is limited) and the ability of trucks to access the airports because of heavy congestion. Because air freight tends to be high-value time-sensitive goods, unexpected congestion at the landside can be an acute problem.

- *Oceangoing water freight*, as is the case with air freight, is also adversely affected by the two problems of limited land area for terminal operations and landside (road) congestion; an additional problem for water transportation is the need to dredge channels to 50 feet or more to accommodate larger container ships.

- *Rail freight*, on the other hand, is hampered by not only difficulties at the intermodal transfer point but also within-mode limitations, such as bridges that cannot accommodate heavier cars, low-ceiling tunnels that prevent double stacking, a need to share track and coordinate signal systems with passenger service, a single line track, and at-grade rail crossings. For example, a representative of the American Short Line and Regional Railroad Association noted that more than one quarter of all rail carloads originate or terminate on a regional or short line that needs improvements to accommodate heavier carloads that are common on the larger lines.[70] Kupferman, summarizing surveys of large city operations engineers, further noted that although the Transportation Equity Act for the 21st Century (TEA-21) addresses freight intermodal connections for interstates and arterials, more attention needs to be paid to roadways that provide access to rail yards.[71]

- *Highway freight* is hampered primarily by within-mode limitations, notably, a rapid rise in traffic volumes that has not been matched by an increase in highway capacity or efficiency.[63]

Obstacles Common to All Modes

Thus although it is possible to add up freight demand, it should not always be assumed that mode shares will remain unchanged when capacity is exceeded or when performance is degraded. For example, a 2001 study performed by Old Dominion University for the Virginia Port Authority suggested that containerized cargo will grow by 4.3% annually, which by itself could be used to forecast roughly growth in rail and truck traffic since about 75% of container cargo is shipped by truck. Yet the capacity of the port is physically constrained by the current size of its terminals; e.g., the study pointed out that unless the port made planned expansions, such as the creation of a new terminal on Craney Island, the port would be at capacity in 2010.[78] The announcement by the Maersk Sealand Shipping Line to build a new marine terminal at Portsmouth will help extend the port's capacity such that growth can be accommodated at least until 2015 or 2017, at which point the Craney Island Terminal will be needed in order to avoid losing shipping lines that use the port.[72] Similarly the amount of freight that moves by rail or truck throughout the United States is dependent on the extent to which rail improvements are made.[63] Thus although cargo needs will increase and although there are some general tendencies such as growth in truck's market share, the extent to which goods will be shipped by different modes will depend on the reliability and travel times for the various modes.

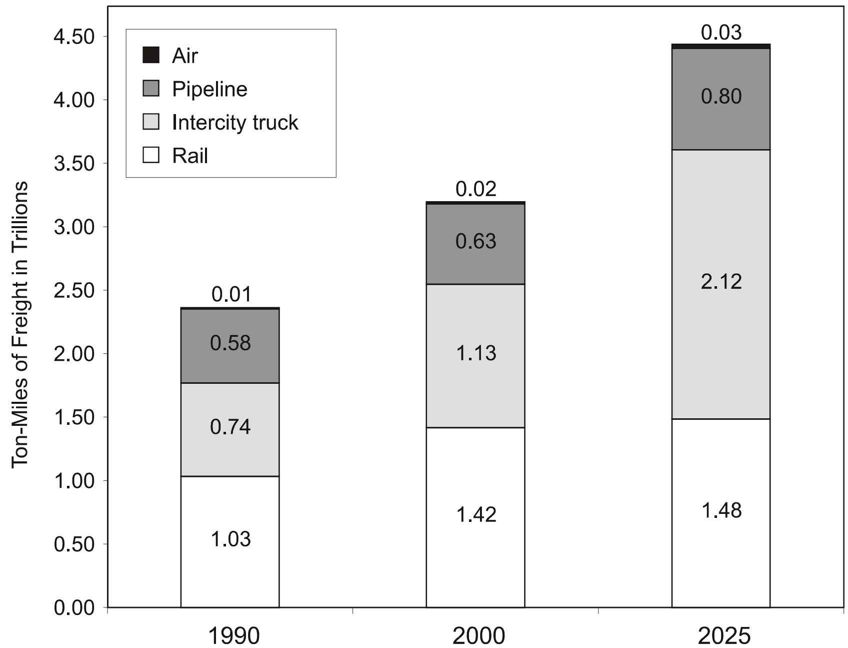
MEASURES OF TRANSPORTATION USE

Measures of transportation use have historically been presented within the context of freight movement and passenger travel. For the former, common indicators are tons of freight, ton-miles of freight, and value of freight moved by air, water, rail, and truck. For the latter, indicators such as automobile ownership, VMT, and the number of trips by passenger mode (pedestrian, bicycle, bus, rail, carpool, and automobile) give a snapshot of transportation system usage.

Freight Movements

The quantity of freight shipped has grown for most modes from 1980 to 2000, and this growth is expected to continue through 2025. The market share of each freight mode, however, has grown at different rates. Modes that that emphasize reliability and speed of travel as opposed to lower pricing have shown the most growth recently and are projected to grow the most through 2025. Since 1980, the mode growing by the largest percentage on a national scale has been air freight, with a 200% increase in ton-miles. Air freight is followed by intercity truck (an increase in ton-miles nationally of over 100%) and rail (a 60% increase in ton-miles).[73] The amount of freight shipped by water dropped about 30% during the same period.

Figure 25a compares ton-miles of freight in the United States using 1990 actual values, 2000 estimated values, and 2025 forecasts according to unpublished BTS sources. Although all modes shown in Figure 25a are expected to grow over the next 25 years, the largest gainer of ton-miles of freight in absolute terms is forecast to be intercity truck, growing from 35% of total freight ton-miles in 2000 to about 48% of total freight ton-miles in 2025.[33] In contrast, rail's share is projected to drop from 44% of the 2000 ton-miles to 33% of the 2025 ton-miles. (Water movements are not shown therein as they have a different unit of measure; the BTS forecasts 3.4 billion tons of domestic and foreign freight moving through the United States, up from a 2000 estimate of 2.5 billion tons.)



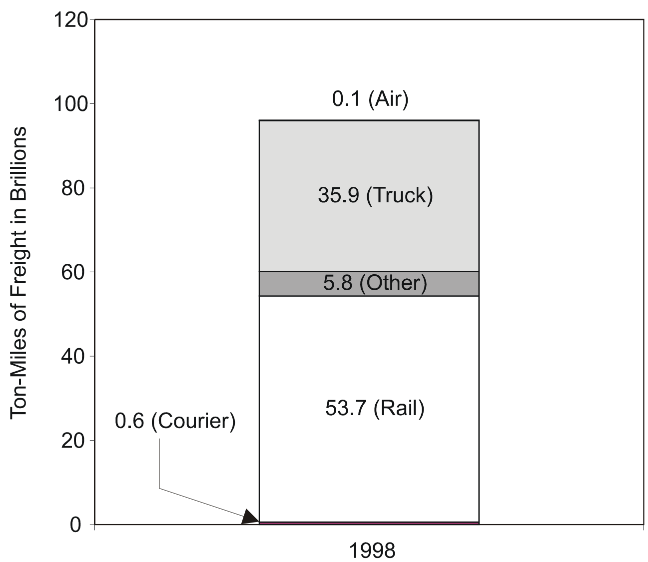


Figure 25. (a) National Freight Forecasts and (b) Current Freight Originating and/or Terminating in Virginia. "Courier" includes parcel and U.S. Postal Service. "Other" includes the following categories defined by the CFS: "multiple modes," "other and unknown modes," and "truck and rail." Figure 25b does not include freight that moves entirely through Virginia without an origin or destination therein.

The 1997 CFS provides specific information for current freight flows by mode and distance. Unfortunately, this data source by itself has weaknesses; those most relevant to this effort are that the 1997 CFS does not provide freight flows moving through Virginia and it provides *some*, but not complete, limited data on freight entering Virginia.[74] It is thus not useful for gaining absolute numbers, but, in concert with other data sources, it may provide insight into freight trends. Figure 25b shows shipments originating and terminating in Virginia in terms of ton-miles, tonnage, and value according to the 1997 CFS. (These data were extracted from CFS State Table 13, which provides flows by mode and by state; the total values obtained from the electronic database were checked against the 1997 Economic Census produced by BTS in order to reduce the odds of data entry error.[3,75])

The CFS shows that for shipments originating and terminating in Virginia, more than half of the 108 billion ton-miles of freight was shipped by rail.[75] The single-mode shipments graphed in Figure 24 account for most of the ton-miles shipped by the state; another 6 billion ton-miles were shipped by a combination of modes, such as rail and water. One reason for air cargo not being as small as it may seem is the sheer volume of freight that even a small portion of the market represents. For example, Dulles International Airport accommodates 10 billion pounds of air cargo annually.[76] Although the CFS does not include freight that moves entirely through Virginia (e.g., freight that has an origin and destination elsewhere) it is apparent that market shares by mode in Virginia in 1998 are similar to national trends in 2000.

Figure 26 compares total freight movements for 1998 with those predicted for 2020 in Virginia according to the U.S. DOT's FAF. Unlike the CFS data shown in Figure 25b, the data shown in Figure 26 are based on a variety of data sources in addition to the CFS. As is the case with national data, most of the market share in terms of value and tons is expected to be held by the highway mode, although air cargo should have an increasing portion of freight by value as compared to 2000. In fact, air and rail are quite comparable at present in terms of value of freight shipped, with air already ahead of rail at present and growing faster than rail between now and 2020. Further, FHWA pointed out that the largest commodity by value in 2020 will be what the BTS defines as "secondary traffic," which is freight that moves to and from "distribution centers or through intermodal facilities."[77]

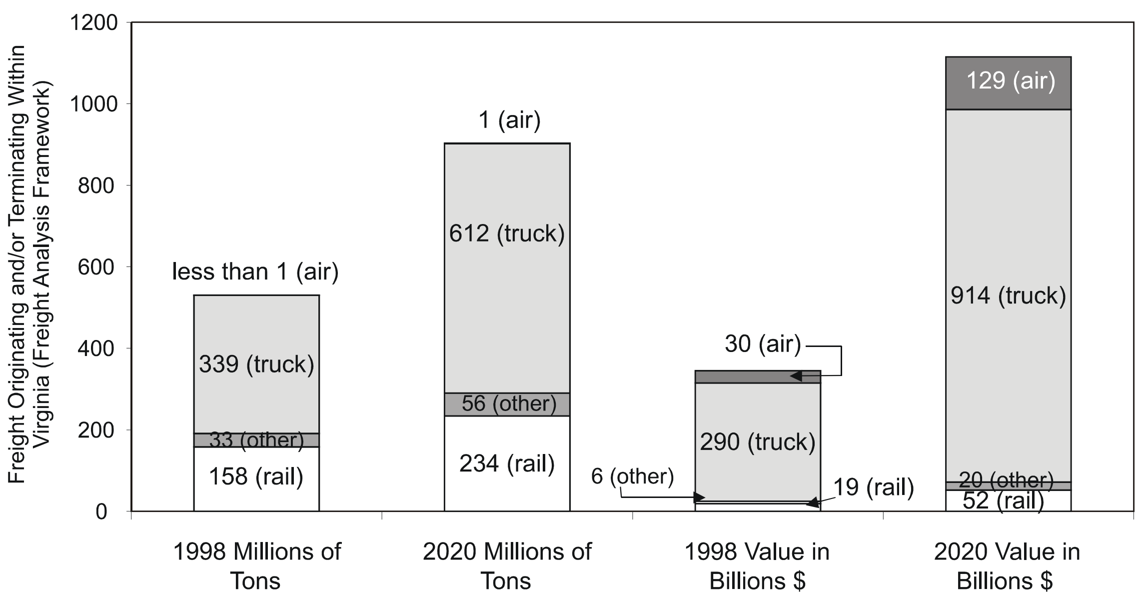


Figure 26. 2020 Virginia Forecasts for Freight Movements by Mode (U.S. DOT Freight Analysis Framework). Figure 26 does not include freight that moves entirely through Virginia without an origin or destination therein. "Other" includes water, pipeline, and shipments that moved by an unspecified mode.

Virginia Port Trends

The Port of Hampton Roads includes terminals in Norfolk, Newport News, and Portsmouth, and the total tons of freight handled by the Port of Hampton Roads dropped from approximately 73 million tons in 1991 to about 55 million tons in 1999.[78] This total reflects two types of cargo that are handled by the port: bulk cargo (e.g., coal, all of which is shipped by rail to the port) and general cargo (e.g., television sets, most of which are containerized.) As shown in Figure 27, this drop was due to a decline in coal shipments, whereas containerized cargo has

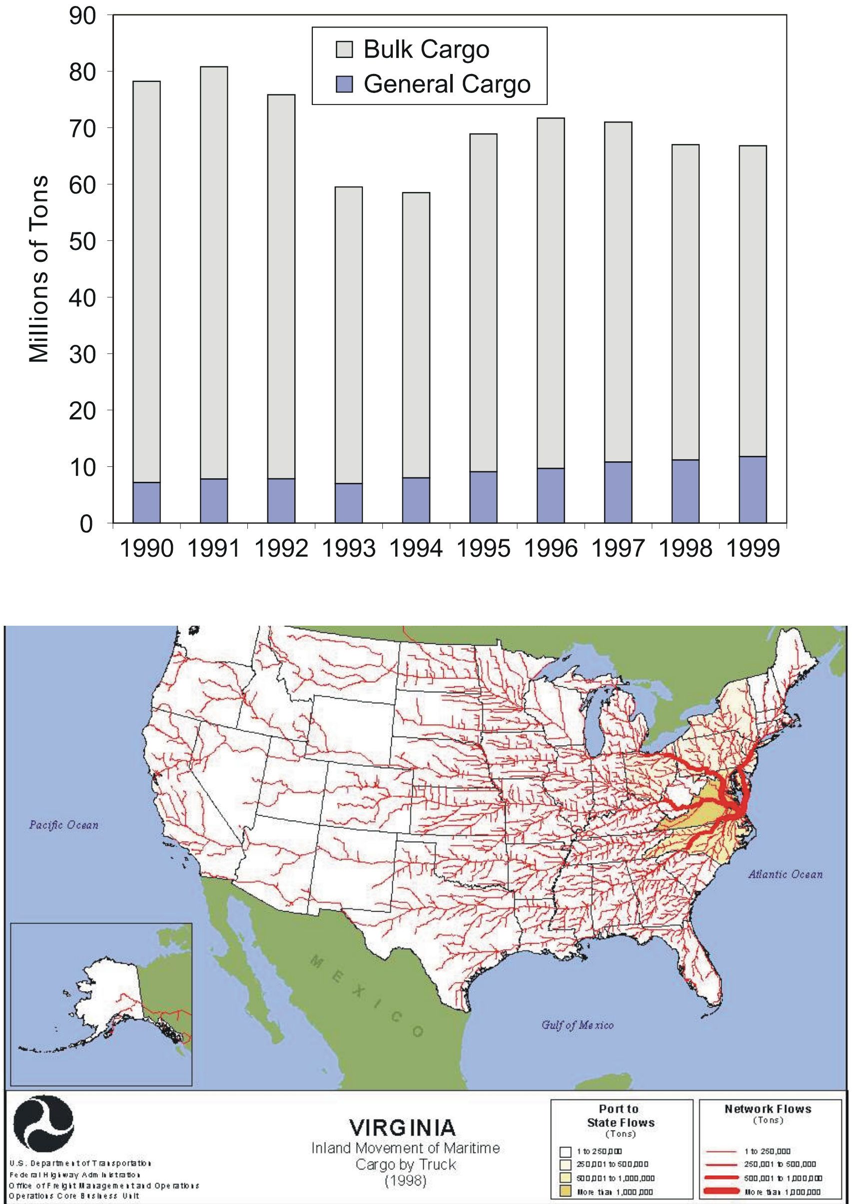


Figure 27. Port of Hampton Roads and (a) Cargo Shipments and (b) Truck Freight Shipments. Figure 27a redrawn from data provided by Old Dominion University; Figure 27b is courtesy of the U.S. Department of Transportation.

been increasing. During the same period, port-related employment grew from approximately 14,500 to 27,500 jobs, mostly because of the increase in containerized cargo.[78] This makes the port's forecast annual containerized growth of 4.3% all the more relevant to the task of predicting port-based freight flows. At present, more than 1 million tons of freight cargo is shipped by truck from the port to the neighboring states of West Virginia, North Carolina, Maryland, and Pennsylvania as shown in Figure 26, and Old Dominion University reports that 75% of the container freight shipped through the port arrive via truck.[78] The growth in these time-sensitive shipments is important because it suggests, in the absence of investments in rail, a greater share of freight may be shipped by truck as opposed to rail in the future.

Air Cargo Trends

Within the United States as a whole, air cargo (measured as revenue ton-miles) is expected to grow an average of 4.3% annually between 2001 and 2021, with slightly higher growth during the first 10 years of that period.[79] Variation in this growth rate over the forecast horizon is noted, however, with a low rate of 3.4% and a high rate of 5.3% suggested. Variation within key markets is also noted; e.g., air cargo shipments between the United States and Canada are expected to average 7.1% annually, with the low-high forecast range being 3.8% to 8.9%.[79] These rates are reasonable given the projected Virginia air cargo tonnage growth shown in Figure 28, and the range encompasses the estimate published by the Federal Aviation Administration of domestic air freight increases averaging 4.9%, in terms of route ton-miles, over that period.[80] (Generally freight includes express and charter shipments but does not include mail; thus air freight is a subset of air cargo.[79])

Growth in trucking is expected to accompany growth in air cargo, partly because of a trend where "truck flights" are used in place of air flights, a trend that has resulted from the use of "fewer widebody aircraft" for domestic passenger flights, which in turn decreases air cargo capacity.[79] Another reason for growth in trucking relates to the increased use of "time definite delivery" where shippers continue to face high inventory costs and can reduce expenses by arranging for shipment to be within a certain period of time, regardless of mode.[81] Taking advantage of the facts that more than half of all shipments in the United States travel less than 700 miles, demand is growing for 2-day service, and it is cheaper to ship goods by truck than by plane, carriers are using the most efficient mode to provide service at a lower cost.

Table 8 shows the top 10 commodities that will comprise tons of air cargo originating and terminating in Virginia in 2020 according to the FHWA's FAF. The commodities account for at least 97% of all air cargo for 2020.[82] Table 8 suggests two trends: mail is the predominant commodity by air and is expected to grow; doubling and tripling of growth are not uncommon across most of the commodities shown.

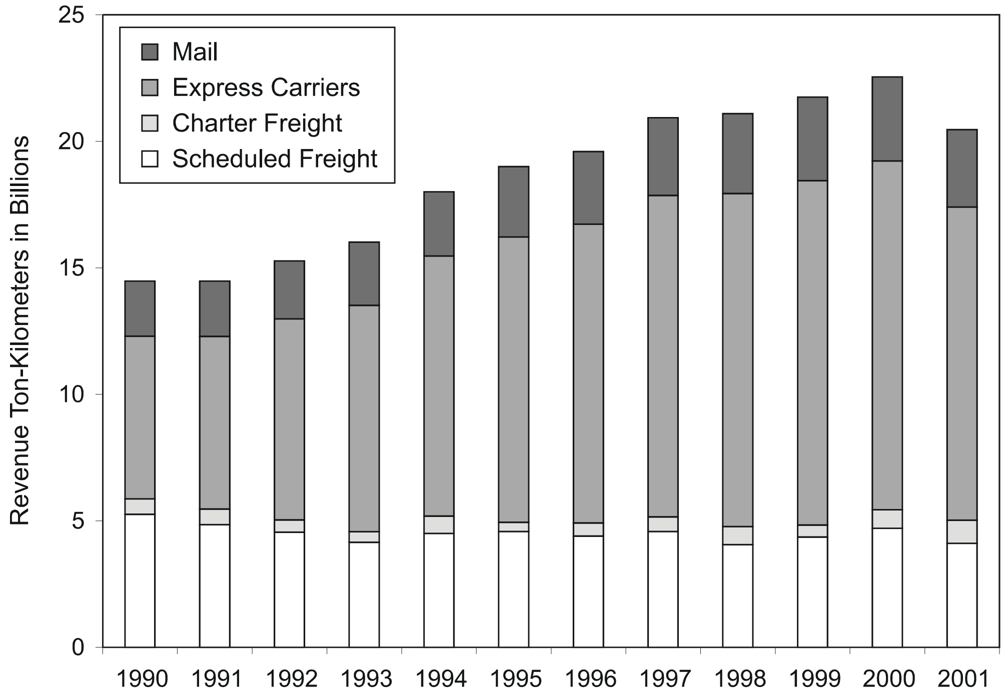


Figure 28. Air Cargo Breakdowns for U.S. Domestic Airlines

Table 8. Top Ten Virginia Commodities Shipped by Air, 1998 and 2020 (Freight Analysis Framework)

Freight Originating in Virginia	1998	2020	Freight Terminating in Virginia	1998	2020
Mail	109	393	Mail	90	340
Machinery Excluding Electrical	17	67	Machinery Excluding Electrical	20	50
Electrical Machinery, Equipment, and Supplies	8	15	Freight All Kind	20	49
Transportation Equipment	9	15	Electrical Machinery, Equipment, and Supplies	13	30
Instr/Optical/Watches/Clocks	3	7	Transportation Equipment	12	19
Fabricated Metal	3	6	Printed Matter	9	18
Printed Matter	3	6	Chemicals/Allied	9	16
Chemicals/Allied	2	4	Apparel	3	12
Clay/Concrete/Glass/Stone	2	4	Instr/Optical/Watches/Clocks	5	11
Farm	2	2	Fabricated Metal	5	8
Miscellaneous Manufacturing	1	2	Rubber/Plastics	4	7
Pulp/Paper/Allied	1	2	Pulp/Paper/Allied	4	6

An interpretation of Table 8 is that the reliance of air cargo on mail will increase: in 1998, mail accounted for 55% of the air cargo market, whereas in 2020 mail will account for 68% of the air cargo market. In comparison, the modes of highway, water, and rail (where rail data are available) are not as dependent on a single commodity for growth.

The high reliance on mail in 2020 might initially appear spurious, given the continued growth in Internet traffic. Boeing's *World Air Cargo Forecast: 2002-2003*, however, does not rule out the growth in mail traffic.[79] The forecast does acknowledge that ". . . the Internet and e-mail are siphoning off this high-yielding [express]air cargo traffic" but also forecasts worldwide mail route-ton-kilometers to increase by 3% annually through 2021, noting that some items such as "legal documents do not lend themselves to electronic transmission." Compared to the forecast's worldwide airfreight growth rate of 6.3%, therefore, mail will grow more slowly, but growth is still expected.[79] Data for U.S. domestic airlines show that through 2001, mail has been approximately 15% of U.S. air cargo in terms of ton-kilometers, whereas express carriers (defined as a carrier with a time-sensitive component) now occupies a greater market share of air cargo than it did a decade ago.[79] (Data for 2001 are labeled as "preliminary" according to Boeing.)

The Shipping Distance at Which Truck, Rail, and Air Become Profitable

Freight transportation is market driven, and the mode selected is generally a function of cost, travel time, travel distance, and reliability. Historically, for example, rail has proven more cost-effective than truck at longer distances, with the threshold being nominally cited as 400 to 500 miles. (That is, goods that can be placed in an intermodal container, such as manufacturing tools or refrigerated foods, can plausibly be shipped by intermodal train when the distance exceeds that threshold; for shorter distances, truck will usually be preferable.) This value of 400 to 500 miles, however, is affected by the economic conditions, congestion, timeliness of the commodity, weight of the commodity, and the corridor itself.[63] Thus the distance at which a given mode becomes competitive is of course different for each mode.

For shipments *originating* in Virginia, Figure 29 shows the distribution by value and trip length for each mode, with the proportion of the total value of freight shipped for each mode within a given trip length bin. For example, about 37% of all freight shipped by truck is within the 0 to 99 mile trip length range whereas 5% of truck freight is shipped within the range of 1,500 miles or more. An interpretation of Figure 29 is that whereas the trucking mode sees a lot of its value in the lower ranges (trip lengths under 250 miles), rail sees its comparable "bulge" in the trip length of 250 to 750 miles, whereas more than half of the total value of air freight occurs with trips longer than 1,500 miles. (It should also be noted that about 9% of the value for all three modes occurred within the 500 to 750 mile range; this means that in the 250 to 500 mile range, both rail and air have incentives to be competitive given that a significant portion of their market occurs with those trip lengths.)[75]

Figure 29 represents only a portion of the total freight moving in Virginia. Figure 30 compares the sample sizes for the freight movements shown in Figures 25b, 26, and 29. The FHWA's Freight Analysis Framework (FAF) shows that in 1998, almost $350 billion in freight originated or terminated within Virginia, and these data were used to create Figure 26. Modal breakdowns by ton-miles, however, are available not from the FAF but rather from the CFS, which is based on the smaller set of data used to create Figure 25b. The freight characteristics based on the smallest sample size are the trip length distributions shown in Figure 29 since those are based only on freight originating in Virginia. In sum, the inferences drawn herein for trip length and ton-miles in Virginia are tentative because some of them do rely on incomplete samples; however, these samples are roughly one third of all freight by value.

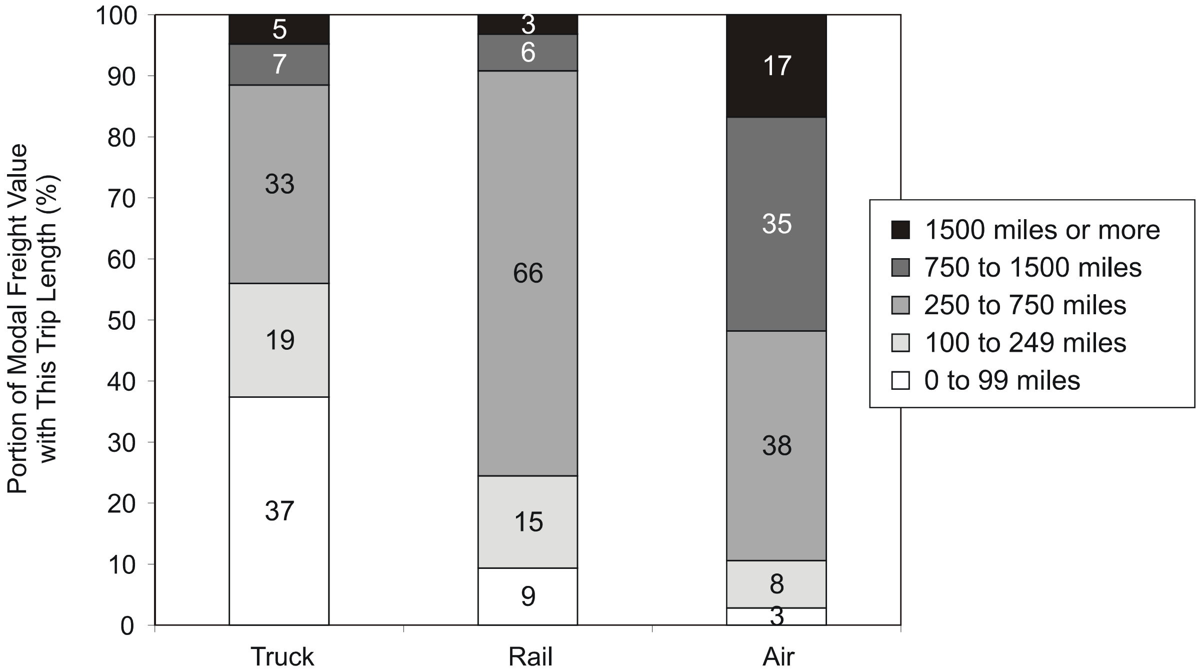


Figure 29. Freight Shipments Originating in Virginia by Value

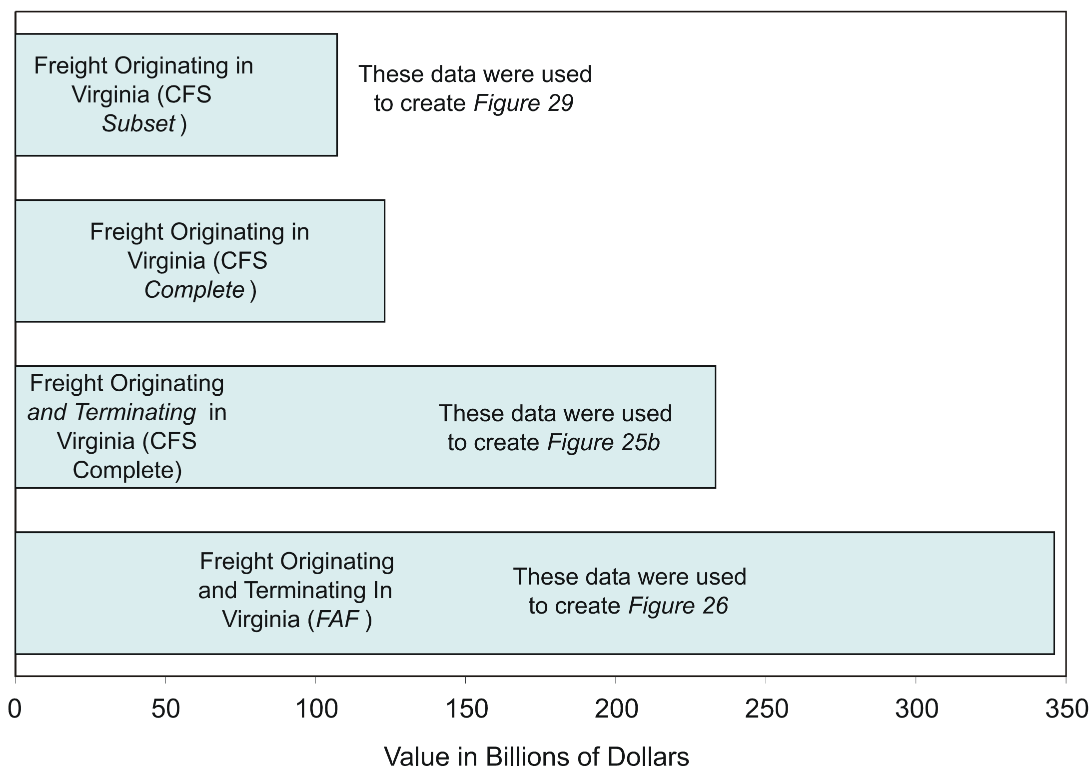


Figure 30. Sample Sizes of Freight Represented in Various Freight Figures 25b, 26, and 29

Figures 25b, 26, 29, and 30 do not include freight moving through Virginia without an origination or termination point within the Commonwealth. As shown in Figure 31, the FAF does, however, report limited information on these through movements for trucks. According to the FAF, the proportion of truck traffic moving entirely through Virginia (26%) is roughly equal to the amount originating, terminating, or remaining within Virginia (24%). The remaining 50% of Virginia's truck traffic is not classified in either category: the FAF could not identify it "with a route specific origin or destination."[77]

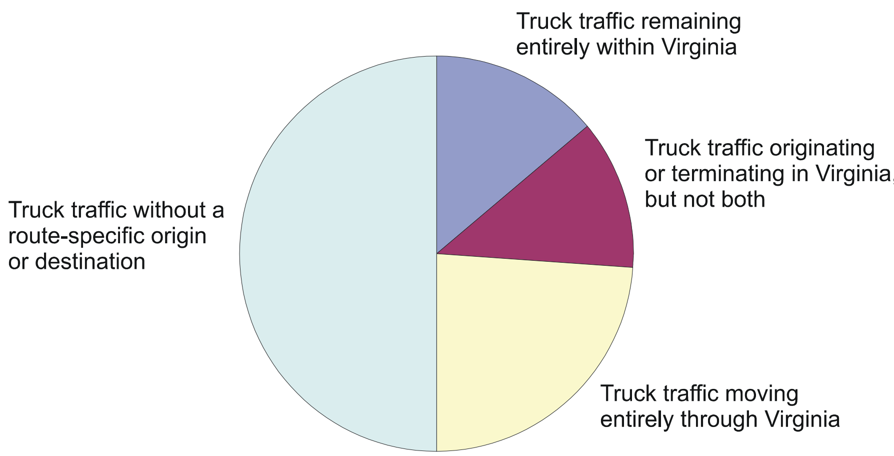


Figure 31. Breakdown of Virginia Truck Traffic According to Freight Analysis Framework

The graphical comparison of the 1999 Virginia freight flows for truck and rail in Figure 32a shows that both modes have substantial nationwide activity; further, long-haul truck trips are commonplace, including along the western route to California, as shown in Figure 32b.[83] A comparison of the figures is also useful because it shows the potential for rail to capture some of the longer haul trucking trips above 500 miles if, and only if, rail could offer adequate reliability and speed of travel for the commodity being shipped.

Summary of Freight Trends

In sum, six freight trends are apparent.

1. *Freight shipments for all modes are expected to increase over the next two decades, with percentage cargo increases outpacing percentage population increases.* In the northeast-southeast corridor, total freight flows are forecast to reach 37 million tons by 2020; 74% of this tonnage will be by rail, and 26% will be by truck.[63]

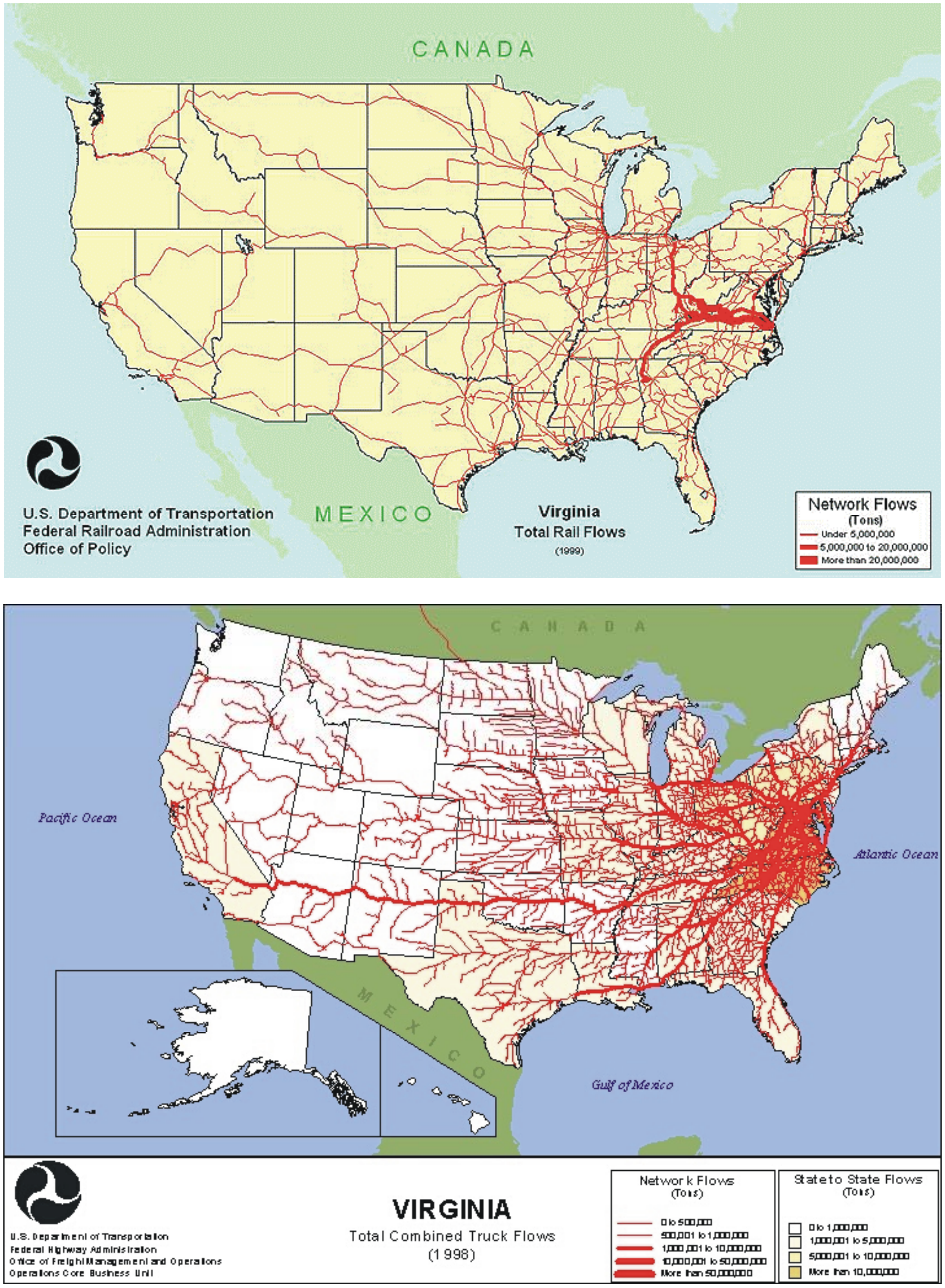


Figure 32. Virginia Freight Activity by (a) Rail and (b) Truck. Courtesy of the U.S. Department of Transportation, 1999.

2. *Unless there is a change in the transportation environment, a greater proportion of freight will be shipped via truck instead of rail in terms of ton-miles moved, although both modes should see increases in the absolute number of ton-miles moved.* The proportion of Virginia's truck traffic known to remain entirely within the Commonwealth (14%) is approximately equal to the proportion known to have exactly one origin or destination within the Commonwealth (12%).

3. *Air freight will increase.* Although it remains a small proportion of total freight movements in terms of ton-miles or tonnage, it is on a par with rail at present in terms of value and that value is expected to increase over the next two decades.

4. *Problems with one mode—truck traffic congestion—affect all three non-highway freight modes (air, water, and rail) because these modes often rely on truck traffic at the intermodal transfer point; in fact, air freight capacity is limited solely by truck traffic congestion or landside capacity.* Thus a strong intermodal case can be made to improve truck traffic at least to accommodate these transfers.

5. *A strong intermodal case can also be made to invest in rail capacity in order to shift additional long-haul traffic from truck to rail;* investments will be needed just to maintain the existing market share of rail, but the literature suggests that benefits will exceed the costs if rail capacity is increased. Note that most of these benefits are in the form of reduced user or shipper costs.

6. *The conventional wisdom with respect to freight movements has been that as distance increases to some threshold in the vicinity of 500 miles, it becomes profitable to ship at least some freight by rail as opposed to truck. As shown in Figure 31, however, this threshold is not fixed: clearly there are very long truck trips.* Although air freight occupies increasing market shares in terms of value at longer distances, air freight still occupies a small portion of the market in terms of tonnage.

Finally, it is plausible that given the increasing role of just-in-time delivery, shippers will increasingly need to forecast with accuracy the time required to move goods. If this statement holds true, then shippers will need either (1) accurate travel forecasts or (2) extra inventory as a cushion for instances when materials shipments take longer than expected. Given this tradeoff, the implication is that accurate travel forecasting methods shown as Option 1 could decrease inventory costs compared to Option 2. Ideally, this information could enable shippers to choose the most cost-effective mode of transportation. The question is whether there is any role or need for the public sector to provide some assistance with travel forecasting.

Passenger Travel

Automobile travel has risen consistently over the past 50 years, as shown in Figure 33. The number of occupants per automobile, the distance vehicles are driven, and the number of trips made by mode are at present primary indicators of passenger surface travel in the United

States. Factors affecting mode choice for passenger travel are generalized to be cost and travel time; however, other factors can become important in particular circumstances.

Automobile Use

Virginia data from the Virginia Department of Motor Vehicles (DMV) graphed in Figure 33a show that for the 1990s, growth in VMT was moderately higher than growth in registered vehicles and that both were substantially higher than annual growth in the number of licensed drivers.[84] This decade of data is reflective of a longer term trend since the 1970s in the sense that over time, VMT or registered vehicles have generally risen faster than population; however, Figure 33b shows that starting around 1980, VMT growth began to outstrip growth in vehicle registrations.[85,86] (For the sake of year-by-year consistency, data from the DMV were used. For data through 2001, the last year of DMV data that were used for this analysis, DMV has estimated VMT using gasoline consumption, in that report DMV indicated that 2002 and future data would show VMT based on traffic counts.

VDOT's Transportation & Mobility Planning Division projects VMT for Virginia.[87] Three caveats to these projections are that (1) VMT from facilities that are functionally classified as local roads are not included, (2) the future projected traffic volumes are based on historical traffic trends, and (3) VMT computations are thus based on future projected traffic volumes using existing facilities and thus do not include new facilities to be built. Statewide VMT is projected to increase by 68% from 2000 to 2025. By planning district, VMT growth over that 25-year period ranges from 43% (Cumberland Plateau) to 79% (Northern Virginia). With a median PDC VMT growth rate of 63%, the significance of these VMT projections is that all PDCs are forecast to see an increase in travel demand, not just those that represent urbanizing (or urbanized) areas.

Pickrell and Schimek, in an article in the *Journal of Transportation Statistics* based on an analysis of the 1995 NPTS, suggest that although household ownership and VMT are continuing to grow, the rates of growth are decreasing, with only "modest" annual VMT growth since 1990. On a national basis, the investigators speculated that VMT growth would slow to equal automobile ownership growth; however, they pointed out that growth in VMT per driver was related to "rapid growth in driving among women across a broad age spectrum (20 to 64 years)" whereas VMT among young adults and middle aged men appeared to be leveling.[88]

At the national level, VMT and automobile ownership have increased steadily since 1960, as shown in Figure 34, although the last decade of data suggests that VMT (measured herein as the sum of miles traveled by passenger car, motorcycle, and other two-axle/four-tired vehicles) has been rising faster than automobile ownership (measured as the sum of private and commercial automobile registrations).[89] The U.S. Census shows that from 1990 to 1999, VMT, the number of registered vehicles, and the number of licensed drivers increased by 26%, 15%, and 12%, respectively.[90] Thus Virginia changes throughout the 1990s in VMT, registered vehicles, and licensed drivers are similar to national data.

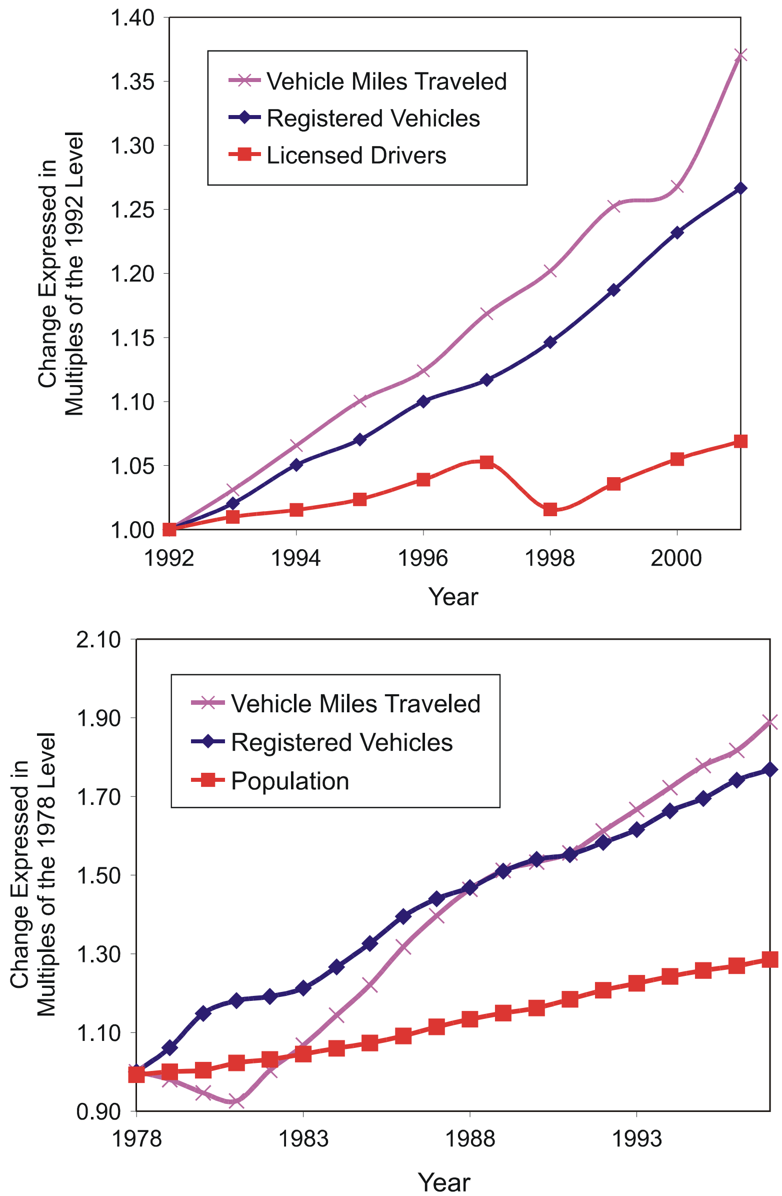


Figure 33. Increases in Virginia VMT, Registered Vehicles, and (a) Licensed Drivers and (b) Population

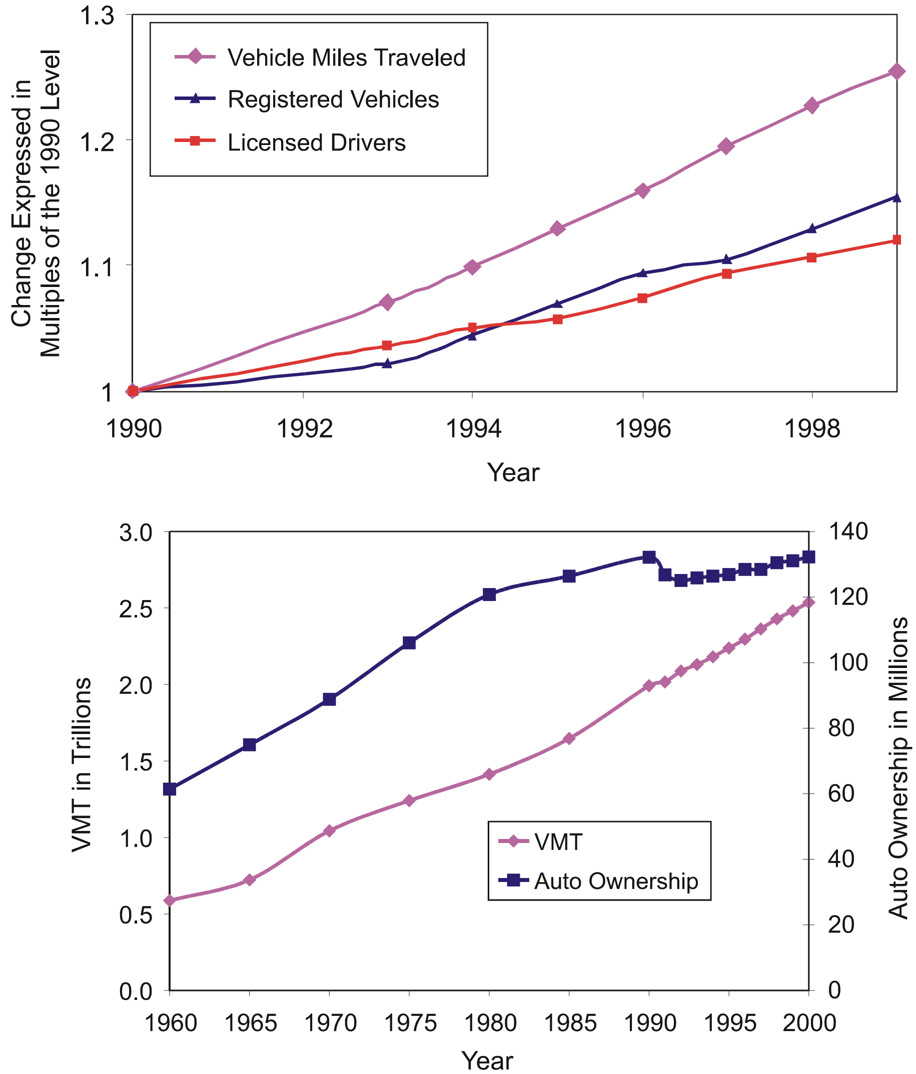


Figure 34. Relative Growth in VMT and Automobile Ownership in the United States, 1960-2000

Nationally, vehicle occupancy—the number of persons in an automobile—has decreased steadily for the past two decades for all trip categories. Work trips, which have always had the lowest occupancy rate, dropped from 1.3 occupants per vehicle in 1977 to 1.14 occupants per vehicle in 1995. Similarly, social and recreational trips, which have the highest occupancy rates, dropped from 2.4 to 2.04 occupants per vehicle.[90] (To some extent one would expect lower occupancies given the shrinking household sizes shown in Figure 17; however, given that VMT has increased at a rate greater than household sizes have decreased, it also seems that other factors, such increased dispersion of trips or increased automobile availability, also explain change in automobile occupancy.)

In sum, automobile occupancies have been dropping and VMT has been rising, and there is no evidence that these trends will reverse. Given that automobile ownership rates may start to level off, however, it is possible that these trends will not continue to increase as fast as they have in the past.

Mode Choice

Although passenger travel's dominant mode has been the automobile for daily trips, it is not necessarily used exclusively—and in some households not at all. Accordingly, trends pertaining to other passenger modes also comprise transportation demand. Passenger mode choice therefore denoted the means of transportation used such as pedestrian, bicycle, personal auto, carpool, bus, light rail, and air.

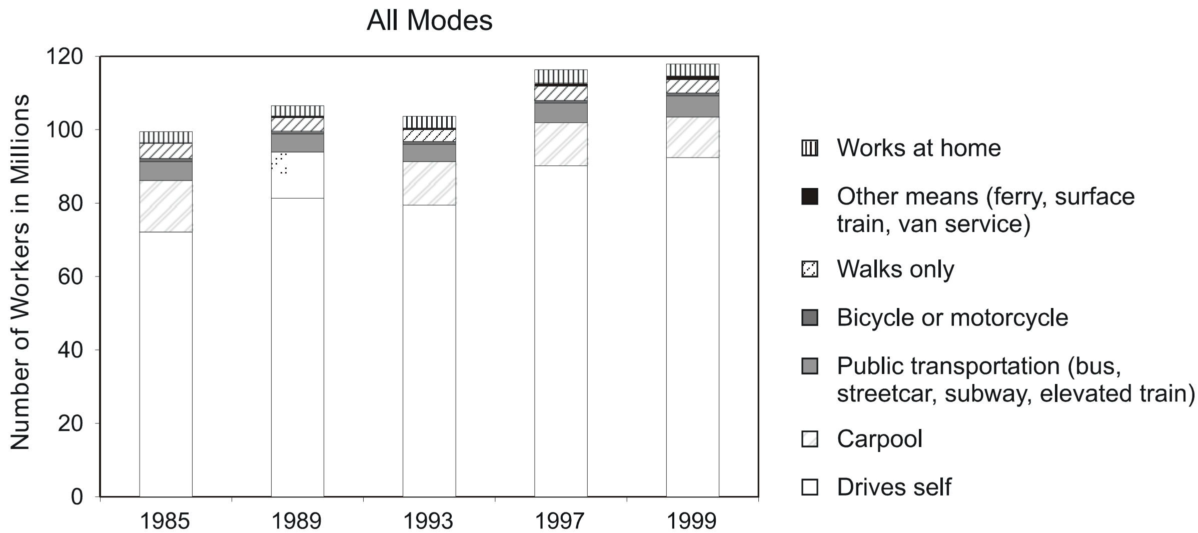
Mode choice has typically been measured longitudinally through three mechanisms: the nationally based U.S. Census "Journey to Work" series, nationally based travel surveys such as the 1995 NPTS and the 2001 NHTS, and regional surveys conducted for the purpose of long-range planning models.[91] The Journey to Work Survey is advantageous in that it stems from a large data set; the disadvantage is that it reflects only the trip to work.[91] The nationally based travel surveys reflect other trips, but their disadvantage is that they use a smaller sample size such that their applicability to a state or a metropolitan area is limited. Regional surveys are potentially quite useful and detailed but are limited in scope to a particular region; in addition, for some regions, some of these latter surveys are more than a few years old.

Mode choice has also been measured to determine its sensitivity to various factors such as mode cost, mode travel time, and socioeconomic variables. This sensitivity influences the decision as to whether changes in cost, travel time, and socioeconomic variables allow forecasting of changes in mode choice for passenger travel.

Mode Choice Trends Based on the U.S. Census Journey to Work Survey (Commuter Trips Only)

Nationally, the total number of workers who drive to work has been increasing steadily over the past few decades; in fact, the proportion of persons driving alone has also increased at the expense of other forms of transportation.[91] As of 1999, Figure 35a shows that more than 85% of all persons drove alone as their primary method of getting to work; Figure 35b shows the trip purposes, with the single-occupant automobile trips excluded. Although most absolute trip numbers tended to remain constant, the number of persons using the category of "other means" (ferry, surface train, or van service) increased from 1985 to 1999 as did the number of persons using public transportation (bus, streetcar, elevated train, or subway). The number of persons carpooling has also decreased.

One surprise in the national survey is that the absolute number of persons who primarily work at home increased only slightly from 1985 (2.9 million) to 1999 (3.3 million). Since the number of workers also increased from 1985 to 1999, the proportion of workers who work at home decreased from 3.0% to 2.8% over that period. (It should be clarified that working at home is not necessarily the same as telecommuting; e.g., some persons are self-employed.[92])



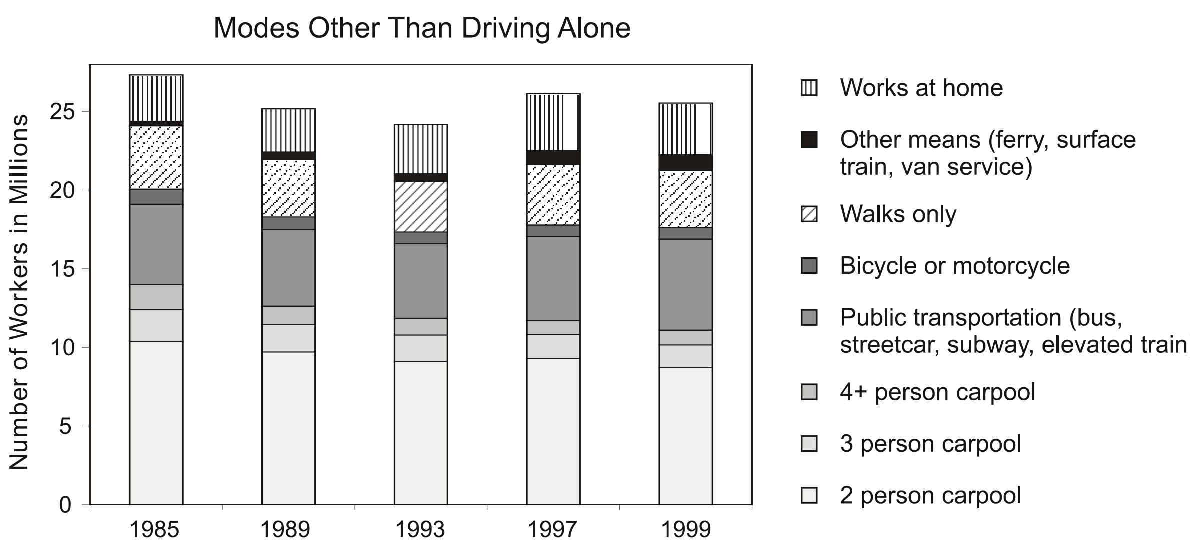
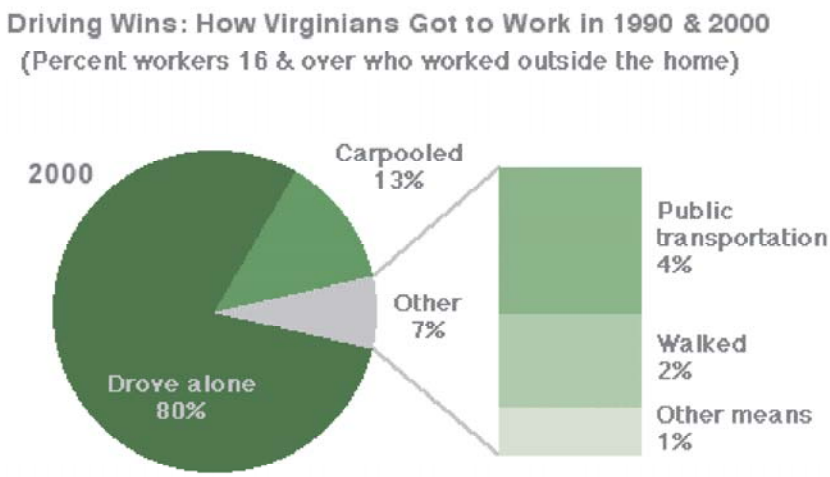


Figure 35. National Journey to Work Trips by Mode: (a) All Trips and (b) Single-Occupant Vehicle Trips Removed

At the state level, such trends are continuing, but Virginia shows a slightly greater percentage of modes used for the journey to work other than the automobile (20%) than is the case nationally (15%). As with the rest of the nation, Virginia citizens have shown an increasing trend to drive alone to work: 80% of employees in 2000 up from 76% in 1990.[93] The average values, however, mask a wide diversity in the Virginia jurisdictions: Arlington County has the lowest proportion of persons driving alone to work (slightly less than 55%) whereas the City of Colonial Heights has the highest (almost 89%). Travel times to work have also increased steadily over the past decade, such that as of 2000, the average commute time ranged from 21 minutes in Roanoke to 32 minutes in Northern Virginia.

The journey to work data are available in an interactive fashion at various geographic levels ranging from statewide summaries to census tract levels. Figure 36 shows Virginia journey to work data by mode and travel time. Figure 37a shows journey to work data from the statewide perspective, and Figure 37b shows journey to work travel times for the Greater Richmond area.



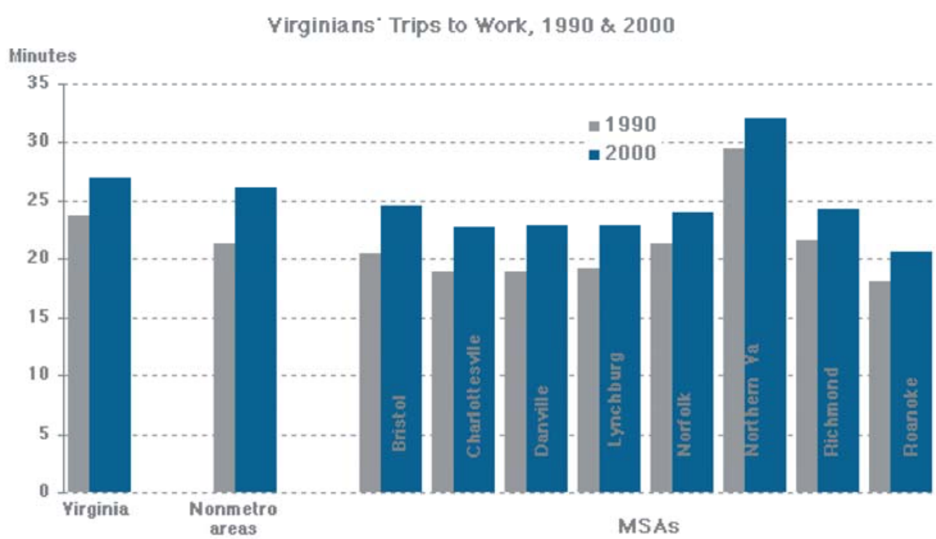


Figure 36. Virginia Journey to Work Trips by (a) Mode and (b) Travel Time (Courtesy of the Weldon Cooper Center for Public Service at the University of Virginia)

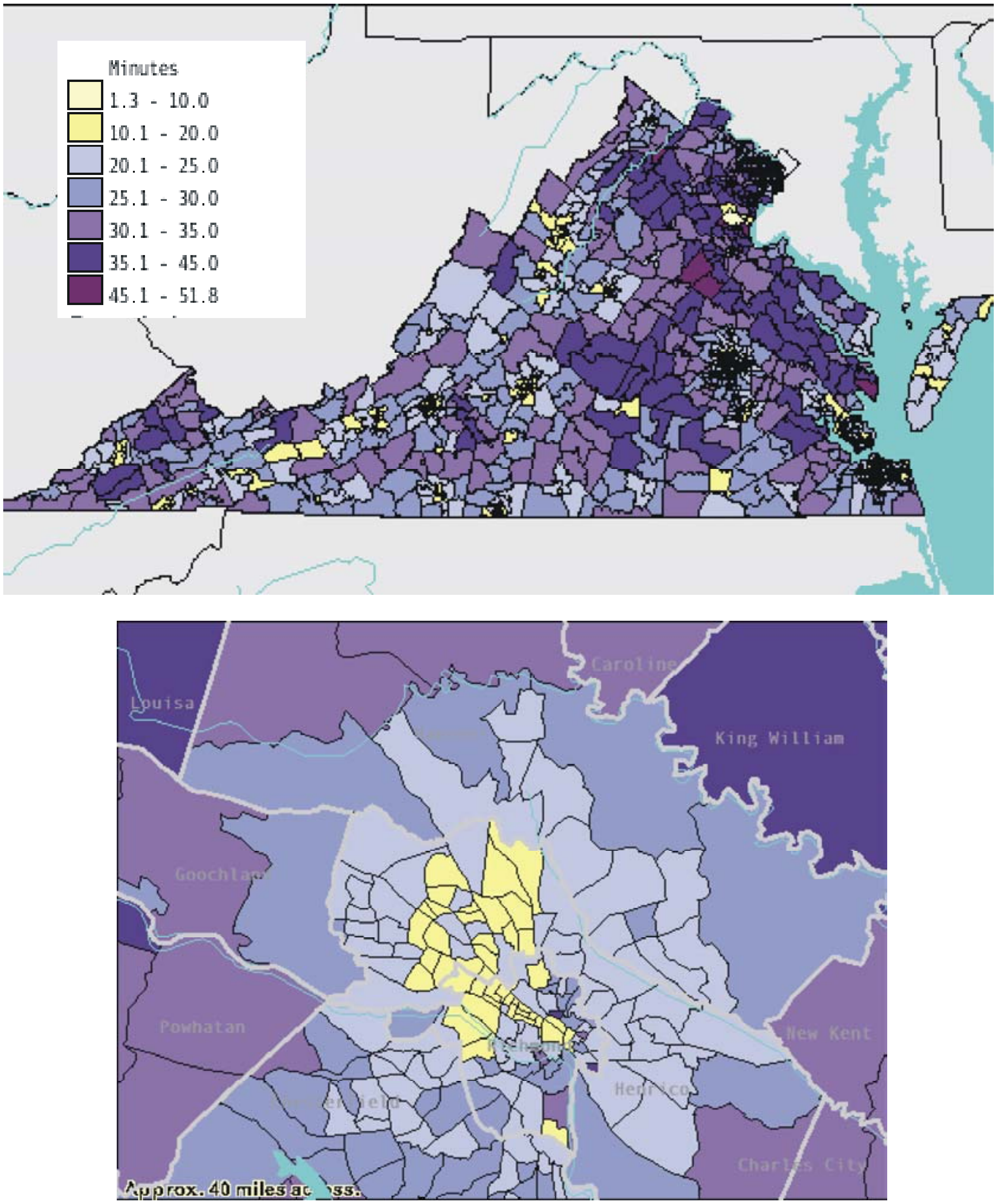


Figure 37. Journey to Work Travel Times for (a) Virginia and (b) Greater Richmond

Two trends are evident from Figure 37. First, although commute times are generally greater in urban areas, travel times are also generally smaller closer to the urban core.[94] (A disadvantage of these data is that congestion levels are not known; logically, the larger travel times for the outer ring in Figure 37b likely reflect longer work trip distances.) Second, from a statewide perspective, the geographic areas with longer commute times are not necessarily suburban or rural in character: the top 10 Virginia jurisdictions in terms of longest commute times include Amelia, Buckingham, Rappahannock, Stafford, and Surry counties. It appears that these longer commuting tendencies can occur in two situations. Rural areas are one possibility, where a lack of employment within the county causes residents to drive to another county to find employment. Suburban areas are also candidate locations for long commutes: although substantial employment may exist, this employment is either dwarfed by the resident population or not matched to employment sought by residents. The interesting trend is that a resident-employment imbalance seems possible in both rural and suburban settings.

It is tempting to ask whether journey to work travel time is correlated with the proportion of workers using a mode other than driving alone, such as carpooling, walking, public transportation, or working at home. There was no statistical correlation at the 95% confidence level when the journey to work time and the percentage of persons driving alone for member jurisdictions were compared for either individual metropolitan statistical areas or the state as a whole. Logically, this result is not surprising, since many factors affect journey to work travel time, such as the proximity of the jurisdiction to employment centers, traffic congestion within the regions, and the quality of the transportation options.

Figure 38 shows the travel times relative to the proportion of workers driving alone and the proportion of workers using public transportation for the MSAs of Hampton Roads, Richmond, Roanoke, and Northern Virginia. Within an MSA, there certainly are cases where high public transportation usage matches lower travel times; there was no statistical significance at the 95% confidence level but there was at the 94% confidence level. If a significant correlation had existed, further analysis would have been necessary to determine whether public transportation usage or the physical location of the jurisdictions within the region, as implied by Figure 37 or even some other factor, was responsible for the shorter commute times.

Nationally, Polzin reported that the "transit dependent market appears to have quit declining" based on transit mode shares shown in the NHTS and that transit use will continue to reflect specific niches, such as households without vehicles.[95] Returning to the portions of Figure 35b that quantify workers using public transportation (bus, streetcar, subway, or elevated train), it is apparent that from 1985 to 1999 the number of workers using transit has not decreased although the proportion using transit has given that employment levels are rising. For work purposes, therefore, there continues to be a transit market based on national level statistics. Although the proportion of workers using transit is substantially higher in metropolitan areas, even within these areas there is variation among the individual jurisdictions. Figure 39 shows the proportion of workers using transit from jurisdictions that comprise five regions—Northern Virginia MSA, Norfolk MSA, Richmond MSA, Roanoke MSA, and the Northeastern Peninsula Region. With a statewide use rate of 3.6%, the relatively low percentages in many jurisdictions are not surprising; what is informative, however, is the nonzero percentages in locations that are not considered to be ideal for transit. These data suggest that the niche for persons dependent on transit exists in several locations in the Commonwealth, although it is more heavily concentrated in the urban areas.

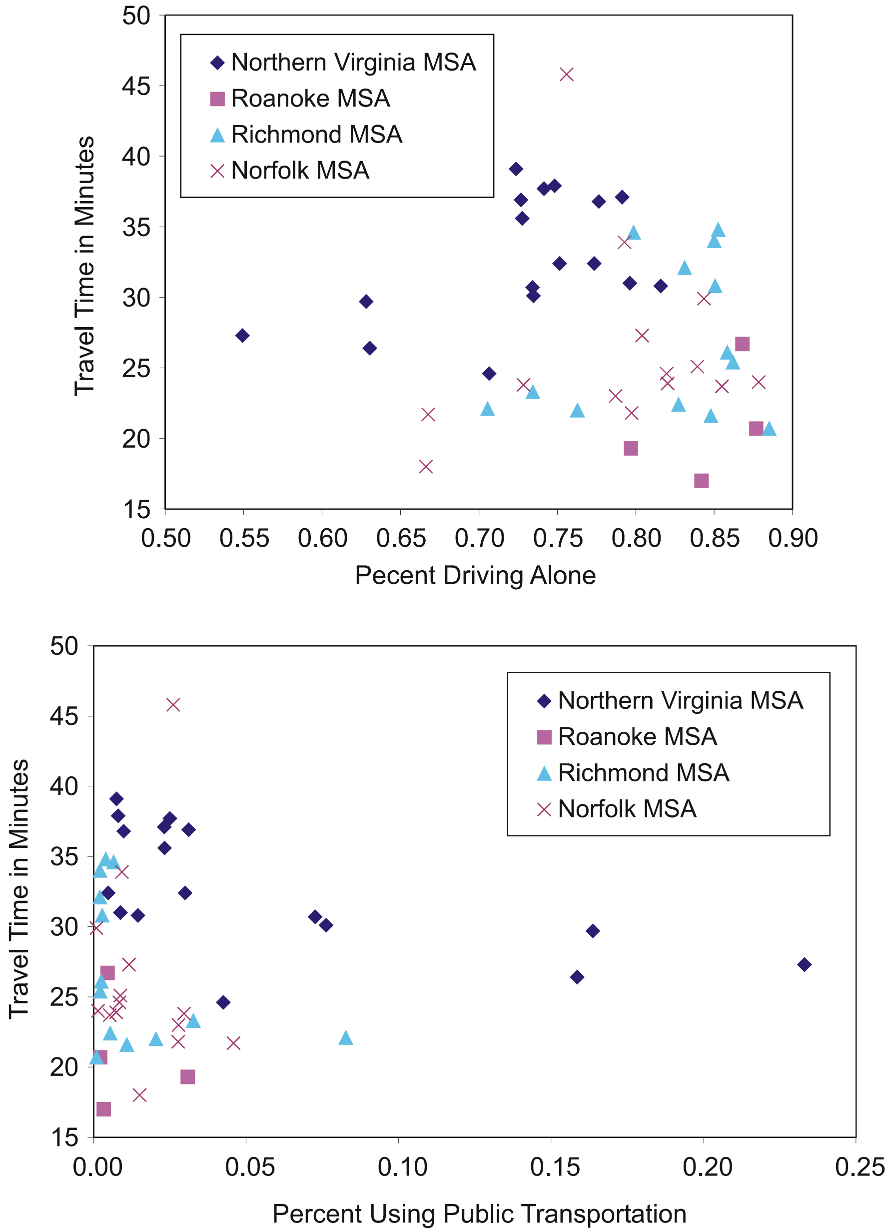
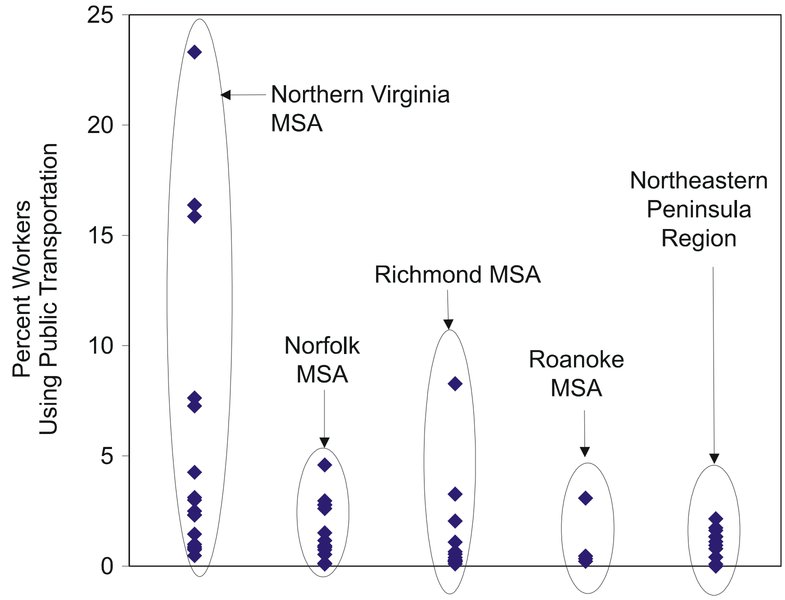


Figure 38. Relationship Between Journey to Work Travel Time and (a) Percentage of Workers Driving Alone and (b) Percentage of Workers Using Public Transportation



Each dot represents one jurisdiction in a given region. For example, the Roanoke MSA is composed of four jurisdictions with the following percentages of workers using public transportation:

- Roanoke City (3.1%)
- Botetourt County (0.5%)
- Salem City (0.3%)
- Roanoke County (0.2%)

Public transportation as defined by the U.S. Census includes bus, streetcar, elevated train, subway, and taxicab.

Figure 39. Proportion of Workers Using Public Transportation From Jurisdictions in Five Virginia Regions

Mode Choice Trends Based on the National Household Transportation Survey (All Trips)

Journey to work facts are frequently cited because they follow from a large, reliable data set; however, they describe only work trips. Given that work trips account for only a fraction of total trips made daily (on the order of 20%), they are perhaps more useful as a surrogate for travel conditions rather than as a direct measure of travel conditions. For example, although national data show a mean work trip time of slightly greater than 25.5 minutes in 2000, up from 22.4 minutes in 1990, data from the 2001 NHTS show that drivers aged 16 and over spent 81 minutes on the road on a daily basis, up from 73 minutes during 1995—an 11% increase.[96,97] Annual miles per driver were up but by a slighter margin, from 13,476 to 13,836—a 3% increase.

These averages do not tell the entire story; e.g., when reporting on key findings from the NHTS, Shaver of *The Washington Post* noted that children between ages 6 and 18 spend an average of 61 minutes in a vehicle, not including time spent on the school bus, which has implications for children's exercise and resultant health needs.[98] AASHTO extends the discussion of children's needs to modal choice, pointing out that parents and children may not use transit as currently designed unless bus stops and rail stops are located near day care centers and supermarkets.[99] The extension is significant, because it suggests that efforts to broaden transit's market may not work without explicit attention paid to the ability to serve destinations children and their parents are likely to visit.

Unlike the case for work trips, detailed trip data for nonwork trips at the state level is lacking. A possible source of information is the NHTS; however, the BTS advises against using the NHTS for state-level data at this point in time because the sample sizes are small.[100] It is still technically possible to extract state level data from the NHTS, however, and with this caveat in mind, three state level pieces of information are available:

1. *Virginians living in an urban cluster spent an average of 80 minutes per day in a personally owned vehicle.* The U.S. Census defines an *urban cluster* as a densely populated area with a population between 2,500 and 49,999; examples of urban clusters in Virginia are Abingdon, Chincoteague, Bluefield, and Staunton.[101]

2. *Virginians who lived in urbanized areas averaged almost 64 minutes per day in personally owned vehicles.* An *urbanized* area is a settled area of 50,000 or greater; Virginia urbanized areas include Virginia Beach, Roanoke, Winchester, Northern Virginia, and so forth.[102]

3. *Virginians located outside urban areas, that is, Virginians who lived in neither an urban cluster nor an urbanized area, spent approximately 76 minutes per driver per day.*

Longer distance trips are a key part of the transportation market, and the potential for mode sharing is clear; e.g., Dittmar and Bernstein noted that as of April 2002, about half of all flights (47%) were less than 500 miles.[103] (The 500-mile mark is noteworthy because some persons view trips of fewer miles as being feasibly served by modes other than air, such as rail, if such modes provide a high quality of service.) Similarly, despite the small share of intercity trips captured by bus, the market is large in terms of absolute numbers, with 860 million passengers served by all bus operations combined (charter, tour, commuter, and regular route.) Version 2 of the NHTS, released in March 2003, contains data for trips greater than 50 miles. Although state level data are not reliable according to BTS, it is feasible to use census division level data for the South Atlantic Division (the states of Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, and West Virginia).[100] Unfortunately, these data do not show trip lengths for trips greater than 50 miles.

Sensitivity of Mode Choice to Cost, Travel Time, Ethnicity, and Other Socioeconomic Factors

Meyer and Miller pointed out that socioeconomic factors (e.g., automobile ownership and income) and trip factors (e.g., travel time, cost, comfort, and convenience) influence a traveler's choice of mode.[30] Indeed it is possible to make several aggregate observations; e.g., when Pisarski examined the influence of socioeconomic characteristics on transit use, the largest impact was automobile ownership: whereas 5.1% of all commuters used transit, almost 40% of households with no vehicles used transit. Other socioeconomic factors had less of an effect: female workers living alone in the central city (16.3% of this group used transit), African American (14.8%), renters (9.5%), and so forth. Petitte still found that subway ridership on the Washington Metropolitan Area Transit Authority (WMATA) was inelastic to price; the study found that price had more of an effect on ridership than suspected if one did not assume that riders were commuting to a central city station. (That is, under the central city assumption, a 10% increase in fares would have decreased ridership by between 33% and 38%; without this assumption, a 10% increase in fares was estimated to decrease ridership between 51% and 57%.)[104] In terms of using a given mode at a specific time, U.S.-based literature suggests that a 10% increase in price may reduce demand between 1% and 4% based on the influence of congestion pricing on automobile travel.[105] When the same authors studied sensitivity using data from Lee County, Florida's, Variable Pricing Program, sensitivities at the upper end of this range were observed during periods of congestion (e.g., a 10% increase in price corresponded with a 3.6% reduction in demand). During periods of lower congestion, elasticity was lower: a 10% increase in price reduced demand by amounts ranging from 0.3% to 2.0%.[105]

The literature also suggested two caveats for understanding mode choice demand:

1. *Existing modal choices may or may not mask critical underlying factors that greatly influence a traveler's decision*. Ben-Akiva and Morikawa concluded that although rail systems are viewed as more attractive than bus systems, the reason for this attraction is that rail is perceived as offering a higher quality of service and that survey research shows no difference between the two modes provided travel time and cost are equal.[106] Konig and Axhausen argued that travel time reliability is a critical factor that is considered by travelers when selecting a mode, and since reliability has been neglected in developing mode choice models, it may need to be reconsidered. (A transit example is that it may be more important to have reserve transit drivers and vehicles than to have shorter transit headways.)[107]

2. *Mode choice sensitivities may vary substantially for specific situations*. Marshment and Wedel found that for urban transit service, out-of-vehicle travel time appears 2 to 4 times longer than the same amount of time spent traveling in the vehicle (which is consistent with previous literature) but for rural transit service, in-vehicle and out-of-vehicle travel time are comparable (which is initially surprising). The authors offered a reasonable explanation, which was that for the types of rural service studied, passengers were picked up at their home and/or a lounge.[108] The lesson therein is that out-of-vehicle travel time is not the same across all situations. In reference to another transit market segment, Franklin and Niemier found that elderly or disabled riders' demand for paratransit versus regular transit was inelastic to price but not to age.[109]

The extent to which knowledge of population distribution by ethnicity assists in the assessment of transportation needs is not clear. Certainly literature sources that have suggested that race and ethnicity affect travel behavior; e.g., a study funded by the Transit Cooperative Research Program states that "Blacks, Hispanics, and Asians—are substantially *more* [emphasis added] likely to use transit, even when controlling for income."[110] In a separate effort focusing on transportation needs of the elderly, the primary author of the study concluded that there is a statistically significant difference between the likelihood of Hispanics and non-Hispanics choosing public transportation, with Hispanics being *less* likely to use public transportation.[111] In a study of transit accessibility in Dade County, Thompson noted that "all else equal, Hispanics have a greater affinity for automobiles than either non-Hispanic whites or African Americans."[112]

Without a deeper understanding of how ethnicity affects travel demand, it appears advisable to avoid using ethnicity or race as a simple predictor of transportation needs. The most straightforward reason is that other characteristics, such as income or residential location, are better predictors of particular types of travel behavior. Yet caveats from the previously cited studies—even when they controlled for factors such as income—suggest that further research is needed. For example, Rosenbloom and Waldorf, although writing that "Racial minorities are less likely to go by car and more likely to choose public transportation," also note that their findings are not statistically significant (except in the case of the elderly drivers cited in the previous paragraph) and that additional research is thus underway.[111] Thompson did *not* find that transit accessibility increased labor force participation by any of three groups (African Americans, Hispanic whites, and non-Hispanic whites) but did conclude that automobile ownership and labor force participation were influenced by sex: males were likely to have an automobile regardless of whether they were in the labor force, whereas females' automobile ownership was influenced by whether they were in the labor force.[112] Interestingly, Polzin et al. noted that differences in mode choice among ethnic groups have declined over time, based on a review of data from the 1983, 1990, and 1995 NPTSs.[113] On the other hand, Zmud and Arce suggested that increased purchasing power of African Americans and Hispanics will magnify, rather than reduce, differences in future travel behavior among ethnic groups. The authors' reasoning was that increased purchasing power will lead to additional nonwork trips made by these groups and that these nonwork trips would tend to be "more familistic and group oriented than White travel."[114]

A separate question raised but not answered by the literature is the extent to which immigrants and non-immigrants may have different transportation needs. For example, Sen wrote that "within major ethnic categories . . . [used in the 1995 NPTS] . . . there may be major differences which are hidden;" she cites as an example that the category "Black women" includes women from the "Caribbean islands, South and/or Central America, or Africa . . . who may have their travel patterns totally submerged by the larger black group."[115] Sen further wrote that observed differences in transit usage among broad ethnic categories in the NPTS may be the result of socioeconomic differences cited previously, such as automobile ownership, or may be attributed to cultural differences. In a critique of the available data, to understand older women's mobility needs, Wallace and Franc noted that the proportion of older women will increase because of increased survivorship and increased immigration, and they recommended that detailed surveys need to be conducted concerning the mobility needs of older women.[116]

Summary of Passenger Travel Trends

Table 9 summarizes national forecasts for the year 2025 for national passenger travel. The passenger miles traveled in the first data row is composed of highway travel (about 90% in 2000), air travel (about 9% in 2000), and any other modes (about 1% in 2000).[33] A clear interpretation of Table 9 is that demand for passenger travel will continue to grow, both as a national total and as the amount of travel per person.

That said, Table 9 shows that the *rate of growth increase* may be less than in the past in some categories. FHWA, for example, suggested that national average rates of statewide VMT growth may decrease slightly from almost 3% annually (the rate between 1990 and 2000) to almost as low as 2% annually (the projected rate to 2020).[117] Clearly, using the FHWA forecast and the data in Table 9, passenger travel per person is still expected to grow, even though the number of vehicles per licensed driver should drop slightly.

Table 9. Summary of National Level Passenger Travel Forecasts to 2025[*]

Forecast	2000	2025	% Change
Passenger miles (trillions)	5	8.4	68
Passenger miles per capita	18,000	25,000	36
Licensed drivers (millions)	190	243	28
Vehicles (millions)	219	262	20
Vehicles per licensed driver	1.15	1.08	-7
Vehicles per capita	0.80	0.78	-3
Vehicle miles traveled[**]	51% increase from 2000 to 2020		
Transit passenger miles traveled[**]	37% increase from 2000 to 2020		

[*]Numbers were rounded for ease of presentation.
[**]Reflects 2020, not 2025, forecast based on FHWA projected annual growth rate of 2.08% (VMT) and 1.6% (transit PMT).

In sum, six mode choice trends are clear, four of which are widely known and two of which may not have been apparent:

1. *The proportion of workers driving alone has been steadily increasing, both in Virginia and in the nation as a whole;* slight increases in the number of workers using public transportation have been more than offset by decreases in the number of workers carpooling.

2. *There are small but measurable numbers of Virginians using public transportation to get to work even in smaller, rural areas,* corroborating the statement that there will continue to be niche markets for transit (although, as stated earlier, traditional transit programs may not be appropriate for employment growth in the service sector where varied working hours are common).

3. *Statewide and nationally, when all trip purposes are considered, persons are spending over 1 hour daily in their vehicle.* In that sense, increases in commuting time are an imperfect but useful surrogate for transportation needs as a whole.

4. *To the extent that Virginia will mirror the national trends shown in Table 9, passenger travel should increase by 2025; the national average forecast increase of 68% in passenger miles traveled is driven by increases in population and the amount of passenger travel by person. Virginia-specific VMT are expected to increase by 68%.*

5. *Although a generalized mode choice principle is that passengers choose to use a mode of transportation based on automobile ownership, income, travel time, cost, comfort, and convenience, it is more appropriate to look at specific situations to judge the sensitivity of mode choice to a given factor.* Studies from the literature suggesting this need for specificity cite examples such as (1) automobile ownership being the predominant reason for determining transit use in one setting, (2) greater perceived reliability of rail to bus being the reason rail was preferred to bus in another setting, and (3) the finding for a given rural transit system, the waiting time outside the vehicle, was no more of a disincentive to passengers than the waiting time inside the vehicle. Usually it is the case that time spent waiting outside the transit vehicle is more of a disincentive than time spent inside the transit vehicle; typical practice by mode choice modelers is to multiply this outside-vehicle waiting time by a factor of 2 or more to convert it to in-vehicle travel time. The fact that this multiplication was not needed for the particular rural transit system in question was unusual but was readily explained in the literature as the relative comfort of the waiting facilities.

6. *The findings of the literature are inconsistent with respect to the impact of ethnicity on mode choice: after controlling for income, some authors argue that ethnicity makes a difference and some do not.* (The one area where the literature does seem to be in agreement with respect to ethnicity is on the aspect that additional research is needed.)

SUMMARY OF EXPECTED TRENDS

The historical trends combined with sources from the literature suggest several trends that appear likely between now and 2025. To summarize, the following trends should be considered as Virginia moves forward with multimodal planning.

1. *Population growth in four of Virginia's urban or urbanizing PDCs*—Hampton Roads, Richmond Regional, Northern Virginia, and RADCO—represents more than three quarters of the growth in new population expected between 2000 and 2025. The disparity in land use densities within some of these regions, coupled with counties' and cities' interest in some cases in restricting growth, suggests that in the metropolitan regions especially there will be pressure for development—and thus transportation demand—to continue to expand outward beyond current metropolitan boundaries. Variance in home prices within some metropolitan regions may also contribute to this trend.

2. *Population growth outside of these four urbanizing PDCs is also noteworthy*, even though it a small portion of the statewide population increase, since in some cases the PDC itself is expected to grow rapidly relative to its current population. Double-digit employment growth in the Charlottesville MSA, the Northeastern Peninsula Region, the Roanoke MSA, and the Northwest Region may contribute to residential dispersion in these lower density locations.

3. *Changes in age distribution and household size indicate that there will be an increase in persons aged 65 and over to 18% of the total population by 2025, up from 12% in 2000. Further, some research suggests that in the future, persons aged 75 and over will drive more than members of that age group drive at present.* At present, the percentage of the population over 65 is not evenly distributed.

4. *The estimated 50% increase in per-capita income and employment statewide projected for 2025 also suggests additional demand for travel since historically both of these socioeconomic factors have encouraged additional transportation.* Yet the disparity between the PDCs may move in different directions: by 2025, it appears that there will be less of a difference between the richest and poorest PDCs in terms of per-capita personal income; however, the three largest PDCs will have a slightly greater proportion of total statewide employment (68%) than at present (65%).

5. *Expected income and employment trends pose special challenges to making traditional transit work.* With more employment expected in the service sector, some persons have suggested traditional transit is less likely to succeed given the resultant nontraditional work hours and/or the fact that an important component of the journey to work is taking a child to day care or to the supermarket. Given that over 200,000 households do not have a vehicle—plus the measurable public transportation trip rates for work purposes observed in some jurisdictions—the implication from the literature that innovative transit strategies are needed or should be continued is clear.

6. Short-term organizational and legislative trends that are apparent today may or may not persist to 2025 but probably will be meaningful through the next federal reauthorization.

    - *To at least some degree, capacity expansions will probably be replaced by an emphasis on operations.* One implication for multimodal planning is that the provision of updated traveler information may become a high priority, which would necessitate a high degree of coordination across modal authorities if such information was provided by the public sector. An alternative scenario is that the private sector may attempt this effort if a profitable business model can be found, with the incentive of a large market—200 million vehicles—if successful. Regardless of the provider of the information service, factors other than travel time, such as travel time variability or accurate updated forecasts of trip length, may come to be viewed as equally important metrics when congestion is assessed.

- *If funding flexibility continues, at least with the next federal reauthorization, states will have wider discretion regarding how to allocate funds*. ISTEA and TEA-21 gave states flexibility but placed a responsibility on states to give serious consideration to a wide range of transportation alternatives. Promising alternatives, such as bus rapid transit and telecommuting, have been mentioned in the literature, but it is not yet clear if these will materialize into long-term solutions; thus further investigation is probably needed.

- *Increased user fees or some other form of transportation financing* may be implemented to augment the gasoline tax. It is not known at this time if the transportation financing structure will even change, let alone what that change could be, but events over the past decade suggest two likely trends: (1) an increase in transportation program flexibility, thereby allowing states to invest funds in modes, connections, and operations that are most productive and (2) an increase in opportunities to implement user fees, such as the high-occupancy toll (HOT) concept.

7. *Based on U.S. Census journey to work data, public transportation use appears to have stabilized, rather than continue to drop, in terms of total number of workers using public transportation*. At present, 3.6% of Virginians use public transportation to get to work, with higher percentages in the more urban locations.

8. *VMT should keep increasing, but eventually the rate of growth should at least stabilize*. Over the past few decades, VMT has risen slightly faster than automobile ownership and much faster than population. The literature noted, however, that as incomes continue to rise, a point will come at which the auto ownership market will be saturated. The literature for the United States as a whole suggests that over the next 25 years, therefore, VMT growth rate should start to level. This statement should be tempered by three observations. First, VMT is not evenly spread across all demographic groups (e.g., one source attributes recent VMT growth to women of all age groups driving more). Second, there are significant differences in automobile ownership forecasts between credible sources. Third, automobile occupancies have dropped for the past couple of decades. Thus a "safe" observation is that VMT will probably keep increasing until the automobile ownership market is saturated, but there is not a clear conclusion as to whether that point will be 2015, 2025, or some other time altogether.

9. *Within a given metropolitan area, the counties with the shorter average commute times tend to be those located closer to the urban core*. This suggests that public transportation options combined with shorter distances may plausibly contribute to these shorter commutes, although this study did not attempt to prove this finding statistically.

10. *National freight forecasts show an increasing amount of freight, as measured in ton-miles, shipped by air, rail, pipeline, and intercity truck*, *with intercity truck overtaking rail as the most heavily used mode.* Virginia-specific data at present

mirror national data at present, with slightly more than half of all freight originating in Virginia currently being shipped by rail, again when measured by ton-miles. With Virginia port containerized traffic expected to more than double by 2025, Virginia air, rail, and truck freight tonnage expected to increase by about 70% by 2020, and the value of freight shipped over the same period expected to triple, demand will be placed on Virginia's network. Improvements to individual modes will affect, of course, the share of freight claimed by individual modes.

These trends are based on the assumption that historical data, combined in some cases with an understanding of the transportation environment, can be used to predict the environment over the next quarter century. This is probably accurate for statewide population totals and may possibly be accurate for employment and personal income within large geographical subareas. Yet historical examples of changes in behavior, such as the mode of transportation chosen by passengers or the number of miles driven, are also affected by significant technological or social changes—and it is difficult to predict key technological and social developments decades into the future, such as the innovations in the rubber-tired bus over the streetcar during the 1920s, World War II during the 1940s, the oil embargo of the 1970s, or the continued rise in personal income of the 1990s. In a similar vein, it is not yet clear whether technologies, such as hybrid vehicles, or social movements, such as telecommuting, will see the rate of market penetration deviate from recent trends.

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APPENDIX A. SAMPLE 2000 AND 2025 POPULATION PROJECTIONS, COPYRIGHT AND COURTESY OF NPA DATA SERVICES, INC.

Region	Population		Region	Population	
	2000	2025		2000	2025
Accomack	38,390	43,820	King George	16,900	24,530
Albemarle, Charlottesville	124,630	158,730	King William	13,210	18,150
Alleghany, Clifton Forge, Covington Gap	23,480	23,390	Lancaster	11,590	13,430
Amelia	11,460	14,440	Lee	23,550	27,450
Amherst	31,910	36,640	Loudoun	173,810	313,050
Appomattox	13,720	16,780	Louisa	25,760	35,170
Arlington, Alexandria	318,200	348,960	Lunenberg	13,080	14,470
Augusta, Staunton, Waynesboro	109,260	131,900	Madison	12,550	15,360
Bath	5,040	5,410	Mathews	9,200	10,940
Bedford, Bedford City	66,920	89,050	Mecklenburg	32,370	35,220
Bland	6,850	8,430	Middlesex	9,960	12,750
Botetourt	30,570	39,920	Montgomery, Radford	99,420	127,440
Brunswick	18,430	20,350	Nelson	14,480	16,990
Buchanan	26,820	28,330	New Kent	13,530	21,210
Buckingham	15,630	19,500	Northampton	13,070	13,190
Campbell, Lynchburg	116,340	129,680	Northumberland	12,280	14,610
Caroline	22,130	28,180	Nottoway	15,710	17,110
Carroll, Galax	36,160	41,120	Orange	26,050	35,710
Charles City	6,930	7,650	Page	23,190	27,630
Charlotte	12,450	13,140	Patrick	19,420	22,910
Chesapeake, Norfolk, Portsmouth	535,370	595,630	Pittsylvania, Danville	110,050	121,680
Chesterfield	260,910	404,110	Powhatan	22,620	35,510
Clarke	12,700	16,360	Prince Edward	19,700	23,360
Craig	5,100	6,270	Prince George, Hopewell	55,530	62,440
Culpeper	34,500	48,360	Prince William	329,480	554,260
Cumberland	9,020	10,940	Pulaski	35,150	39,180
Dickenson	16,360	18,280	Rappahannock	7,000	8,630
Dinwiddie, Colonial Heights, Petersburg	75,160	77,210	Richmond	8,820	10,690
Essex	10,000	11,970	Roanoke, Roanoke City, Salem	205,310	225,260
Fairfax, Fairfax City, Falls Church	1,006,790	1,428,700	Rockbridge, Buena Vista, Lexington	34,070	38,570
Fauquier	55,570	81,660	Rockingham, Harrisonburg	108,170	137,160
Floyd	13,960	17,240	Russell	30,320	36,550
Fluvanna	20,240	32,230	Scott	23,390	25,120
Franklin	47,440	61,970	Shenandoah	35,220	44,440
Frederick, Winchester	83,220	115,950	Smyth	33,090	36,020
Giles	16,690	17,720	Southampton, Franklin	25,760	27,830
Gloucester	34,880	52,980	Spotsylvania, Fredericksburg	110,860	193,030
Goochland	16,950	22,660	Stafford	93,590	163,480

Grayson	17,920	19,600	Suffolk	64,230	83,150
Greene	15,360	24,170	Surry	6,830	7,780
Greensville, Emporia	17,220	19,190	Sussex	12,480	13,520
Halifax, South Boston	37,320	39,290	Tazewell	44,470	51,320
Hanover	87,040	131,640	Virginia Beach	426,840	638,770
Henrico, Richmond	460,690	513,870	Warren	31,730	44,840
Henry, Martinsville	73,250	80,600	Washington, Bristol	68,450	79,730
Highland	2,540	2,720	Westmoreland	16,700	19,750
Isle of Wight	29,890	39,950	Wise, Norton	44,000	50,660
James City, Williamsburg	60,560	93,220	Wythe	27,640	31,890
King and Queen	6,630	7,450	York, Hampton, Newport News	394,920	481,530