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COMPARISON OF VIRGINIA'S MULTIMODAL TRANSPORTATION CORRIDORS USING COST AND DEMOGRAPHIC ANALYSES

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16. Abstract

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With the cost analysis, the report seeks to compare the corridors using capital cost estimates from four readily available sources of data: multimodal agency plans, a highway needs assessment, a statewide highway plan, and MPO/PDC long-range transportation plans. The cost analysis highlights the challenges of preparing and comparing cost estimations, including the non-uniformity of assumptions about constituent projects and overlapping or noncontiguous jurisdictions. The results of the cost analyses suggest needs for the consideration of operations and maintenance costs in comparing corridors, and a consideration of whether the benefits of particular multimodal initiatives in corridors might be equivalent to those of particular highway-only initiatives.

With the demographic analysis, population density studies within each of the corridors suggest several corridors have densities that might readily support non-automobile modes. The results of the demographic analyses suggest extending the approach to study accessibility metrics by mode and addressing which spatial scales—local, regional, and statewide—are appropriate for various questions of investment policy.

The recommendations identify opportunities for improving coordination among government and stakeholder organizations that are engaged in cost and benefits analyses for long-range multimodal transportation planning. Cost-benefit analysis of major transportation projects is required by the recent Transportation Act of the Commonwealth of Virginia.

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With the cost analysis, the report seeks to compare the corridors using capital cost estimates from four readily available sources of data: multimodal agency plans, a highway needs assessment, a statewide highway plan, and MPO/PDC long-range transportation plans. The cost analysis highlights the challenges of preparing and comparing cost estimations, including the non-uniformity of assumptions about constituent projects and overlapping or noncontiguous jurisdictions. The results of the cost analyses suggest needs for the consideration of operations and maintenance costs in comparing corridors, and a consideration of whether the benefits of particular multimodal initiatives in corridors might be equivalent to those of particular highway-only initiatives.

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The recommendations identify opportunities for improving coordination among government and stakeholder organizations that are engaged in cost and benefits analyses for long-range multimodal transportation planning. Cost-benefit analysis of major transportation projects is required by the recent Transportation Act of the Commonwealth of Virginia.

INTRODUCTION

The Intermodal Surface Transportation Efficiency Act (ISTEA), the Transportation Equity Act for the 21st Century (TEA-21), and most recently, the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) have each emphasized multimodal statewide planning. Transportation planning processes have evolved quite differently in each state to meet federal requirements. Variation is due to statutory and institutional responsibilities of the state's transportation services, its size, its degree of urbanization, its growth rate, its amount of through-passenger and goods movement, its management of growth, its levels of multimodalism, its technical capabilities, and the role of planning in its department of transportation (Pedersen, 1999). These differences have resulted in numerous organizational configurations, methods of cooperation between state agencies, and transportation planning goals and objectives. Regardless of how states have chosen to meet federal requirements, those that have implemented coordinated multimodal planning are reaping the benefits. In a recent survey of statewide multimodal planning best practices, states cited the following advantages of a multimodal approach over one that investigates modes individually (Miller, 2005):

- Increased focus on freight studies
- Greater participation in multimodal planning studies
- Stronger linkages between transportation and land use
- Implementation of initiatives that resulted from multimodal planning
- Improved communication and relationships between modal agencies

Virginia is one of many states working toward a long-range plan coordinated among its many transportation modes. Indeed, Section 33.1-23.03 of the Code of Virginia directs the Commonwealth Transportation Board (CTB) to develop a multimodal long-range transportation plan with a statewide focus. A multimodal advisory committee composed of representatives from the Virginia Department of Transportation (VDOT), the Virginia Department of Aviation (DOAV), the Virginia Department of Rail and Public Transportation (DRPT), the Virginia Port Authority, the Federal Highway Administration, and the state's Planning District Commissions (PDCs) and Metropolitan Planning Organizations (MPOs) developed its twenty-year transportation plan early in FY2005. VTrans2025, as the plan is titled, establishes common visions, goals, and objectives across all modes and identifies the need for additional resources to achieve a cohesive and interconnected transportation system (VTrans2025 2004).

The VTrans2025 plan predicts that during the twenty-year span from 2005-2025 $108 billion in unmet transportation needs could accumulate ($74.2 billion for highways, $30.7 billion for rail and public transportation, $3.1 billion for aviation, and $0.4 billion for ports). Thus, a critical element for implementation of the long-range transportation plan is cost-effectiveness of expenditures. To aid in cost-effective project programming and to maintain a focus on multimodal solutions, the VTrans Multimodal Advisory Committee has identified eleven multimodal corridors of significance in the movement of people and goods throughout and within the Commonwealth of Virginia. This research addresses the following questions: What are the differences in perspective of cost estimation for multimodal transportation projects among state, regional, and modal planning organizations? What are the reasons for these differences? How do the corridors compare within each perspective? Where in Virginia do opportunities exist for cost-effective, statewide multimodal investment? Some of these issues are examined in this report.

PURPOSE AND SCOPE

This effort supports the new Multimodal Office, Virginia transportation agencies, and regional entities (MPOs, PDCs) in planning and resource allocation for multimodal corridors of statewide significance. In particular, the effort compares the eleven multimodal corridors (MINs, multimodal investment networks) by complementary sources of data that include demographic, behavioral, infrastructural, environmental, institutional, land-use, cost-efficiency, and other characteristics. These characteristics were identified as important considerations of a multimodal transportation planning process in consultation with the VTrans2025 Multimodal Advisory Committee. Though all characteristics will eventually be addressed, this report explores only two of them: cost-efficiency characteristics and demographic characteristics.

Results of this research are not intended to influence prioritization or programming decisions at this time. Rather, the aims of the effort are:

- Improved methods for prioritization of transportation policies, plans, and modal projects that comprise corridor-level investments
- Improved understanding of what criteria, with emphasis on infrastructural, behavioral, social, geographic, and other data and characteristics, are the best rationale for multimodal investments in the major corridors

In the cost part of the effort, we will limit the collection of data from the numerous regional entities (MPOs and PDCs) to what can be obtained readily from their constrained and unconstrained long-range transportation plans.

The comparisons of the multimodal corridors (or MINs) by demographic, behavioral, infrastructural, environmental, institutional, land-use, cost-efficiency, and other data will enable the upcoming statewide long-range multimodal transportation plan called VTrans2030 (due to be initiated in December 2006) to recommend policies and solutions that are the feasible and logical next steps for the evolving statewide transportation system, and that are appropriately specialized and distributed according to regional and local needs.

Furthermore, these comparisons of Virginia's eleven multimodal corridors, which complement and transcend existing political and institutional jurisdictions, will inform the broad perspectives and consensus that are useful for (1) marshaling federal, state, and local transportation resources over the long term toward 2030, (2) interpreting what transportation investments have already been made or are underway across the corridors.

BACKGROUND

The three subsections that follow provide reviews of literature on the topics of statewide multimodal planning efforts, multimodal performance metrics, and cost analysis of transportation projects. The reviews suggest opportunities for coordinating multimodal strategies between transportation agencies, in identifying appropriate multimodal performance metrics and applying them to the decision-making process, and in conducting cost-based analysis for long-range transportation planning, ultimately leading toward more advanced techniques such as cost-effectiveness and cost-benefit analysis.

Statewide Multimodal Planning

Three pieces of federal legislation have directly impacted statewide multimodal planning efforts. ISTEA, TEA-21, and most recently, SAFETEA-LU have each emphasized the need for multimodal statewide planning.

Specifically, Title V of ISTEA established the Office of Intermodalism within the Office of the Secretary of Transportation. This title also created $3 million in grants for states to develop their own intermodal transportation plans and established a National Commission on Intermodal Transportation to study a wide variety of opportunities and effects of intermodalism (ISTEA Summary, 1991). TEA-21 explicitly called for "balanced investment in highways, transit, intermodal projects, and technologies such as Intelligent Transportation Systems." It encouraged development and use of non-automobile modes by increasing tax-free employer-paid transit benefits from $65 to $100 per month, expanding provisions to encourage biking and walking, and funded $270 million to create and maintain recreational trails. It authorized $42 billion for transit operations and improvements and gave states and localities greater flexibility in the use of federal funds (TEA-21 Summary, 1998). Most recently, SAFETEA-LU renews the federal emphasis on multimodal planning by expanding the use of tolling and other approaches that are aimed to divert travelers from highways. The Value Pricing Pilot Program is continued, funded at $59 million through 2009, to support up to 15 variable pricing pilot programs to manage congestion and benefit air quality, energy use, and efficiency. Transportation Infrastructure Finance and Innovation Act (TIFIA) financing is extended to fund investments in intermodal freight transfer facilities and private freight facilities that will benefit public users. Requirements are added for state and MPO plans to address the environment, system performance, multimodal capacity, and enhancement activities (FHWA 2005).

In an effort to meet the federal requirements, each state has adopted a planning process that uniquely reflects its geography, popular sentiment, socio-economic background, and political climate (Pedersen 1999). These processes are manifested in a wide variety of goals, objectives and organizational structures. Miller (2005) conducted and reported results from a survey meant to elicit positive and negative aspects of decentralized versus centralized multimodal planning efforts. Miller's literature review discusses several external factors that may adversely affect the efficacy of statewide multimodal planning. The survey results contain responses from 41 states demonstrating a wide variety of organizational strategies. Advantages of a centralized approach toward multimodal planning are reported as follows (Miller 2005):

- Consistency of planning efforts
- Coordination of planning efforts
- Holistic examination of the transportation system
- Greater attention to smaller modes that need it
- Employee development and efficiency
- Planning is accomplished because it does not compete for resources with operational responsibilities (as it might in a modal division).

Zemotel and Halvorson (1999) suggest that states emulate Minnesota's centralized structure, which houses statewide long-range planning and programming under one leadership. Advantages of a decentralized multimodal planning structure, however, are reported by Miller (2005):

- Modal support for the long-range plan is more likely to exist
- Modal expertise exists
- Ability to focus on the mode most critical to the state transportation system
- Less bureaucracy.

Regardless of a centralized or decentralized approach, the survey highlights four important insights:

- Some planning functions should be centralized and some should be decentralized
- Coordination is not synonymous with centralization
- Restrictions on funding could limit the authority of a statewide multimodal planning effort
- Multimodal planning efforts in some states are performed largely by MPOs.

These insights suggest the importance of coordination among modal agencies and state, regional, and local planning authorities. Among the various levels of government, transportation planning can be characterized less as a 'layer cake' in which division of responsibilities is well-defined, and more as a 'marble cake' in which "different governments cooperate, compete, regulate, and represent their unique interests and concerns" (Wachs 2004). Bishop et al. (1997) provide evidence of this, citing wide variation among MPOs in their approaches to fiscally constrained planning as a result of similarity among MPO jurisdictions. Since their inception, MPOs have contended with local jurisdictions over ownership of transportation planning. MPOs claim that transportation plans should set regional rather than local goals, as ISTEA and TEA-21 advocate, despite the opposing view that they lack the political and economic authority to implement large-scale regional initiatives (Bishop et al. 1997).

The role of MPOs calls into question the effectiveness of a top-down, state-driven multimodal planning approach versus that of a bottom-up, regionally or locally driven process. Indeed, a search of abstracts concerning multimodal and/or intermodal planning returns a preponderance of research about local and regional efforts compared to a scant amount of literature applying multimodal concepts to entire states. Miller (2005) suggests a reason for this may be that "data-driven statewide multimodal planning requires substantially more effort than a comparison of common performance characteristics of different modes." Indeed, little has changed since Fleet et al. (1979) suggested that "multimodal programs . . . are rarely developed at the statewide level." The authors suggest the main reason for this is the difficulty in assessing the comparative advantages of each mode. Another probable reason is that regional and local scopes are more amenable to a greater number of modes, including walking, biking, transit, auto, and commuter rail, while statewide multimodal efforts are largely limited to auto and rail for movement of passengers and goods.

Virginia's multimodal planning organizational structure is self-described as decentralized (Miller 2005). Section § 2.2-229 of the Code of Virginia ensures the planning process is coordinated, however, by establishing the Intermodal Office of the Secretary of Transportation. Coordination entails a technique or method for enhanced resource management, often resulting from teamwork of different agencies and backgrounds (Burkhardt 2004). Numerous sources identify the need for a long-range transportation plan to coordinate among stakeholders.

To fulfill this need for coordination, the Virginia Intermodal Office oversees the work of the Multimodal Advisory Committee composed of experts from each agency, the Federal Highway Administration, and the state's MPOs and PDCs. The committee coordinates the needs of all the participating planning organizations and creates a single statewide transportation plan known as VTrans. The most recent statewide plan, VTrans2025, included input from the following more narrowly-defined plans: Statewide Highway Plan, Small Urban Area Transportation Studies, Corridor and Feasibility Studies, Virginia State Rail Plan, Virginia Public Transportation and TDM Plan, MPO Constrained Long-Range Plans, the Virginia Air Transportation System Plan and the Virginia Port Authority Master Plan (VTrans2025, 2004). VDOT and DRPT (2004) have developed a taxonomy of Virginia transportation plans and the programming process.

Performance Metrics for Multimodal Transportation Planning

An objective comparison of projects across transportation modes poses several challenges.

Fleet et al. (1979) note that although characteristics such as speed, frequency of service, capacity, and operating cost can be measured for each mode, these characteristics are not appropriate for making modal trade-offs. The authors provide an example calculation of a company choosing to ship via truck or rail. While the actual transportation costs may be less expensive by rail, the additional inventory costs of rail make trucking the least expensive solution. Inventory costs, among other similarly important characteristics, are not traditional performance measures used during the planning process, but Fleet et al. suggest maybe they should be.

Hendren and Meyers (2006) similarly suggest that most of the measures used for planning purposes are similar to those proposed fifty years ago at the beginning of transportation planning in the United States. The authors suggest that rather than adopting the value judgments of civil engineers primarily responsible for facility operation, planning efforts should today apply "non-traditional performance measures" that provide decision-makers a broad perspective on how transportation relates to economic development, environmental quality, and perceptions of quality of life. Hendren and Meyers (2006) define non-traditional performance measures as "those measures or indicators of either transportation system performance or of phenomena external to the transportation system (but which are affected by transportation system operations) that are not commonly used in transportation planning." As examples of common mobility measures, the authors enumerate average daily hours of travel per person, average speed (perhaps by functionally classified system), average vehicle minutes of delay and, total passenger- and ton-miles traveled as common mobility measures. They offer "personal or household consumption expenditures on transportation" as a potential non-traditional measure of mobility.

Cambridge Systematics (1998b) provides a useful example of traditional and non-traditional performance measures used to monitor congestion. From a perspective of operators, level-of-service (LOS) or volume-to-capacity (V/C) are standard, output-oriented measures of performance. But from a perspective of users, there are different characteristics, such as average travel times for specific origin-destination pairs taken within the context of known average trip lengths, which reflect actual trip patterns (Cambridge Systematics 1998b). These measures are known as outcome-oriented measures because they reflect the outcome of the end user, whereas LOS and V/C reflect output statistics of links in the system.

In practice, transportation planners and providers have had difficulty defining and collecting performance measures that reveal the outcome of transportation planning processes and investments. "Availability of certain types of data, whether due to data collection or forecasting techniques, has a tendency to determine what measures are developed, regardless of what set of measures may have been defined at the outset of the process. The result is that goals are inadvertently modified to fit the available measure and data, and the pursuit of measures becomes the overriding focus rather than the pursuit of goals. Most of our case studies and interviews revealed this continuing problem" (Cambridge Systematics 1998a).

Examining survey results from 36 of 50 state DOTs in regard to performance measurements, Poister (1997) found that few states reported tracking multimodal performance measures. Those states that did report tracking measures reported funding for non-motorized travel, accidents at highway/rail grade crossings, number of intermodal projects, and amount and quality of non-automobile facilities. Poister suggests that state DOTs determine modally blind performance measures for cross-modal analysis as they engage in multimodal planning efforts.

Cost Analysis of Multimodal Corridors

Several studies and best practices are relevant to the development of cost analysis of multimodal corridors in long-range transportation planning.

Virginia is estimated to require $108 billion in transportation needs over the next twenty years and is one of many states facing a large transportation-spending deficit. Pedersen (1999) describes how ISTEA and TEA-21, combined with long periods for developing transportation projects, gave rise to a massive accumulation of unfunded state transportation needs. Short-term planning processes arose to catch up with previously identified needs and projects. And state, regional, and local transportation authorities struggled over needs and budgets.

Future funding shortages have forced statewide transportation planning efforts to focus on cost-effective spending. Florida's long-range multimodal transportation plan emphasizes causality between program investment and performance measures, noting that this linkage is important politically for obtaining future transportation investment (Cambridge Systematics 1999). Synthesis 243 completed by the National Cooperative Highway Research Program (NCHRP) (1997) points out that aligning capital programming for transportation projects with policy needs is only half the battle. Ensuring funded projects represent the most cost-effective transportation solutions is equally important. For example, technological developments such as advanced public transportation systems (APTS) achieve cost savings not only through reduced capital costs, but also through improved schedule adherence and efficient, automated data-collection methods (Ohene and Kaseko 1998). Funding shortages also force strategic use of existing federal aid programs, a tactic that is broadening the funding horizons of state DOTs (Younger and O'Neill 1998).

A variety of technical approaches have been investigated to ensure efficient spending of transportation funds. Copperman et al. (2004) and Lambert et al. (2005) demonstrate technical methods of coordinating and prioritizing multimodal investments. Reinke and Malarkey (1996) cite integrated transportation planning as a long-range strategic planning process having cost-benefit analysis as its analytical core. The authors develop a systems planning methodology to evaluate the cost-effectiveness of a broad range of transportation alternatives. Kulkarni et al. (2004) investigate need-based project prioritization, Korve and Niemeier (2002) and Khasnabis (1999) employ benefit-cost analysis to examine special phasing at signalized intersections. Latoski et al. (1999) use cost-effectiveness analysis to support the continuation of a highway assistance patrol.

NCHRP Synthesis 243 (1997) suggests that successful cost-effective spending is a direct result of the extent to which DOTs explicitly consider program tradeoffs and the specific methods DOTs use to evaluate program-level tradeoffs. Analyses are therefore required to clearly demonstrate modal tradeoffs amongst varying program options. To help visualize trade-offs, Ba-Ali et al. (2003) developed a novel interface for comparing transportation projects across a single mode. Requiring transportation project costs and performance data as inputs for analysis, this interface tool is primarily aimed at uncovering dominance between various projects. Frohwein et al. (1999) also provide a comparative technical analysis between alternative investment options.

NCHRP Synthesis 290 (NCHRP 2000) suggests comparison of a no-build, base scenario to one or more transportation investment scenarios when considering alternative investment strategies. Additionally, NCHRP Synthesis 238 (NCHRP 1997) directs statewide transportation agencies to conduct cross-modal analyses on an objective basis, using modally blind performance measures and comparable data across all modes.

Cambridge Systematics (1999, 1998a) suggests that communities and states compare the economic impact of alternative transit investments, of non-transit public works projects and of non-investment alternatives with one another. It also suggests a single methodology be applied to two or more investment scenarios and that the results are compared to identify which investment will result in the greatest positive economic impact (Cambridge Systematics 1998a). By combining modal comparison of transportation investment options with performance-based criteria evaluation, a cost comparison can be sought for evaluating alternative highway transportation investments. Giorgi and Pearman (2002) propose a method to analyze transportation investment alternatives based on cost-effectiveness. Due to the complexity associated with analyzing the benefits of alternative transportation projects, they suggest presuming a constant level of benefits across projects and then finding the most effective (least-cost) option that meets those benefits. This least-cost method has an advantage in that the benefits need not be explicitly valued (Giorgi and Pearman 2002).

METHODOLOGY

There are two parts of the methodology demonstrated in this report. First, we explore how long-range costs of investment across the eleven multimodal corridors might be compared from four readily available, complementary sources of data: (1) separate modal-agency corridor studies, including the state highway plan, (2) a highway-only needs assessment, (3) the long-range plans of regional authorities (MPOs/PDCs), and (4) the statewide highway plan. Second, we explore how to compare the multimodal corridors using demographic data including population density analysis with the 2000 U.S. Census.

Cost Analysis of Multimodal Corridors

In the first area of methodology, *cost estimates*, the numerical estimates of cost are provided solely for demonstration. The numerical estimates are not recommended for planning or programming decisions. Recommendations for the development of accurate numerical estimates are addressed later in the report in the results, discussion, conclusions, and recommendations sections. For each of the four sources of data, estimates of lifecycle costs including maintenance and operations costs were not available; thus, the methodology addresses capital costs only.

We address the sources of data in two pairs: (1) and (2) as described previously, and (3) and (4) described previously. Our pairing of the four sources of data in this way is for exploring and illustrating how the perspectives most differ from one another, indeed may even be inappropriate for intra-corridor comparison. Future cost-based comparisons with the four sources of data should resist source-to-source comparisons *within* corridors, and proceed instead to use the four sources of data for four separate cost-based comparisons of needs and opportunities *across* the eleven corridors. Our demonstration of methodology in this report is useful to understand which sources of data of (1) through (4) might be more appropriate for particular types of planning and policy decisions about the corridors.

In the first pairing, with the sources of data (1) and (2), we collect cost estimates from individual modal agency corridor studies and from VDOT's Highway Needs Assessment. The purpose of this pairing is to learn how cost estimates from the modal agencies' corridor studies differ in nature from those of the Highway Needs Assessment. The data collection is described in three steps.

For source (1), this effort determined all projects addressed by modal agency plans (including the State Highway Plan) within each corridor. Project capital costs of the non-highway modal agencies were obtained from agency websites, online documentation of corridor studies, and telephone conversations with agency staff. Cost estimates were added across modes and projects to obtain a multimodal corridor capital cost estimate.

For source (2), the effort aggregated cost estimates from VDOT's 2025 Highway Needs Assessment. Given future demand predictions, the needs assessment applies the Highway Capacity Manual (HCM 2000) to suggest fiscally unconstrained roadway and interstate improvements for over 19,000 planning-level segments of different lengths that were defined by set criteria. The cost estimates of highway-only needs were added within each corridor to provide a highway-only capital cost estimate. To illustrate the collection of data from source (2), we can consider two of the eleven corridors. The Northern Virginia (NOVA) Connections corridor comprises seven jurisdictions: Arlington County, Fairfax County, Loudoun County, Prince William County, City of Alexandria, Town of Vienna, and Town of Dumfries. To obtain the costs of the highway-only needs for this MIN, the effort consulted the Highway Needs Assessment to identify all highway projects and their capital costs within these jurisdictions. The roadways costs were added to arrive at the highway-only cost for the NOVA Connections corridor. The I-95 Passenger/Goods Movement corridor traverses north and south along Interstate 95 from Maryland to the North Carolina borders and is relatively more troublesome due to its yet unspecified footprint across multiple, large jurisdictions. This corridor spans four highway construction districts of Virginia—namely, the Fredericksburg, Hampton, NOVA, and Richmond districts. In obtaining a highway-only cost, it is not accurate to consider all roadway improvements within these districts, as the corridor does not encompass the entire area of each. Spatial comparisons were made between the transportation networks within each corridor and the highway projects specified within the Highway Needs Assessment. The total capital costs of all highway-only improvements within a corridor's geographical area were aggregated to arrive at a highway-only alternative cost.

We made a joint accounting of the data source (1) with the data source (2), exploring the reasons for differences between the two resulting cost estimates per corridor. Such accounting is controversial, not least because the benefits of the multimodal and the highway-only solutions are unlikely to be the same. In this report however, we proceeded without rejecting the notion that the benefits could be the same. The cost-differences between estimates using source (1) and estimates using source (2) were used to explore hypothetical cost differences between current multimodal transportation plans and highway-only needs estimates, without addressing life-cycle costs.

Next we made a joint accounting of the data source (3) with the data source (4). The purpose of this accounting was to explore differences between MPO/PDC and highway agency cost estimates and highlight opportunities for improving coordination. Again, only capital costs were available.

For data source (2), the effort collated all of the readily available MPO/PDC long-range transportation plans. Virginia has 14 MPOs and 21 PDCs. While each is considered to be a separate entity, some regional long-range transportation plans result from collaboration between MPOs and PDCs. The effort was able to obtain 12 of the 14 long-range transportation plans of the MPOs and eight of the 21 plans of the PDCs. The effort identified all projects within the MPO and PDC plans that geographically overlapped each of the statewide corridors. Discrepancies among agency plans provided challenges to the research effort. Because the state and each of the MPOs and PDCs create individual long-range transportation plans, differences exist in content, financial basis, and format. The contents of the numerous MPO/PDC plans are not uniform. Some contain a wide variety of transportation initiatives covering multiple modes, while others focus primarily on roadway projects and improvements. Some plans were developed as far back as 1997, while others were developed more recently. Cost projections within some plans include a variety of year-of-expenditure dollar projections, while others have no indication of a base year. Cost estimates for which a base year was known were updated to 2005 USD and were entered into a database of MPO/PDC projects. The projects were classified as either fiscally constrained (programmed) or unconstrained (vision). Tables 1 and 2 provide examples of the programmed and vision projects. Though we associated the projects to the corridors, we do not distinguish in this report which of the projects of only local significance and which are of corridor- and state-wide significance. We found that numerous of the projects are plausibly of only local significance. MPO/PDC capital cost estimations for each of the corridors were calculated by adding the costs of all corridor objectives within each corridor. For example, all Route 460 improvements were found within the MPO/PDC plans and entered into the database as part of the Richmond/Hampton Roads Passenger and Goods Movement corridor MPO/PDC cost projection.

For data source (4), the projects of the State Highway Plan were collected for each corridor and the costs of the projects were added. Data source (4) was also described as a component “modal study” for data source (1).

We pursued a joint accounting of the data source (3) and (4) as follows. The projected cost for each corridor based on MPO/PDC plans was juxtaposed with the corridor cost based on the State Highway Plan. The aim was to identify and explore issues where long-range planning estimates differ between source (3) and (4).

Table 1. Illustration of fiscally constrained projects of the MPO/PDC long-range plans

Route	Name	From	To	Length	ADT	Estimated Cost ($Ks)	Previous Funding
664	-	Route 660	Route 761	1.25	1,000	$ 500	$ -
460	Route 460 Business	Route 460	Lynchburg Corporate Limit	3.40	51,400	$ 21,521	$ -
460	Route 460	Odd Fellows Rd Ext. Interchange	-	n/a	n/a	$ 18,545	$ -
460	Route 460	Route 126	Rt 752	2.00	27,700	$ 12,660	$ -
460	Route 460	Route 501 (Campbell Ave)	Rt 29 Bypass N	2.40	53,000	$ 11,079	$ -
460	Route 460	Odd Fellows Rd Ext. Interchange	-	n/a	n/a	$ 1,111	$ -
460	Route 460 Business	Memorial Avenue	12th St	1.00	21,400	$ 611	$ -
460	Route 460	Route 501 (Campbell Ave)	Rt 29 Bypass N	n/a	n/a	$ 278	$ -
460	Route 460	Route 311	Parkdale Dr	n/a	n/a	$ 9,505	$ 5,749
460	Route 460	Parkdale Dr	Rt 419	n/a	n/a	$ 8,099	$ 7,342
460	Roanoke County - 460	Roanoke CL	Botetourt CL	n/a	n/a	$ 11,850	$ -
460	Route 460	0.20 mi S I-295	4.59 mi S I-295	4.39	n/a	$ 17,138	$ -
460	Route 460	4.59 mi S I-295	Study Area Boundary	2.24	n/a	$ 8,801	$ -
460	US 460	Bowers Hill	Southampton Co. CL	n/a	n/a	$ 642,000	$ 642,000
95	Interstate 95	Rt 630 Interchange	-	n/a	n/a	$ 92,000	$ -
95	Interstate 95	Rt 627 Interchange	-	n/a	n/a	$ 10,600	$ -
95	Interstate 95	Rt 627 Interchange	-	n/a	n/a	$ 19,000	$ -
95	Interstate 95	Rt 627 Interchange	Rt 630 Interchange	3.20	n/a	$ 36,000	$ -
95	Interstate 95	Spotsy Pkwy Interchange	-	n/a	n/a	$ 2,000	$ -
95	Interstate 95	N/A	-	n/a	n/a	$ 8,000	$ -
95	Interstate 95	1.1 mi S	3rd St	n/a	n/a	$ 2,461	$ 962
95	Interstate 95	James River and Broad St Bridge	-	n/a	n/a	$ 59,235	$ 56,659
95	Interstate 95	Atlee-Elmont Interchange	-	n/a	n/a	$ 76,552	$ 51,700
95	Interstate 95	Lewistown Rd Interchange	-	n/a	n/a	$ 2,200	$ 1,400
95	Interstate 95	Belvedere St Interchange	-	n/a	n/a	$ 5,000	$ -
95	Interstate 95	Various bridges	-	n/a	n/a	$ 58,665	$ 1,305
95	Interstate 95	Duval St Interchange	-	n/a	n/a	$ 5,500	$ -
95	Interstate 95	Maury St Interchange	-	n/a	n/a	$ 10,000	$ -
95	Interstate 95	Patrick Henry Rd Interchange	-	n/a	n/a	$ 13,663	$ -
95	Interstate 95	Kings Dominion Interchange	-	n/a	n/a	$ 13,858	$ -
95	Interstate 95	Lewistown Rd Interchange	-	n/a	n/a	$ 14,383	$ -
95	Interstate 95 HOV	-	-	n/a	n/a	$ 1,200	$ -
95	Interstate 95 HOV	Asland HOV	-	n/a	n/a	$ 5,500	$ -
95	Interstate 95 HOV	Rt 10 Southside HOV	-	n/a	n/a	$ 5,500	$ -
95	Interstate 95 HOV	Chippenham Southside HOV	-	n/a	n/a	$ 5,500	$ -
95	Interstate 95	NB ramp at Temple Ave	-	n/a	n/a	$ 3,762	$ 3,199
95	Interstate 95	Woods Edge Rd Interchange	-	n/a	n/a	$ 35,520	$ 34,338
81	Interstate 81	TN State Line	Cordon Line East	-	-	$ 120,000	$ -
81	-	North River	Rt 724 (N Cordon Line)	13.09	-	$ 55,420	$ -
81	-	Rt 17/50 Interchange	-	-	-	$ 33,536	$ -
81	-	Rt 7 Interchange	-	-	-	$ 33,536	$ -
81	-	Rt 37 N Interchange	-	-	-	$ 27,945	$ -
81	-	Rt 37 S	Rt 17/50	3.43	64,800	$ 24,593	$ -
81	-	0.5 mi S Rt 277	Rt 37 S	3.50	91,200	$ 24,257	$ -
81	-	Rt 7	Rt 11 N	2.31	93,600	$ 16,544	$ -
81	-	Rt 17/50	Rt 7	1.94	98,900	$ 13,861	$ -
81	-	Rt 277 Interchange	-	-	-	$ 11,179	$ -
81	-	Rt 37 S Interchange	-	-	-	$ 11,179	$ -
81	-	Rt 11 N Interchange	-	-	-	$ 11,179	$ -
81	-	Rt 11 N	0.5 mi N Rt 37 N	1.50	63,700	$ 9,949	$ -
81	Interstate 81	West SAB	East SAB	n/a	n/a	$ 44,280	$ -
73	Interstate 73	South SAB	Elm / Interstate 581	n/a	n/a	$ 12,146	$ -
64	Interstate 64	VA 288, Bridges & Loops at 250	-	n/a	n/a	$ 46,433	$ 41,749
64	Interstate 64	Oilville Rest Area	-	n/a	n/a	$ 2,900	$ -
64	Interstate 64	VA 288	Henrico CL	n/a	n/a	$ 4,500	$ -
64	Interstate 64	VA 288	1.6 mi W Ashland Rd	n/a	n/a	$ 4,500	$ -
64	Interstate 64	0.7 mi W Airport Dr	0.6 mi E I-295	n/a	n/a	$ 60,497	$ 3,688
64	Interstate 64	Bridge over Acca Yards	-	n/a	n/a	$ 22,897	$ 19,844

Table 2. Illustration of fiscally unconstrained projects of the MPO/PDC long-range plans

Route	Name	From	To	Length	ADT	Estimated Cost ($Ks)	Previous Funding	Remaining Balance
29	Emmet St	Ivy Road	Arlington Blvd	-	-	-	$ -	-
64	Interstate 64 Interchanges	Rt 250	Fontaine Ave	-	-	-	$ -	-
64	Interstate 64 (Easter Segment)	Bland Blvd	Rt 199	-	-	$ 556	$ -	$ 556
64	Interstate 64 (Western Segment)	Rt 199	New Kent	-	-	$ 557	$ -	$ 557
64	Interstate 64	Norview Ave Intechange	-	-	-	$ 63	$ -	$ 63
64	Interstate 64	Interstate 264	Interstate 464	8.22	-	$ 1,080	$ -	$ 1,080
64	Interstate 64 Peninsula	Rt 199	New Kent	18.90	-	$ 557	$ -	$ 557
64	Hampton Roads Bridge Tunnel	Interstate 564	Interstate 664	12.40	-	$ 2,700	$ -	$ 2,700
64	Interstate 64	Interstate 564	Mallory St	3.68	-	$ 480	$ -	$ 480
64	Interstate 64 (Norfolk)	Interstate 564	VB CL	8.39	-	$ 2,700	$ -	$ 2,700
64	Interstate 64	Norview Ave Intechange	-	-	-	$ 63	$ -	$ 63
73	Interstate 73	Interstate 581	South SAB	-	-	$ 55,000	$ -	-
81	Interstate 81	-	-	-	-	-	$ -	-
95	Interstate 95	Stafford/PW CL	Rt 610	5.00	-	$ 10,505	$ -	$ 10,505
95	Interstate 95	Rt 610	Rt 627	8.30	-	$ 21,010	$ -	$ 21,010
95	Interstate 95	Rt 627	Rt 3	6.00	-	$ 10,505	$ -	$ 10,505
95	Interstate 95	Caroline/Spotsy CL	Rt 3	12.40	-	$ 21,010	$ -	$ 21,010
95	Interstate 95	Rt 3	Rt 630	10.90	-	$ 10,505	$ -	$ 10,505
95	Interstate 95	Rt 630	PW CL	8.00	-	$ 21,010	$ -	$ 21,010
95	Interstate 95	Rt 17	n/a	-	-	$ 10,505	$ -	$ 10,505
95	Interstate 95	n/a	n/a	-	-	$ 21,010	$ -	$ 21,010
95	Interstate 95	Ramp at Temple Ave	-	-	-	$ 3,762	$ -	$ 3,762
95	Interstate 95	Rives Rd Interchange	-	-	-	$ 30,000	$ -	$ 30,000
460	Route 460	Isle of Wight	Southampton CL	-	-	$ 642	$ -	$ 642
460	Route 460	Roanoke County CL	East SAP	-	-	$ 34,295	$ -	$ 34,295
460	Country Drive	Hickory Hill Rd	Rt 106	2.16	-	$ 21,604	$ -	$ 21,604
460	Route 460 Alt	Rt 226	Rt 460	-	-	-	$ -	-
-	Hampton Roads Third Crossing	Southside	Peninsula	-	-	$ 4,484	$ -	$ 4,484
-	Midtown Tunnel	Brambleton Ave	Interstate 264	-	-	$ 686	$ -	$ 686
-	Hampton Roads Third Crossing	Hampton Coliseum	Interstate 64	30.00	-	$ 4,484	$ -	$ 4,484
-	Midtown Tunnel	Norfolk	Portsmouth	1.02	-	$ 466	$ -	$ 466

Demographic Analysis of Multimodal Corridors

In the second part of the methodology, we explore population densities across corridors using data from the 2000 U.S. Census. This part of the methodology involved two steps. First, the effort obtained Geographic Information Systems (GIS) shapefiles for the Commonwealth of Virginia. The shapefiles contain a wide variety of data including location of roads, airports, ports, railroads, county boundaries, and census boundaries. Shapefiles of 2000 U.S. Census data were also obtained. Data were aggregated by census block group because this geographical boundary provides a high level of granularity and is visible at a statewide level. The census block group boundaries contain associated information such as land area, population, and number of households, to name only a few characteristics. Next, for each corridor, the effort created a map of counties and block groups using the Geographical Information Systems application ArcGIS. Population density (persons per square mile) was calculated for each block group and was displayed on eleven maps of the corridors using graduated color scales.

RESULTS

This section describes the results of the study.

Cost Analysis of Multimodal Corridors

The results of the corridor cost-estimation analyses from the four data sources (1), (2), (3), and (4) are the following. In the joint accounting of sources (1) and (2) of multimodal plans and a highway-only needs assessment, the projected capital costs were obtained for multimodal improvements for five of Virginia's eleven corridors. The results are illustrated in Table 3.

Table 3. Summary of corridor cost estimate comparisons provided for anecdotal purposes only (supporting detail of the highway-only and multimodal solutions is provided by Wadie [2005]).

Corridor	Highway Only[a]	Multimodal[a]
Nova Connections	$5,700	$1,890
Route 29	$3,400	$630
Franklin Airport	$900	$1,160
Interstate 95	$11,840	$3,476
Hampton Roads	$4,370	$3,920

[a]2005 USD, ($M)

In the joint accounting of sources (3) and (4), the individual MPOs and PDCs plan estimates and the State Highway Plan estimates, the effort obtained data for seven of the eleven corridors from the MPO/PDCs. The results of these comparisons are shown in Table 4, in which the costs have been adjusted to 2005 dollars. An entry in the table of $0 indicates a cost was not available. Descriptions of the results for individual corridors are provided here.

The State Highway Plan, data source (4), cost estimate of the Franklin Airport corridor (M05) significantly exceeds the cost estimate based on projects from the MPO/PDC long-range plans. This discrepancy in the two cost estimates likely arises because the state highway improvement is over 60 miles long, but less than 10 miles of the improvement exist within the Roanoke MPO area. Future study might determine the state's estimate for improvements within the MPO so that the two estimates may reasonably be compared.

Further information is needed for the Richmond to Hampton Roads corridor (M02) as well. The MPO/PDC long-range plans evaluated do not contain cost projections for the third and fourth corridor objectives. The expected cost of the Interstate-64 objective is greater from the state's perspective than from the region's perspective. Conversely, the Route 460 objective has much higher cost estimates at the regional level, in part because the MPO recommendation is to have this route built to interstate standards. The State Highway Plan, however, recommends adding an additional lane but not making it limited access. The difference between recommendations and therefore cost estimates may demonstrate a difference in understanding between the state and the region concerning the importance of this route.

The cost comparison for the Interstate 95 corridor (M03) reveals that many of the corridor objective cost estimates are higher from the state's perspectives, thus confirming Interstate 95's vital role in the entire state's development, from both transportation and economic viewpoints. It is intuitive that localities and regional transportation authorities may prefer to include alternate initiatives for other projects in their long-range plans, as the state would likely pursue improvements to Interstate 95. It is important to consider that the MPOs include projects of statewide significance in their constrained long-range plans so that these projects are eligible for federal highway funding.

Table 4. Summary of state and MPO/PDC cost estimates

Corridor	Objective	State Estimate[a]	MPO/PDC Con-strained[a]	MPO/PDC Uncon-strained[a]	MPO/PDC Total[a]
Franklin Airport					
	Interstate 73	1,140	12	55	67
	Franklin Airport	16	0	0	0
Franklin Airport Total		**1,156**			**67**
Richmond/Hampton Roads					
	Interstate 64	1,700	977	9	986
	US-460	317	763	57	820
	Passenger Rail Tier 1	324	0	0	0
	Jamestown 2007	8,130	0	0	0
Richmond/Hampton Roads Total		**10,471**			**1,806**
Interstate 95					
	Interstate 95	2,770	469	160	629
	Interstate 95 HOV	215	18	0	18
	SE High Speed Rail	486	0	0	0
Interstate 95 Total		**3,471**			**647**
Route 29					
	Route 29	628	427	0	427
Route 29 Total		**628**			**427**
Port Accessibility					
	Route 58	51	204	0	204
	Intermodal Connector	113	0	0	0
Port Accessibility Total		**164**			**204**
Hampton Roads					
	Interstate 664	2	6	0	6
	Third Crossing	2	0	9	9
	Mid-Town Tunnel	0	0	1	1
Hampton Roads Total		**4**			**16**
Interstate 81					
	Interstate 81	Under Study	437	0	437
	Lexington Airport	16	0	0	0
Interstate 81 Total		**16**			**437**

[a]2005 USD, $M

Relative to the other corridors, the M07 corridor showed nearly agreeing cost estimates between the statewide and regional perspectives. The difference between the two alternatives was $200 million, which is relatively small compared to the cost differences for the other corridors. Two findings are evident from examination of the M07 corridor. First, the corridor appears to be of regional and statewide significance, because most of the MPO/PDC suggested improvements are shown in the fiscally constrained list of projects. Second, MPO/PDC cost estimates are less than the statewide estimate because MPOs consider only the improvements that occur within their boundaries.

The cost estimate for the Route 58 corridor (M04) is greater from the MPO/PDC regional source of data (3) than from the state source (4). Considering the Intermodal Connector objective, however, reveals similar corridor costs (less than $50M deviation) from state and regional perspectives.

Unlike many of the other corridors, the Hampton Roads corridor (M01) contains a large number of fiscally unconstrained projects. The Interstate 664 initiative contains a higher, if not overly ambitious, cost projection from the MPO/PDC regional perspective as compared with that of the state. Moreover, its inclusion in the fiscally constrained list of projects suggests its importance to the Hampton Roads region. The Third Crossing, on the other hand, is placed on the fiscally unconstrained list. Its cost estimate is higher from the regional source than from the state source. Similarly, the state does not include the Mid-Town Tunnel objective in its long-range plans, while the MPO/PDC transportation authority includes it as a fiscally constrained initiative.

The Interstate 81 corridor (M04) will be a large initiative, as it is a major interstate and a primary freight corridor in Virginia. The fiscally constrained cost projection from the MPO/PDC regional perspective is high, and one might expect the State Highway Plan projection to be even higher. Because many aviation initiatives are not included in the MPO/PDC long-range plans, the second corridor objective here (Lexington/Rockbridge County Airport) contains a cost estimation from the state perspective only.

Demographic Analysis of Multimodal Corridors

Illustrations of results of the corridor population density analysis are displayed in Figure 1 through Figure 11. Larger versions of the figures are provided in the Appendix. Each figure depicts one of eleven critical transportation corridors in Virginia. The figures show housing units per acre as representative of population density. Each corridor map shows the primary highway as well as projected areas of significant congestion in the year 2030. To project where the increases in population density would be in 2030, shapefiles from the Virginia Highway Needs Assessment were obtained. The needs assessment shows segments of road that would require more than twelve lanes to meet projected automobile travel demand. These segments may be an acceptable proxy for future population density and can be shown on the same map as current population density. These road segments with an unreasonable number of lanes are shown as “unreal” or “unrealistic” needs and have a thick, darker (black) line in Figure 1 to Figure 11. Road segments with a reasonable number of lanes have a thin, lighter (gray) line in Figure 1 to Figure 11.

Statistical data concerning number of counties and population percentages were obtained from a VTrans Multimodal Advisory Committee working document. Additional discussion of the analyses reflected in each map is provided here.

The Interstate 81 corridor shown in Figure 1 passes through 25 Virginia counties having 13% of the state’s total population. With the exception of Roanoke and Winchester, most of the development is low in density, suggesting that this corridor may not be able to support multimodal investments in passenger travel. The large volume of freight traffic, however, may make this corridor well suited to multimodal freight transportation investments.

The U.S. 460 corridor shown in Figure 2 traverses 28 Virginia jurisdictions that comprise 20% of the state's population. It is a major corridor for passenger and goods movement from Southwest Virginia to the Hampton Roads/Norfolk region. There is low-to-moderate density in Roanoke and Norfolk, suggesting this corridor is similar to Interstate 81 in that it may be better-suited for freight multimodal investments rather than passenger.

The U.S. 29 corridor shown in Figure 3 crosses 21 jurisdictions and contains 31% of the state's population. Heavy density in Northern Virginia makes this corridor more amenable to multimodal transportation investment. However, the density tapers off rapidly as one travels south.

The U.S. 58 corridor is shown in Figure 4 traversing over 40 jurisdictions and including 31% of the state's population. With the exception of Norfolk, this corridor contains extremely low density, suggesting it may be a poor candidate for certain types of multimodal passenger transportation investment.

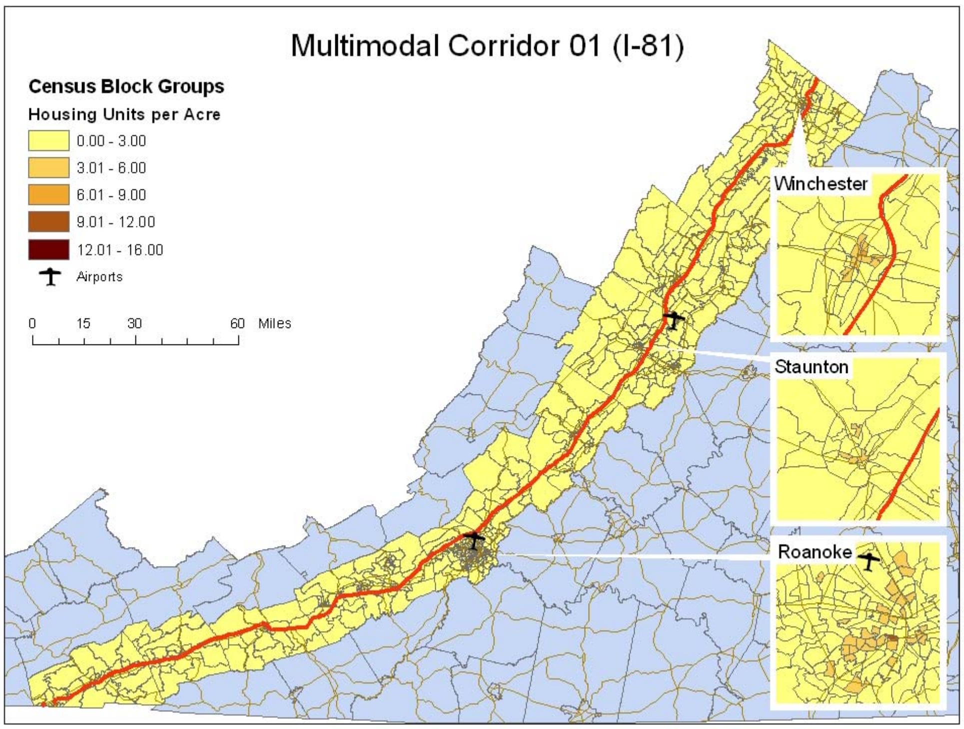

Figure 1. Illustration of the demographic analysis with corridor M01 (Interstate 81)

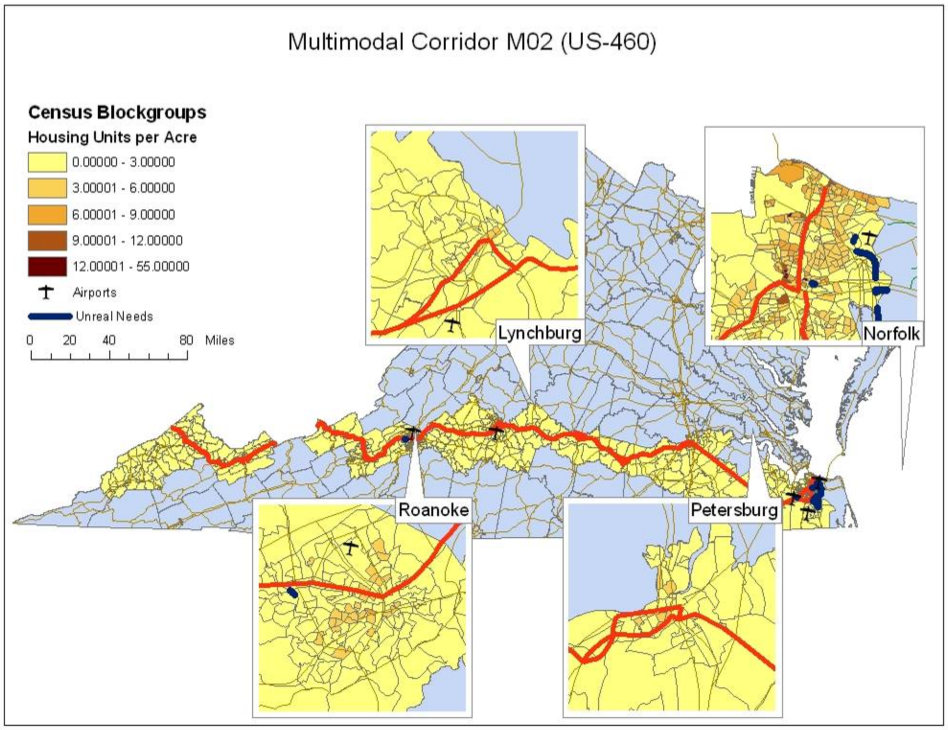

Figure 2. Illustration of the demographic analysis with corridor M02 (U.S. 460)

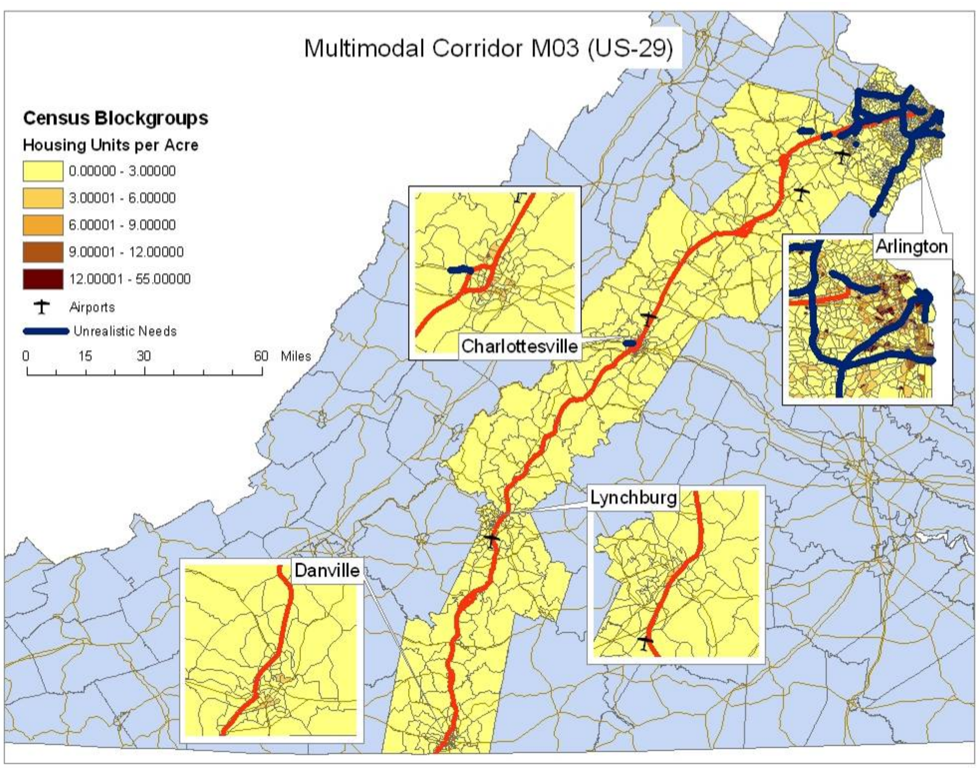

Figure 3. Illustration of the demographic analysis with corridor M03 (U.S. 29)

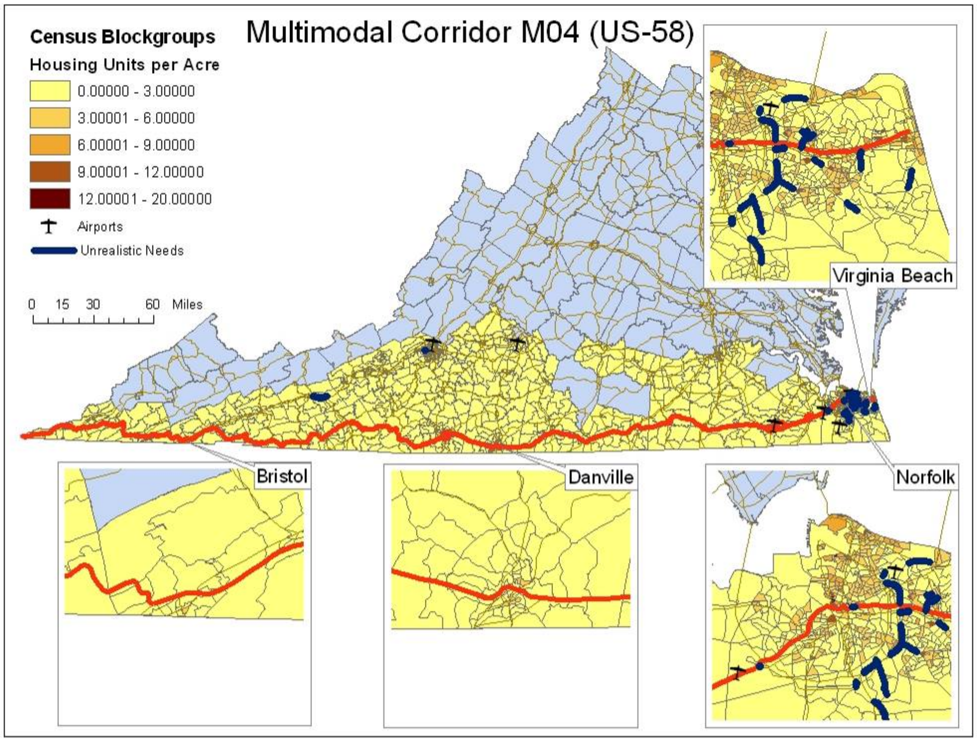

Figure 4. Illustration of the demographic analysis with corridor M04 (U.S. 58)

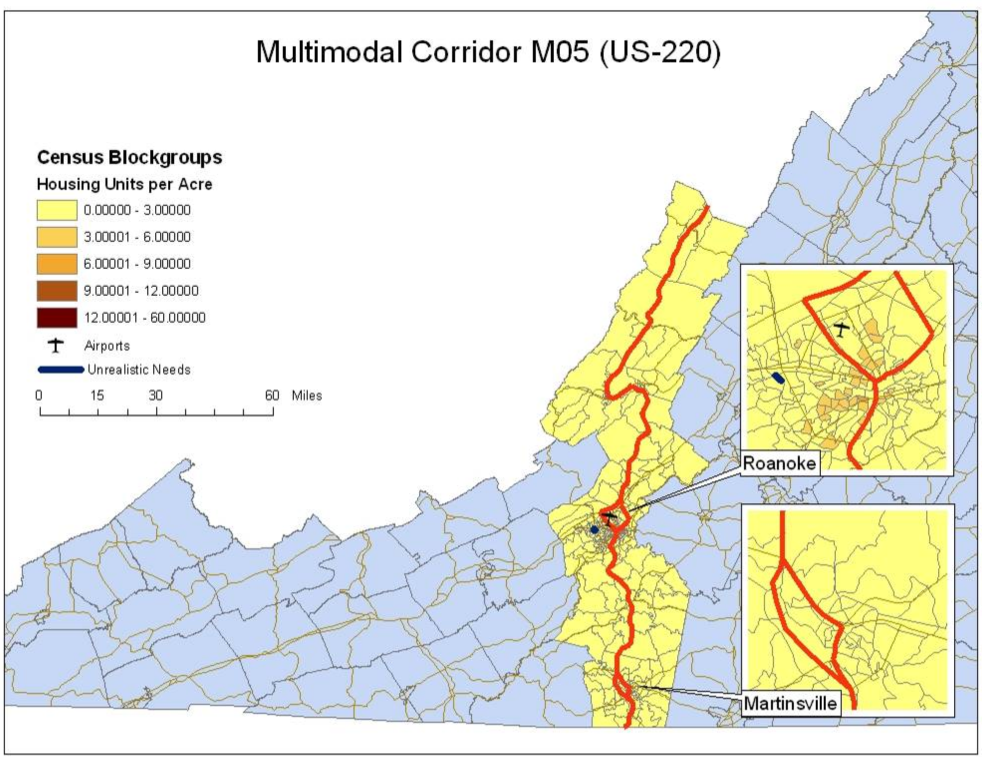

Figure 5. Illustration of the demographic analysis with corridor M05 (U.S. 220)

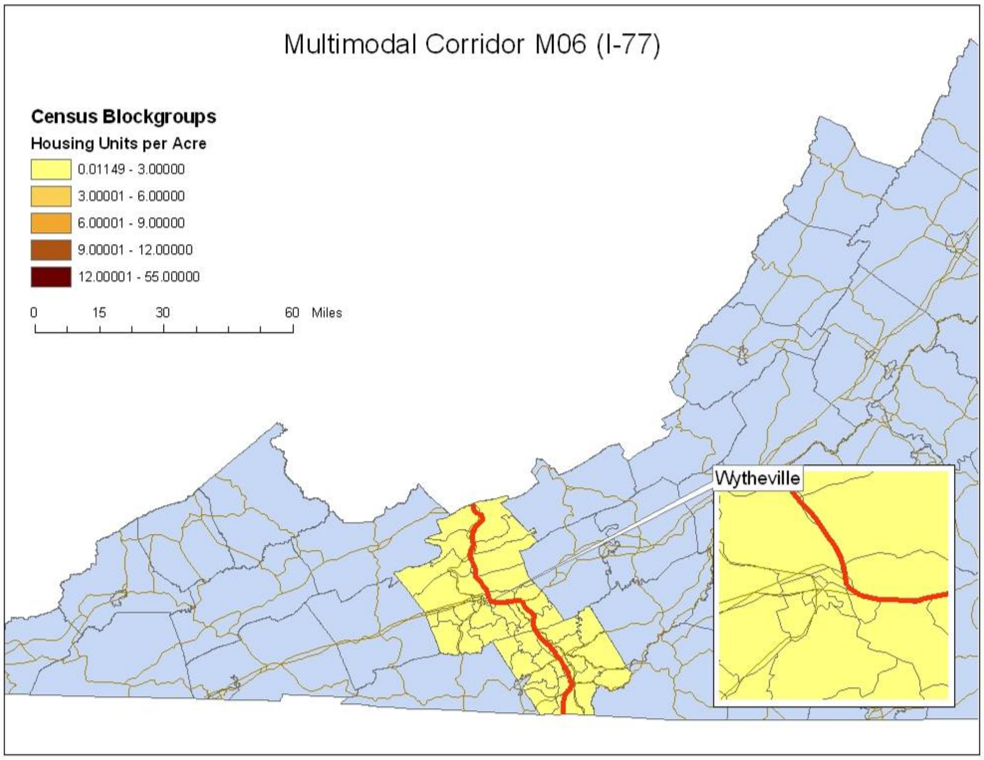

Figure 6. Illustration of the demographic analysis with corridor M06 (Interstate 77)

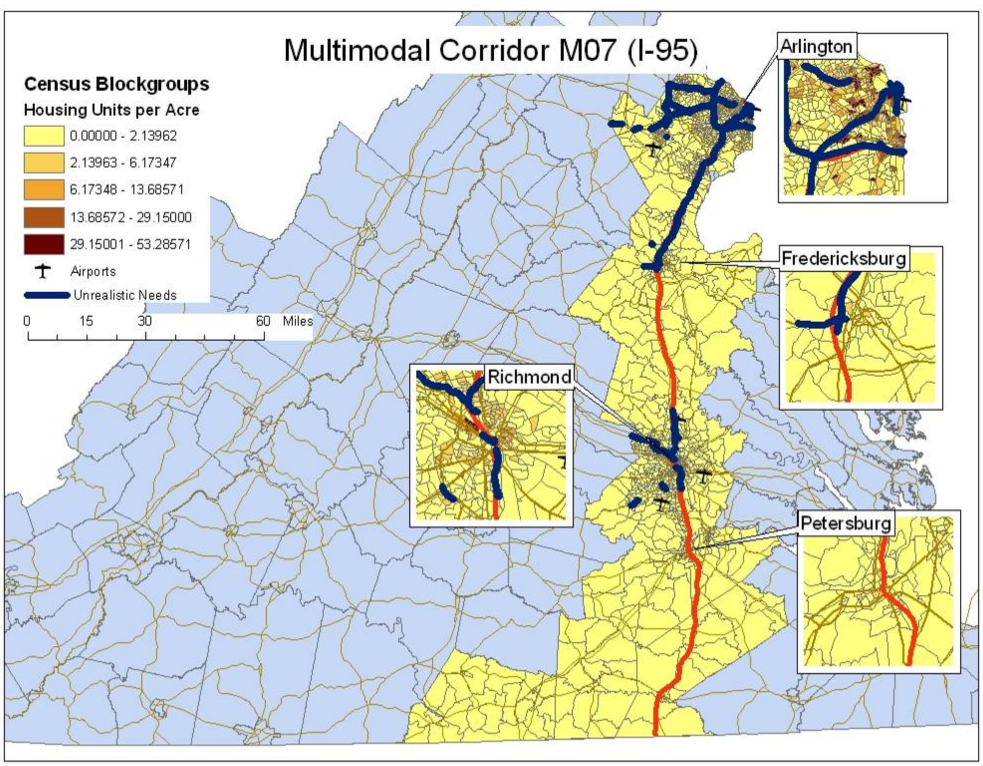

Figure 7. Illustration of the demographic analysis with corridor M07 (Interstate 95)

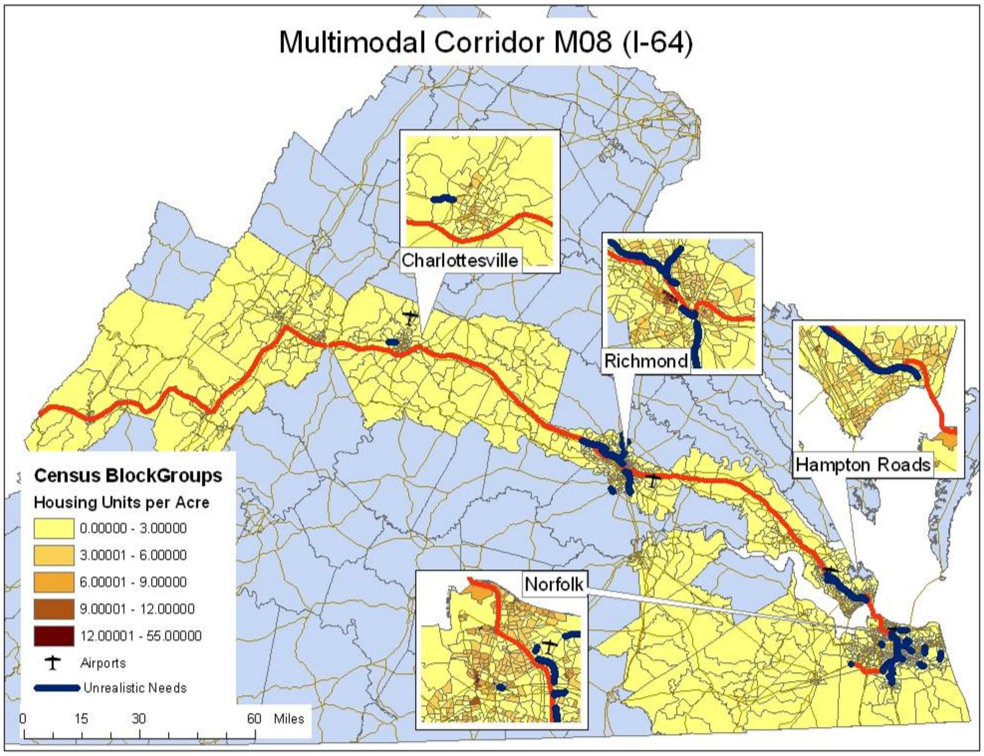

Figure 8. Illustration of the demographic analysis with corridor M08 (Interstate 64)

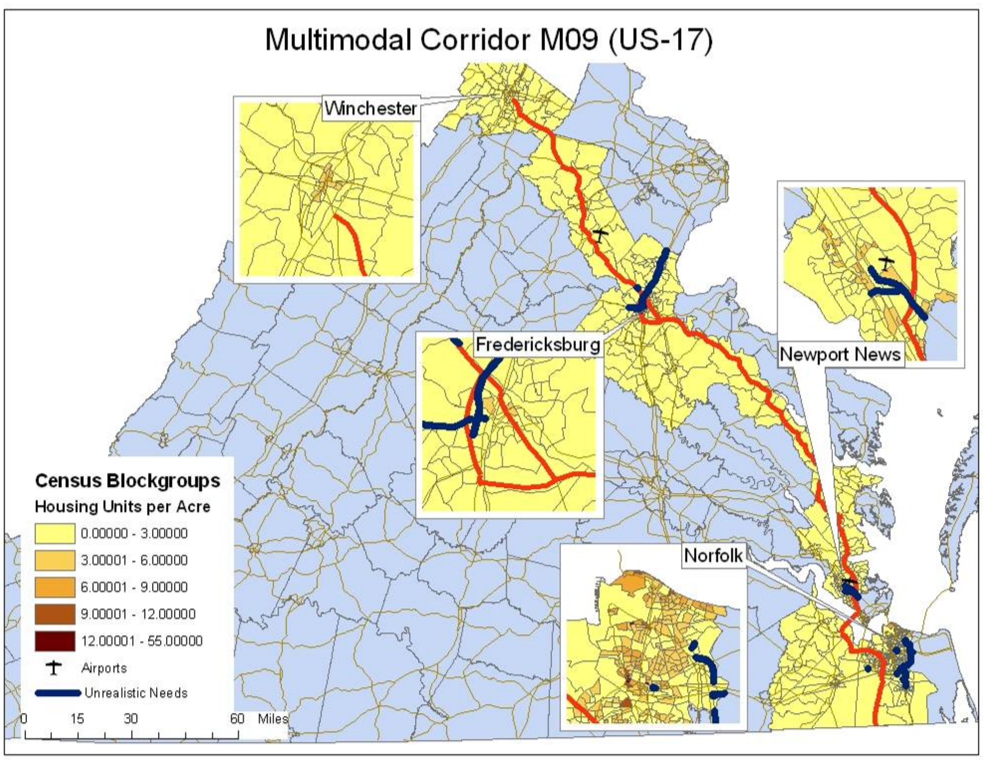

Figure 9. Illustration of the demographic analysis with corridor M09 (U.S. 17)

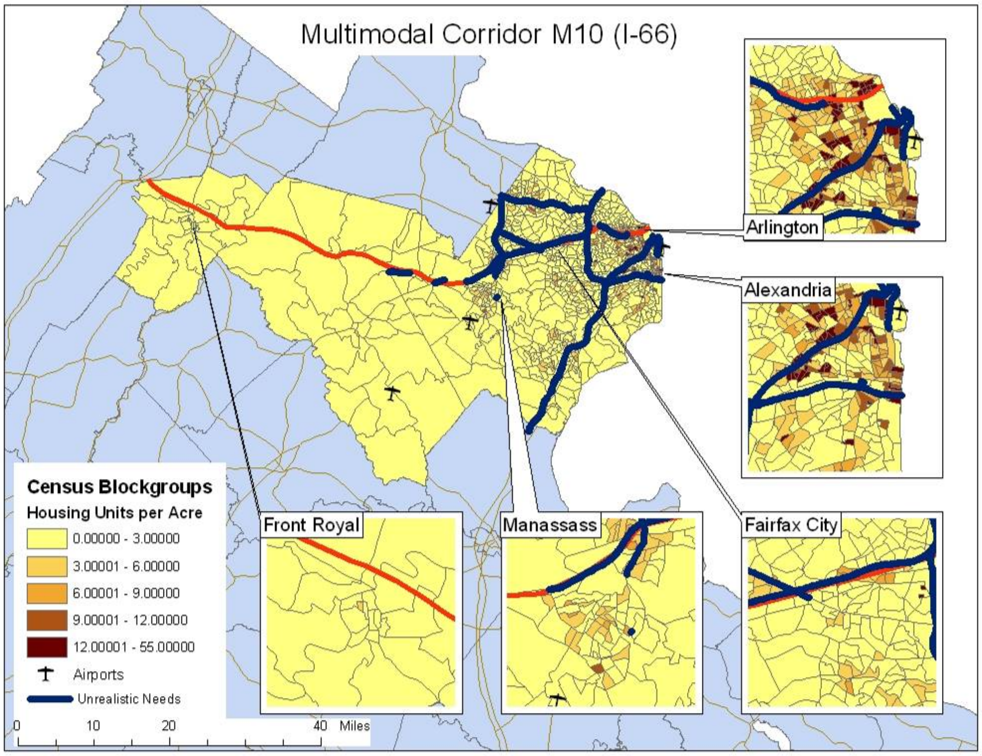

Figure 10. Illustration of the demographic analysis with corridor M10 (Interstate 66)

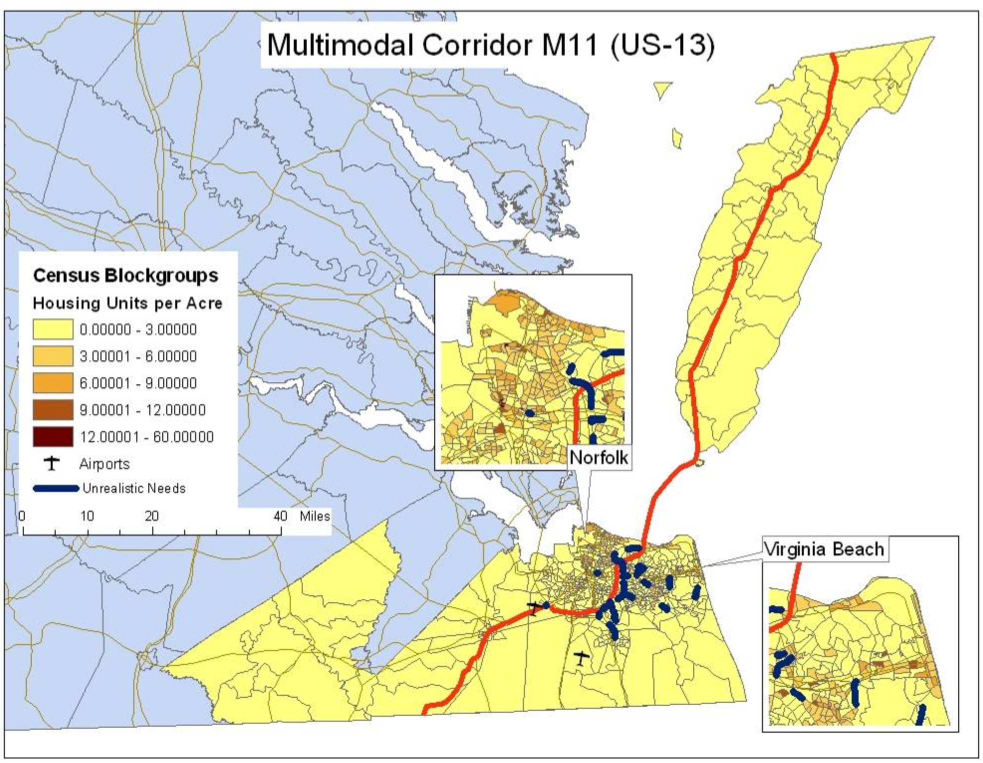

Figure 11. Corridor M11 (U.S. 13)

The U.S. 220 corridor is shown in Figure 5 and contains 5% of Virginia's total population. As it passes through a single city of moderate density, Roanoke, this corridor is also a poor candidate for multimodal passenger transportation investment.

The Interstate 77 corridor shown in Figure 6 is similar to that of U.S. 220. It passes through no areas of significant population density and is ill-suited for statewide multimodal investment in passenger transportation.

The Interstate 95 corridor shown in Figure 7 crosses 27 Virginia jurisdictions and includes 41% of the state's population. As displayed in the figure, it connects Northern Virginia with Richmond, and is a vital connection to the Hampton Roads/Norfolk region via Interstate 64. Supporting heavy volumes of both passenger and freight traffic and passing through areas having the state's greatest density, this corridor is a prime candidate for both passenger and freight multimodal investments.

The Interstate 64 corridor shown in Figure 8 passes through 32 Virginia jurisdictions, home to 34% of the state's population. This corridor passes through Hampton Roads/Norfolk and Richmond, both areas having relatively high population density, and continues west to Charlottesville. This corridor carries a significant amount of freight and passenger traffic, and similar to Interstate 95, it may be well-suited for multimodal transportation investment.

The U.S. 17 corridor shown in Figure 9 crosses 17 Virginia cities and counties and is home to 17% of the state's population. It connects Winchester, Fredericksburg, and Hampton Roads/Norfolk. Although the latter has relatively high population density, this corridor is a poor candidate for multimodal passenger transportation investment.

The Interstate 66 corridor shown in Figure 10 passes through 12 jurisdictions and contains 24% of the state's population. Almost half of this corridor is engulfed in high density development, making it a strong candidate for multimodal passenger travel investment.

The U.S. 13 corridor shown in Figure 11 passes through six jurisdictions that are home to 16% of the state's total population. Although it passes through Norfolk and Virginia Beach, this corridor does not connect areas of high population density and is a poor candidate for multimodal passenger transportation investment.

DISCUSSION

This section discusses the results of the cost and demographic analyses.

Cost Analysis of Multimodal Corridors

We encourage understanding of each source of cost data (1) through (4) for whether it could be meaningful in guiding plans and policies across the eleven multimodal corridors. Such understanding has benefited from our exploring the differences among the various sources of data described previously. In practical applications, we encourage maintaining a separation of the sources of data in multiple, complementary perspectives (see, e.g., hierarchical holographic modeling, in Haimes [2004]) of the corridors. We discourage practical applications of the *cost* results that could be suggested by comparing the numerical results from the sources of data (1) through (4) within corridors. For example, a practical evaluation of the cost-efficiency of multimodal versus highway-only alternatives in a corridor is not supported by the current effort. A cross-corridor comparison of the costs of plans that have been investigated by various modal agencies is supported by the current effort, in particular by data source (1).

The cost analysis of multimodal corridors revealed several issues and challenges of preparing and comparing cost estimates from multiple perspectives. The particular numerical results are illustrative only. For example, although Table 3 appears to show a capital cost savings of multimodal alternatives relative to the associated highway-only alternatives, several cautions must be considered.

First, though the multimodal and highway-only alternatives span equivalent regions defined by the corridors, the benefits and performance of the competing strategies are not assured to be equivalent. Projects defined in the statewide plan and roadway improvements found in the Highway Needs Assessment often fulfill different underlying purposes and have potentially different benefits. Currently, there are sparse data at the state level that demonstrate differences in performance of multimodal solutions compared with that of highway-only solutions. In some instances, a highway-only option may result in increased mobility, decreased congestion, and decreased travel times. On the other hand, a multimodal solution may serve to increase redundancy of the overall network, alleviate environmental stresses caused by air and noise pollution, balance transportation equity, and increase opportunities for implementing travel demand management strategies. Without further studies in areas other than cost analysis, it will be impossible to adequately weigh the trade-offs between the two strategies. Verifying that competing multimodal and highway-only strategies indeed have similar benefits was out of the scope of this study and should be investigated in future efforts.

Second, the literature extensively documents the need for operations and maintenance costs in addition to capital cost projections. Because most transportation agencies and MPO/PDCs did not have operations and maintenance costs for many of the projects, life-cycle costs were not included in the study. Although there appear to be capital cost savings in choosing multimodal over highway-only investments, operations and maintenance costs of multimodal solutions may be greater than those of highway-only solutions. The differences in life-cycle costs may offset or exceed any savings in capital costs. Without life-cycle costs, reliable cost-analysis cannot be executed with confidence.

Third, the 2025 Highway Needs Assessment is an unrealistic basis on which to compare multimodal projects. The assessment developed highway-only solutions that were not constrained, resulting in somewhat unrealistic solutions in some cases, such as 16-lane interstate facilities. The Highway Needs Assessment was not meant for project development. Instead, it was a tool that removed all subjective analysis (thus no lane constraints) and only addressed what would be required from a highway standpoint to meet forecast demand. It does not provide recommendations as such, nor does it consider the feasibility of constructing projects to meet the identified highway needs. Realistic highway-only implementations such as those found in the 2025 State Highway Plan should be used to provide more meaningful comparisons.

Fourth, the multimodal solution and the highway solution do not necessarily provide the same performance. Indeed what constitutes the multimodal solution is not necessarily defined. For example, consider the Route 29 corridor. It may not be clear from Table 2 or Table 3 alone what "multimodal" means. One might consider that *multimodal* means increased transit use (possibly a bus or light rail line) or increased walking opportunities. Such disparate approaches will not necessarily yield the same benefit as the “highway-only” Route 29 widening.

Fifth, the capital costs were not able to be obtained in a consistent manner. Consider the I-95 corridor shown in Table 4, where Interstate 95 is shown to have a cost ($2,770M) that is approximately 13 times the cost of Interstate 95 HOV ($215M). From what is known about HOV, unless this is a bus-only lane, the HOV facility could move between 1.5 and 3 times the number of people as an unrestricted facility thus a factor of 13 may be unreasonable. The reason for this inconsistency may be twofold: (1) detailed estimates were available for highway improvements but not for the other modal improvements, so phone calls and websites were the source of this other information, and (2) the highway improvement had to meet a performance standard (move this number of vehicles per hour) whereas the multimodal improvement did not have to meet any such standard.

Sixth, with respect to the State Highway Plan compared with those of the MPO/PDCs, Table 4 shows the estimates from the statewide plan generally exceed those of the MPO/PDC plans. However this may not be a fair comparison. MPO long-range plans must be financially constrained while statewide plans can include unconstrained projects. The State Highway Plan indicates projects that will resolve all true needs, even if revenues will never exist to support those needs. TEA-21, however, required MPOs only to have a “financially constrained” plan. As a result, the MPOs could only show projects for which they could reasonably expect to have sufficient funds in the next twenty years, and it is natural that the state estimates would appear to be larger.

Other differences in the statewide and regional plans may be attributed to MPO/PDC boundaries not encompassing entire improvements considered by the state plans, the statewide significance of the routes, and the types of projects under consideration. Routes or projects of greater statewide significance are generally granted larger funding allocations in the Virginia DOT plan than in the local MPO/PDC plans. Because Interstates 95, 64, and 73 are responsible for maintaining efficient movement of people and goods across large, vital portions of Virginia, it appears the state expects significant investment in these initiatives. On the other hand, smaller roadway initiatives that connect adjacent regions or directly benefit localities within those regions seem to be of greater interest to the MPO/PDCs, highlighting a desire for investments that benefit regions within the state.

Thus, there are several root causes of the disparity of the cost estimates across the four sources of data. Recognizing and confronting these causes should bring increased understanding and an improved basis for coordination across multimodal agencies. Additional work is needed to understand what sources of cost data can best inform the development of cost-effective statewide multimodal transportation investment strategies.

Demographic Analysis of Multimodal Corridors

Population densities are generally greatest in areas with significant populations, such as Virginia's independent cities and especially Northern Virginia, Hampton Roads/Norfolk, and Richmond. While this is not surprising, this study shows population densities in the context of Virginia's critical transportation corridors and highlights those corridors in which statewide multimodal transportation investments may be comparably most advantageous. It is well documented in the literature that dense development is needed to support transit investments. In what is still a definitive commentary, Pushkarev (1977) suggests an average of 15 or more housing units per acre to support frequent local bus transit, and an average of 12 housing units per acre covering a 100-150 square-mile corridor to support rapid rail transit. As the Interstate 95 corridor connects Northern Virginia and Richmond and is a major conduit to and from Hampton Roads, this corridor is perhaps a strong candidate for multimodal transportation investment. Interstate 64 connects Richmond and Hampton Roads/Norfolk, and is also a potential candidate for multimodal passenger transportation investment.

Although population density is not the only factor in determining ability to support multimodal passenger investment, it is a large contributor toward project viability. Population density data for the remainder of the Virginia corridors seem to indicate limited ability to support multimodal passenger investment. These corridors are generally low in density and connect few large population centers along their routes. In future studies, the subject corridors should be extended to determine whether these routes connect to higher density areas outside the state. In addition, freight characteristics such as volume and capacity and origins and destinations should be researched to determine viability for multimodal freight projects along these corridors.

The demographic analysis is the beginning of a focused and extended effort to use journey-to-work and other demographic and other behavioral data to identify and prioritize opportunities to address multimodal (in) accessibility, unsupported transit needs, and similar circumstances within and across the eleven corridors.

CONCLUSIONS

This report demonstrates the cost and demographic components of an analytical framework that will ultimately be useful for comparing statewide multimodal plans and policies in multimodal corridors. The framework may ultimately encompass demographic, behavioral, infrastructural, environmental, institutional, land use, cost-efficiency, and other characteristics. The report illustrates how multiple sources of data can be used to compare needs and opportunities of Virginia's eleven statewide multimodal corridors based on selected cost and demographic characteristics.

Cost Analysis

- The monetized costs can be used to compare investments across transportation modes and corridors; however, benefits must plausibly be the same when comparing transportation alternatives using only this measure. It was outside the scope of this study to make this determination.

- If benefits are not judged to be equivalent, they should be quantified, instead of using the cost estimates alone as a surrogate for cost-effectiveness. If benefits can be quantified, cost-effectiveness analysis, which compares life-cycle costs with quantifiable, non-dollar benefits, or benefit cost analysis, which compares life-cycle costs with dollar-quantifiable benefits should be used. Transportation planning agencies should work toward the goal of accurately quantifying benefits, thus enabling the use of proper cost-effectiveness and cost-benefit methods of analyses.

- Cost estimates should include all costs incurred during the system life-cycle. Modal agencies and MPO/PDCs did not have operations and maintenance costs for many projects, and without this information reliable cost-analysis cannot be undertaken.

- Greater cooperation is needed among MPOs/PDCs to provide long-range transportation plans in consistent formats. MPOs/PDCs should strive to conform to a single standard in terms of content, basis, and format. All plans should contain lists of both "programmed" (fiscally constrained) and "vision" (fiscally unconstrained) projects.

- The state cost estimations for interstates tend to be higher than those from the regional plans. This discrepancy should be investigated further to determine the cause. And finally, increased coordination between state and modal transportation authorities, and also between the state and regional planning organizations will be useful to proceed toward an integrated, multimodal statewide transportation system.

- A common pitfall of analyses in these topics is inadvertently fitting the goal to the available data (Cambridge Systematics 1999, 1998a). One might consider that the cost analysis did exactly that: using various capital costs as a basis of the study because they were readily available. Overall, of course, to point to the lack of available data to derive accurate cost estimates for all of these projects is progress itself. The effort described in this report is best considered to be a starting point for determining the data needs and opportunities for coordinating data acquisition of multiple modal agencies. The exploration of multiple sources of data in the cost analysis should not be considered to be a quantitative comparison of whether Virginia should invest in the highway only or multimodal alternatives.

Demographic Analysis

- Population densities were greatest in those areas with greatest absolute populations.

- As greater population densities are required for supporting alternative transportation modes, those corridors connecting areas of significant densities are best suited for multimodal transportation investments.

- The literature suggests that preliminary work has been done to identify what thresholds of populations density qualify a region for particular types of multimodal improvements—but additional effort is needed to relate the demographic analysis to these thresholds, in particular to distinguish areas of supported and unsupported needs for transit, rail, and other modes.

RECOMMENDATIONS

1. *Future effort is warranted in several areas:*

   - *In the area of cost analysis, the report suggests two areas of effort to compare long-range transportation plans and policies within and across corridors*. First, state and regional agencies need to develop a common method for developing capital cost estimates when the project itself has not been defined. As described, the uncertainty about what exactly was the multimodal investment being considered naturally makes it difficult to determine the capital cost of this investment. Second, state and regional agencies need to develop a common method for including maintenance and operating costs in these projects. The fact that some of these projects have different durations increases the need for such a common method; clearly, for example, the duration of improved transit service and the duration of a lane addition will be different. Once a common, defensible approach can be developed for considering capital, maintenance, and operating costs, then it should be easier to compare the life-cycle costs of diverse projects.

   - *In the area of demographic analysis, further effort could characterize the corridors as strong or weak candidates for multimodal passenger investment*. The corridor areas should be extended outside state boundaries to ensure that all population centers affecting Virginia transportation are taken into consideration. Freight statistics such as origins and destinations, volumes and capacities, and shipping costs should be studied for consideration of multimodal freight investments. In addition, this population density study can be combined with statewide origin and destination flows to determine statewide accessibility ratios. These ratios can show the relative ease of transportation by a particular mode from origin to destination at a statewide scale. Areas with high population densities but low accessibility ratios for non-automobile modes may be candidates for statewide multimodal passenger investments. In addition, this density analysis can be included in future studies to identify opportunities for localized multimodal transportation investments that are of statewide strategic significance. For example, areas of highway congestion, high automobile mode share, and high population density can be targeted as areas with potential for multimodal transportation investments. High density and congestion should not be the only consideration. For example, some of the less populated areas of the Commonwealth need multimodal options for economic development. Creating better local transportation systems can alleviate congestion on highways of statewide significance. In addition, investing in local multimodal solutions will allow and encourage use of statewide multimodal transportation options. Travelers are more likely to involve a train or bus on a long-distance trip if they know they will not require an automobile once they get to their destination.

- *Effort is necessary to approach the remaining subject areas of the prototype corridor analysis framework.* The areas are behavioral, infrastructural, environmental, institutional, land-use, and other characteristics. In the subject area of institutional, research is necessary to determine whether the vision and planning efforts of all transportation, economic, and government stakeholders are aligned with each other. Institutional coordination and cooperation will be vital in creating integrated multimodal transportation networks. Further research considering public-private transportation projects would likewise be appropriate. In the subject area of infrastructural, data collection and analysis is needed to determine the transportation and other civil-infrastructure facilities that already exist, their owners, and their viability and strategic importance to the multimodal transportation system. Finally, research concerning technology/knowledge must be conducted to determine context sensitive solutions and techniques most appropriate for individual transportation challenges. The environmental and land-use topics present similar needs.

2. *The efforts outlined should be aligned with the ongoing performance-based planning initiatives of the VTrans Multimodal Advisory Committee.* Performance metrics that are being defined and reported on by the committee will provide some of the data necessary to the corridor analysis framework. The framework, in turn, will support decision-makers and policy-makers with knowledge that can be used to plan and implement a cost-effective statewide multimodal transportation system for the Commonwealth of Virginia. The framework is particularly relevant to addressing the new requirements of the Virginia 200 Appropriation Act (Items 427(1) and (2) and 442(A)(3)(b), Chapter 3, Special Session 1, 2006 Acts of Assembly) which directs state transportation agencies in the coordinated development of goals, performance measures, and standard cost-benefit methodology.

COSTS AND BENEFITS ASSESSMENT

This report has described initial steps and associated lessons for the comparison of multimodal corridors. The potential benefits of such a framework include:

- Coordination of four sources of data addressing the projected costs or savings of multimodal plans and policies in corridors: (1) modal agency plans, (2) highway needs assessments, (3) MPO/PDC constrained and unconstrained plans, and (4) statewide highway plans

- Characterization of statewide corridors by population density, highlighting those corridors that most benefit from particular types of multimodal investment

- Identification of lower-cost investment alternatives when considering multiple modes relative to considering only single modes to meet a particular travel demand

- Increased coordination and sharing of data and assumptions in analysis of multimodal corridors among the multimodal agencies.

The costs of implementing such a framework whose development is approached in this report include:

- Resources to improve the availability and accuracy of cost estimation practices across transportation modes and corridors

- Resources to characterize and quantify the benefits of highway and multimodal plans and policies

- One-time tutoring of staff of various transportation agencies in the identified challenges of the corridor analyses that are approached in the current study

- Resources for the continuing dialogue among the staff of the modal agencies and MPO/PDCs that are involved in the data collection, identification, and prioritization of investments across modes.

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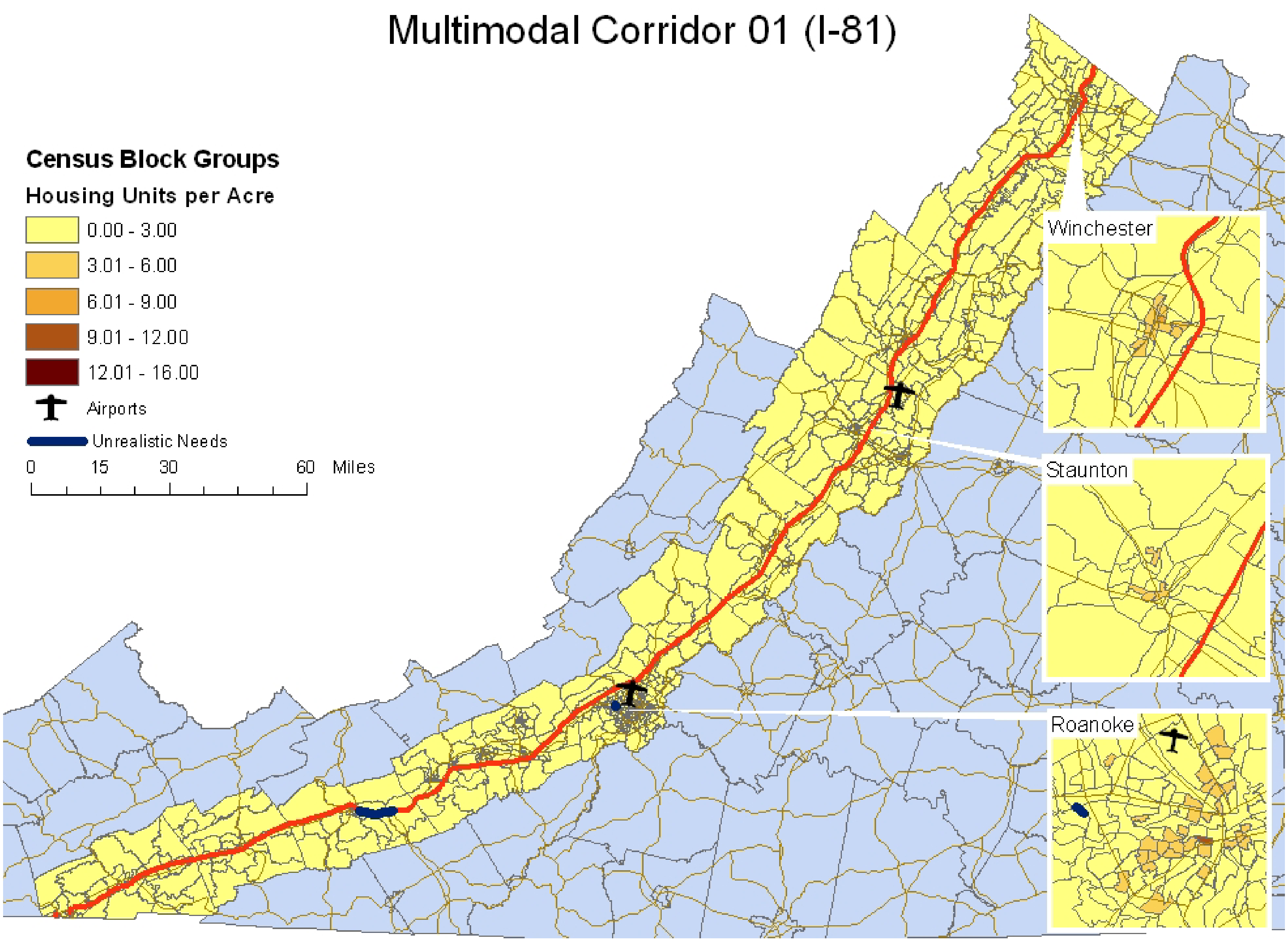
APPENDIX

ENLARGED CORRIDOR MAPS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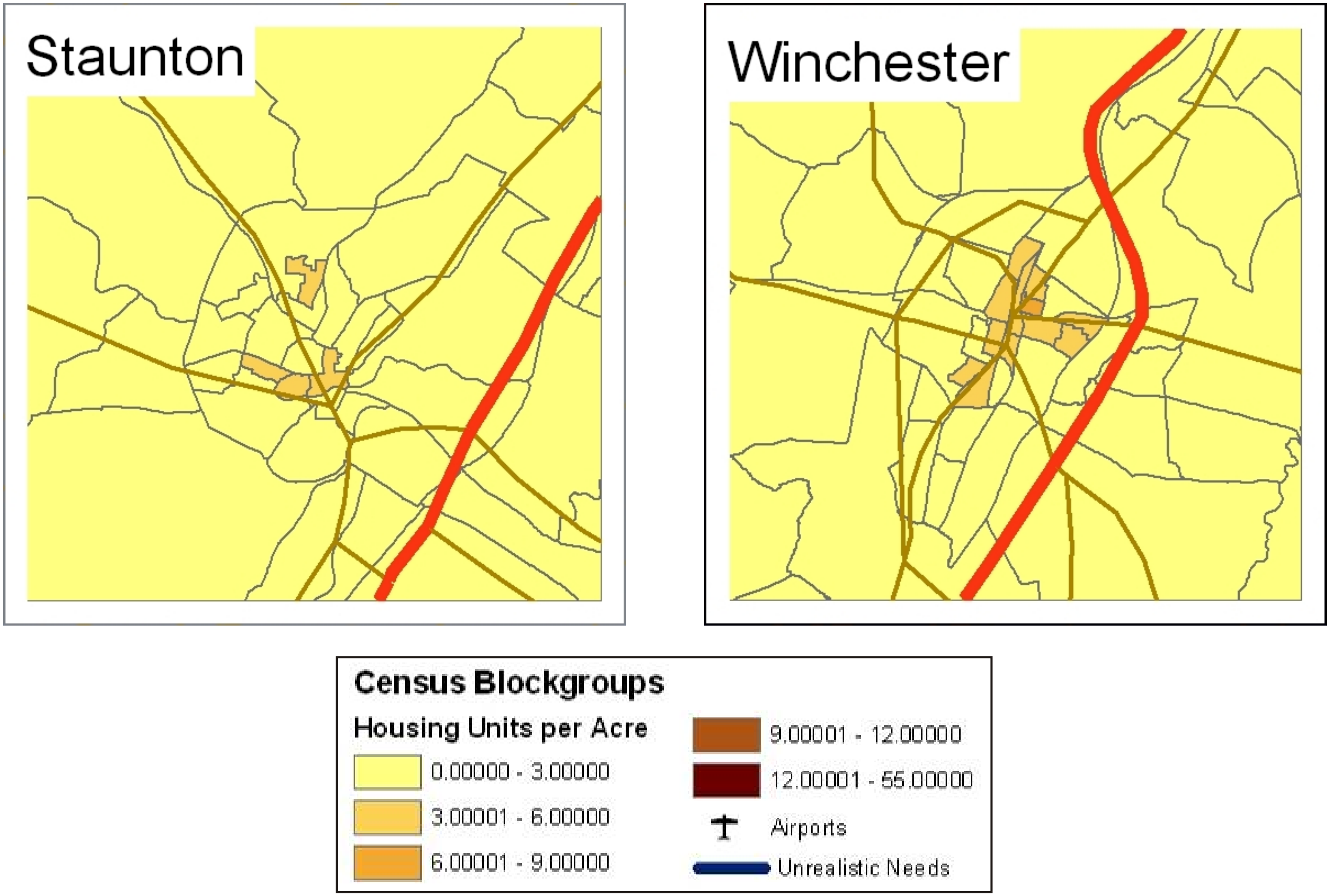
Census Block Groups
Housing Units per Acre
0.00 - 3.00
3.01 - 6.00
6.01 - 9.00
9.01 - 12.00
12.01 - 16.00
Airports
Unrealistic Needs
0
15
30
60
Miles
Winchester
Staunton
Roanoke


Staunton
Winchester
Census Blockgroups
Housing Units per Acre
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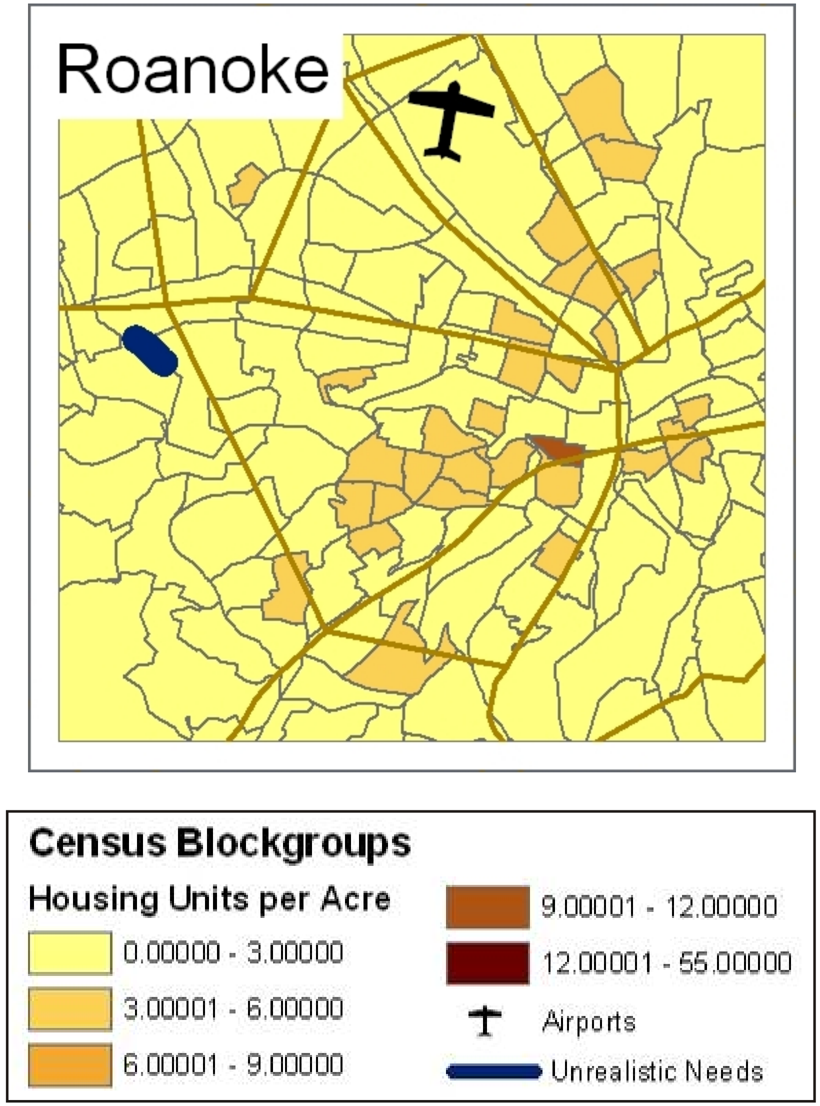
6.00001 - 9.00000
9.00001 - 12.00000
12.00001 - 55.00000
Airports
Unrealistic Needs


Roanoke
Census Blockgroups
Housing Units per Acre
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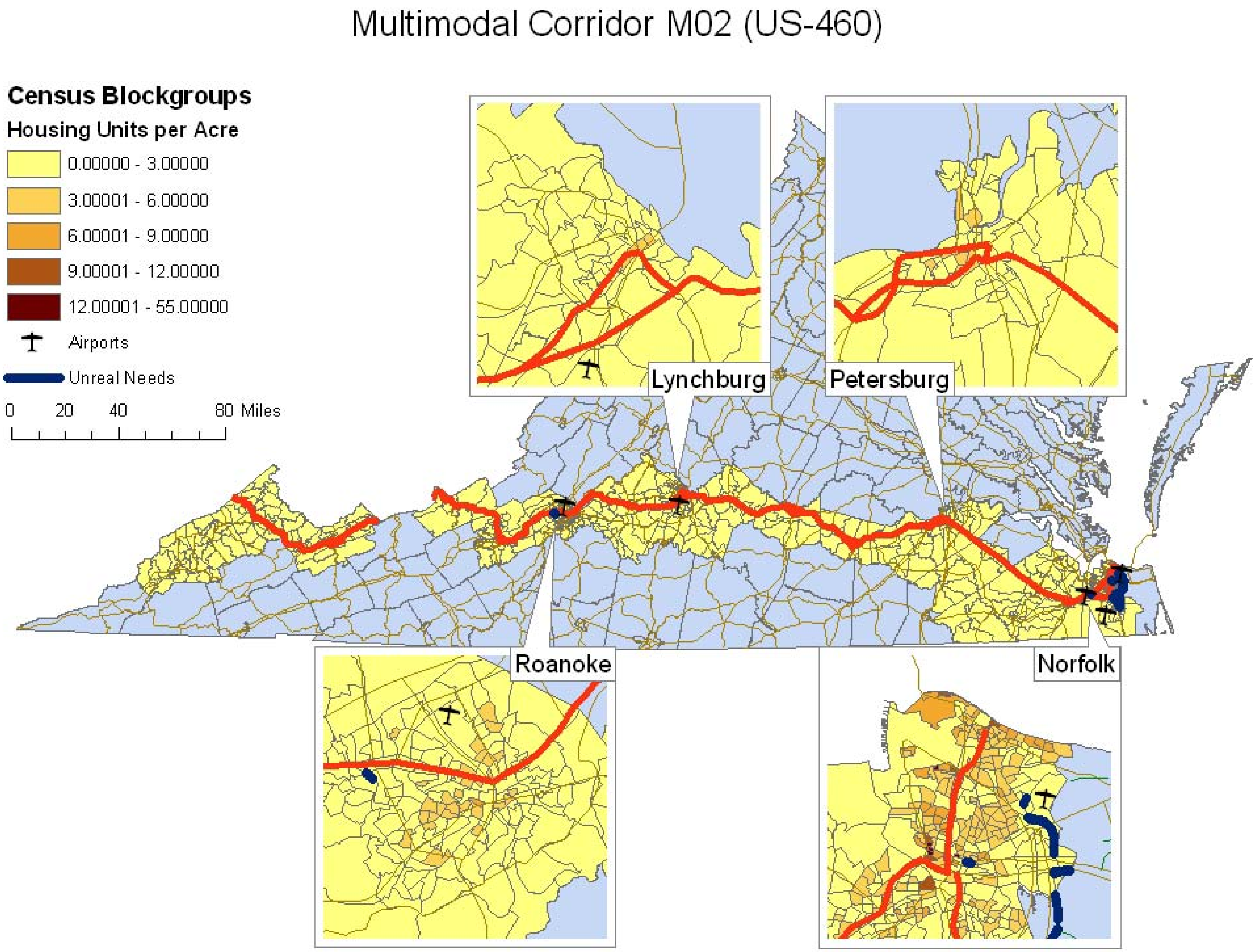
12.00001 - 55.00000
Airports
Unrealistic Needs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6.00001 - 9.00000
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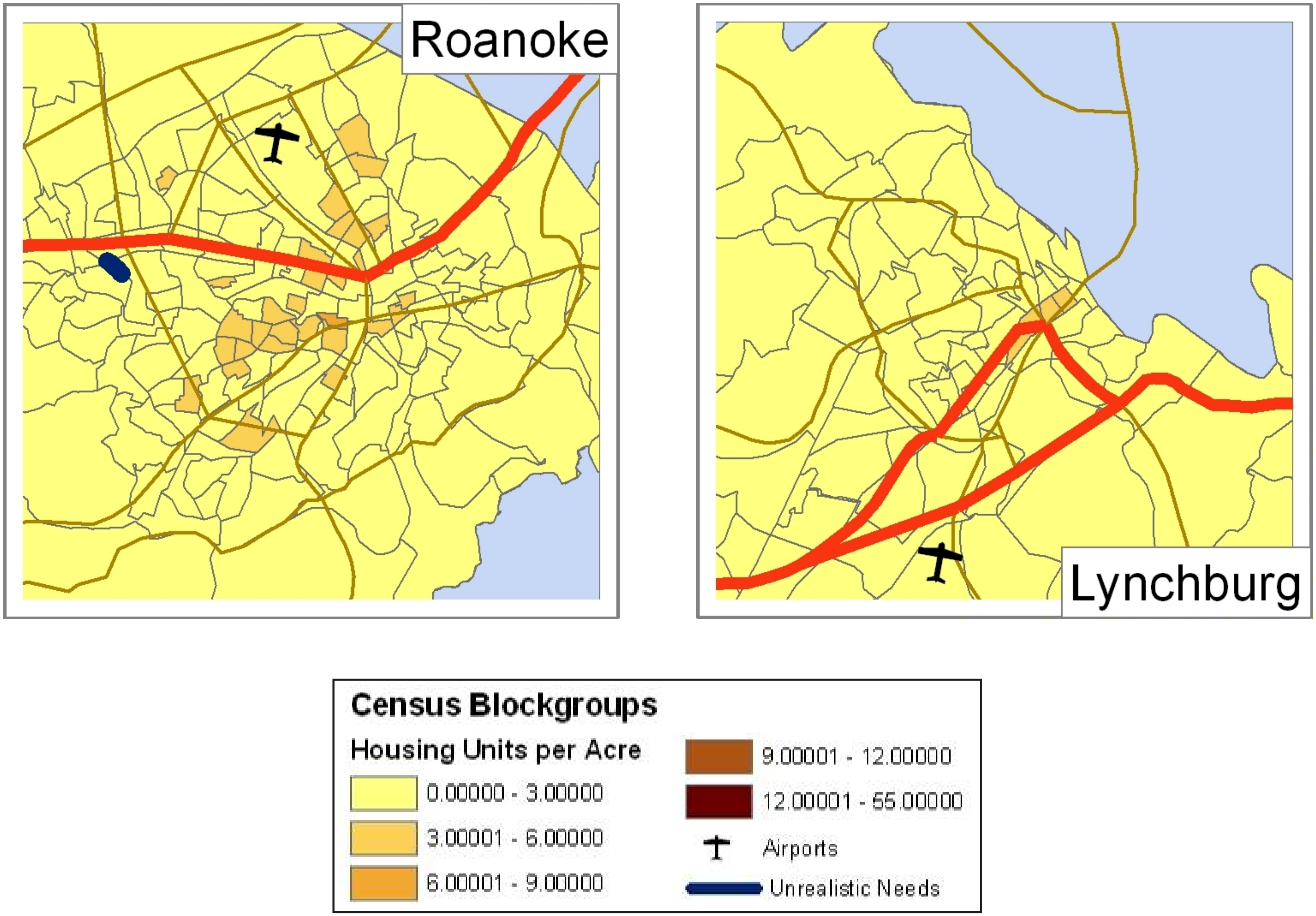
12.00001 - 55.00000
Airports
Unreal Needs
0
20
40
80 Miles
Lynchburg
Petersburg
Roanoke
Norfolk


Roanoke
Lynchburg
Census Blockgroups
Housing Units per Acre
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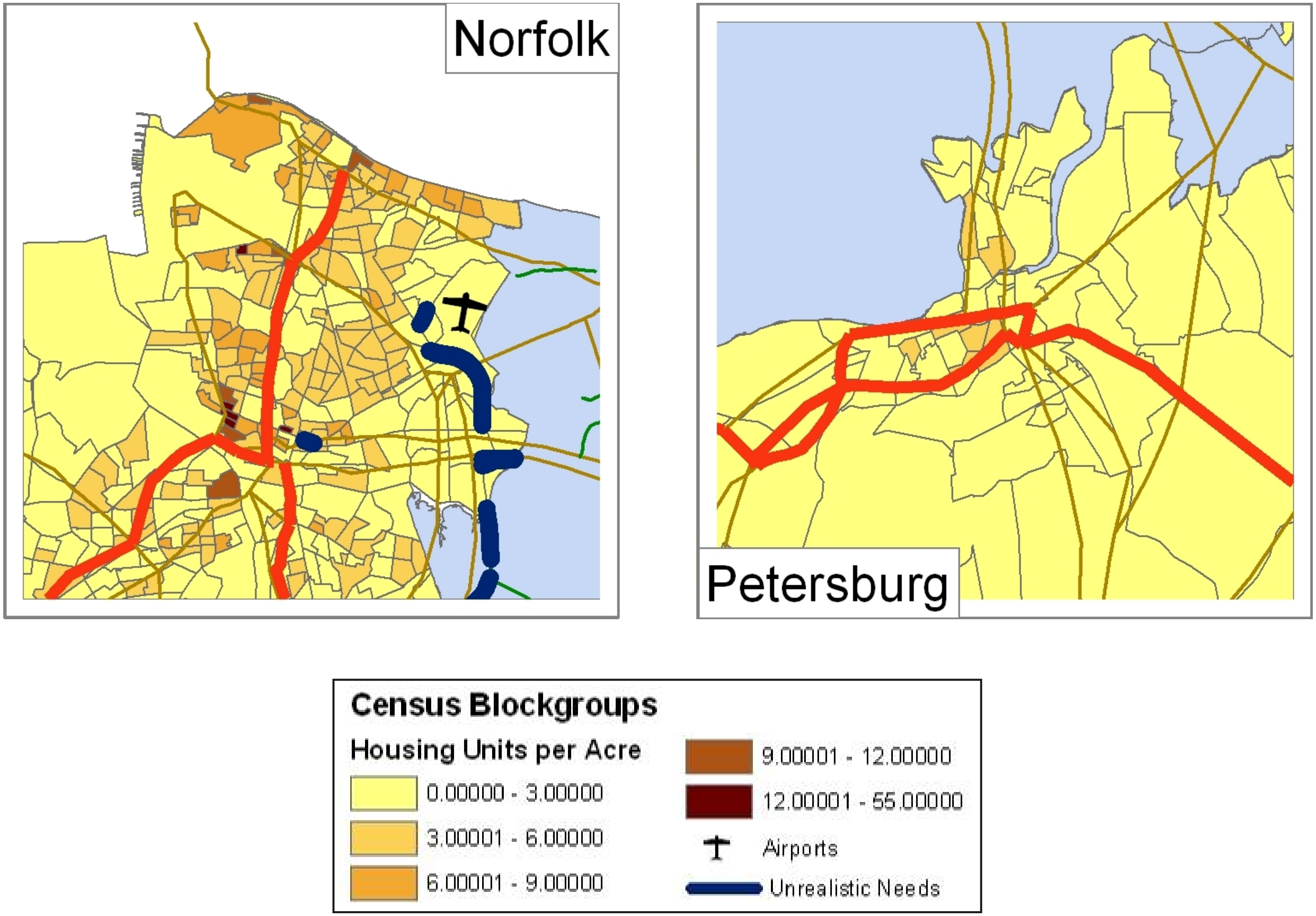
6.00001 - 9.00000
9.00001 - 12.00000
12.00001 - 55.00000
Airports
Unrealistic Needs


Norfolk
Petersburg
Census Blockgroups
Housing Units per Acre
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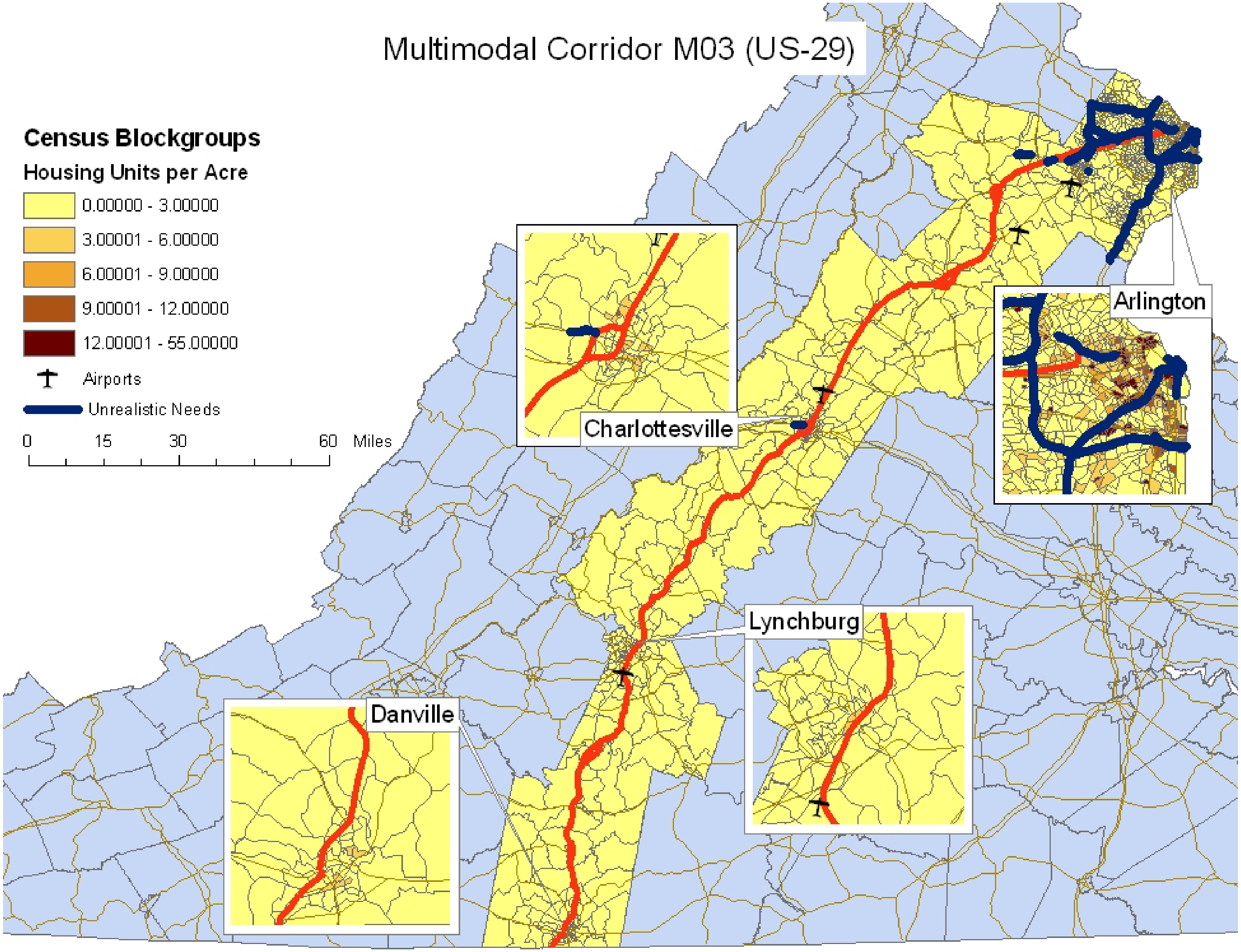
9.00001 - 12.00000
12.00001 - 55.00000
Airports
Unrealistic Needs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Unrealistic Needs
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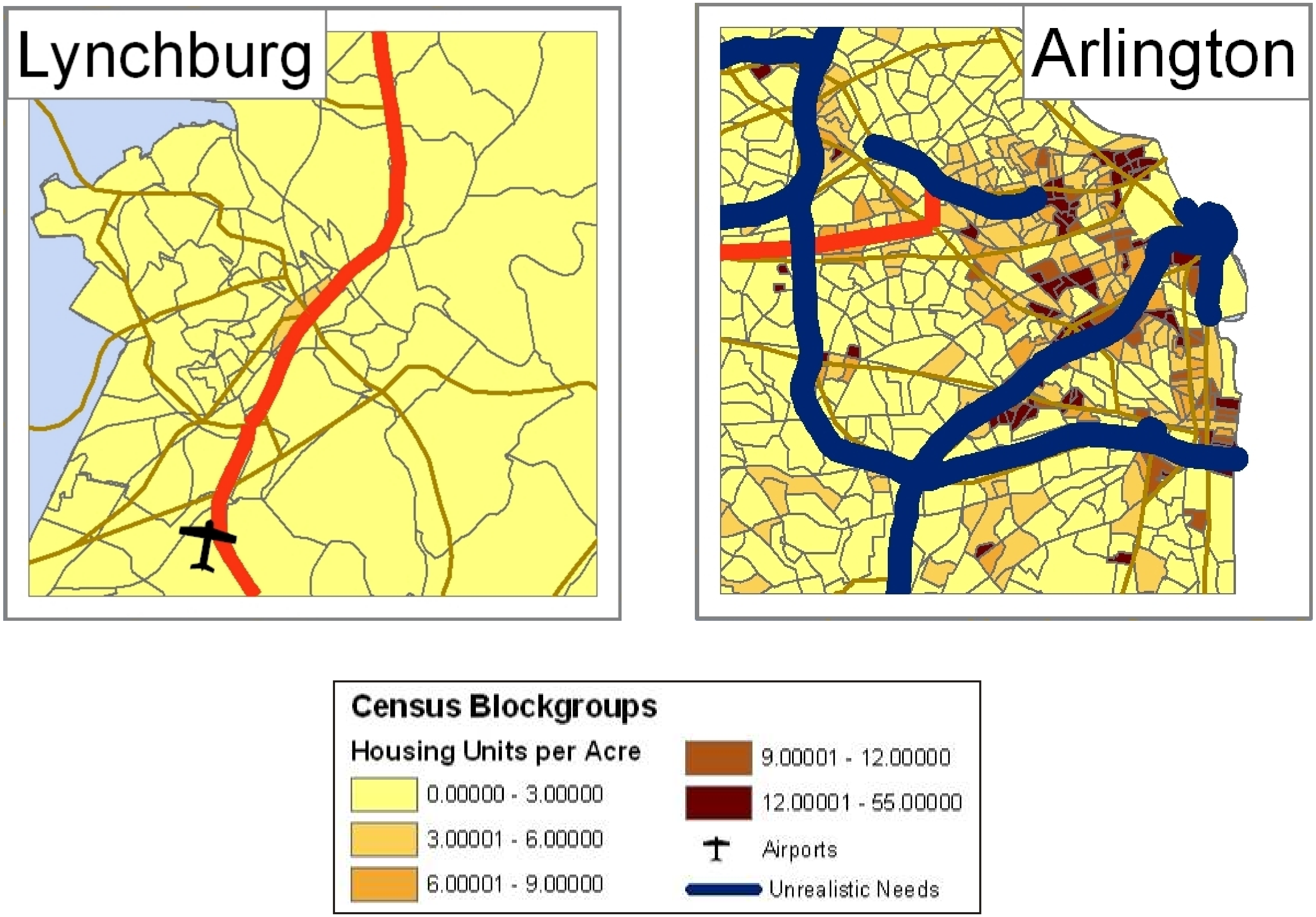
Charlottesville
Arlington
Lynchburg
Danville


Lynchburg
Arlington
Census Blockgroups
Housing Units per Acre
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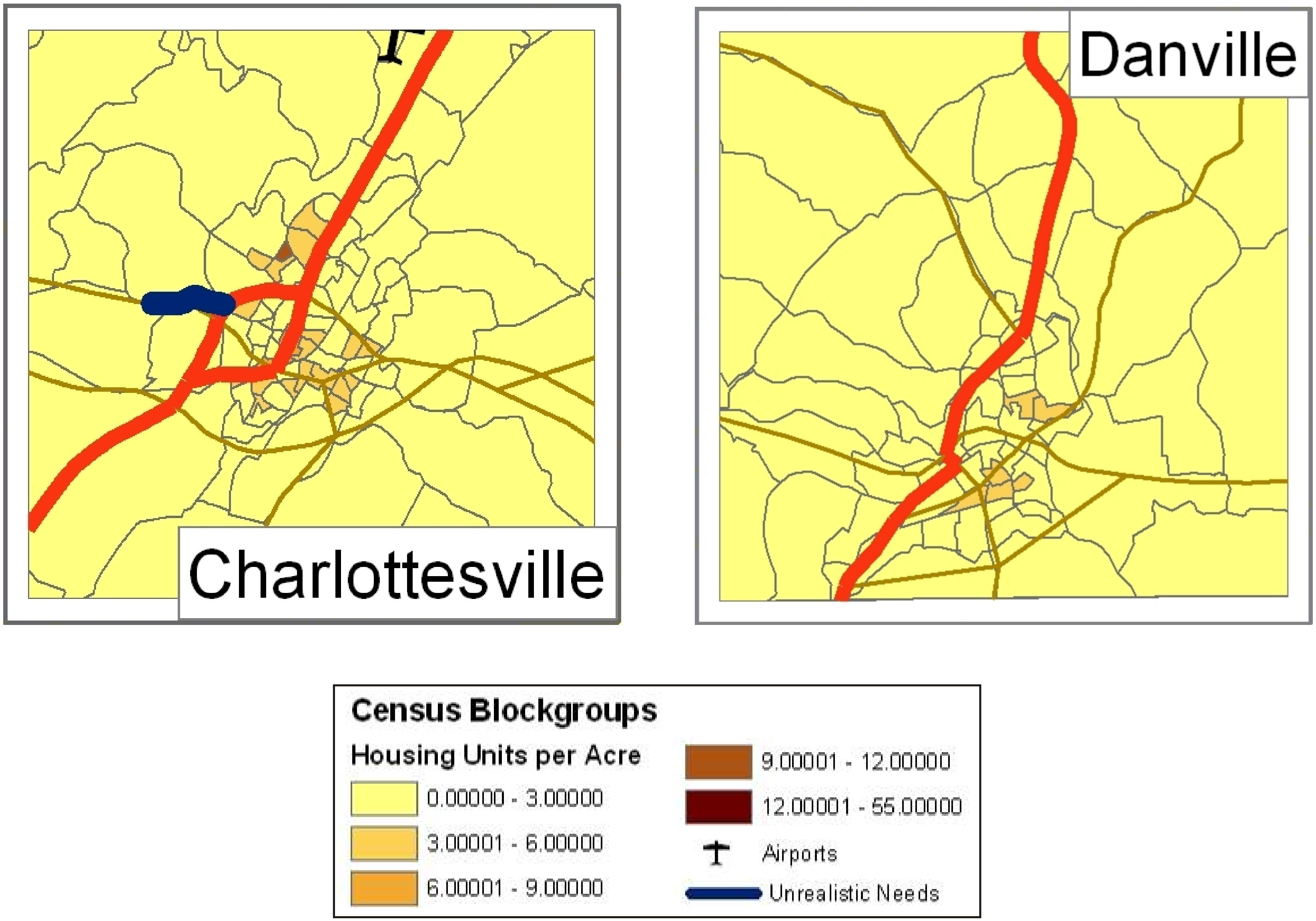
12.00001 - 55.00000
Airports
Unrealistic Needs


Charlottesville
Danville
Census Blockgroups
Housing Units per Acre
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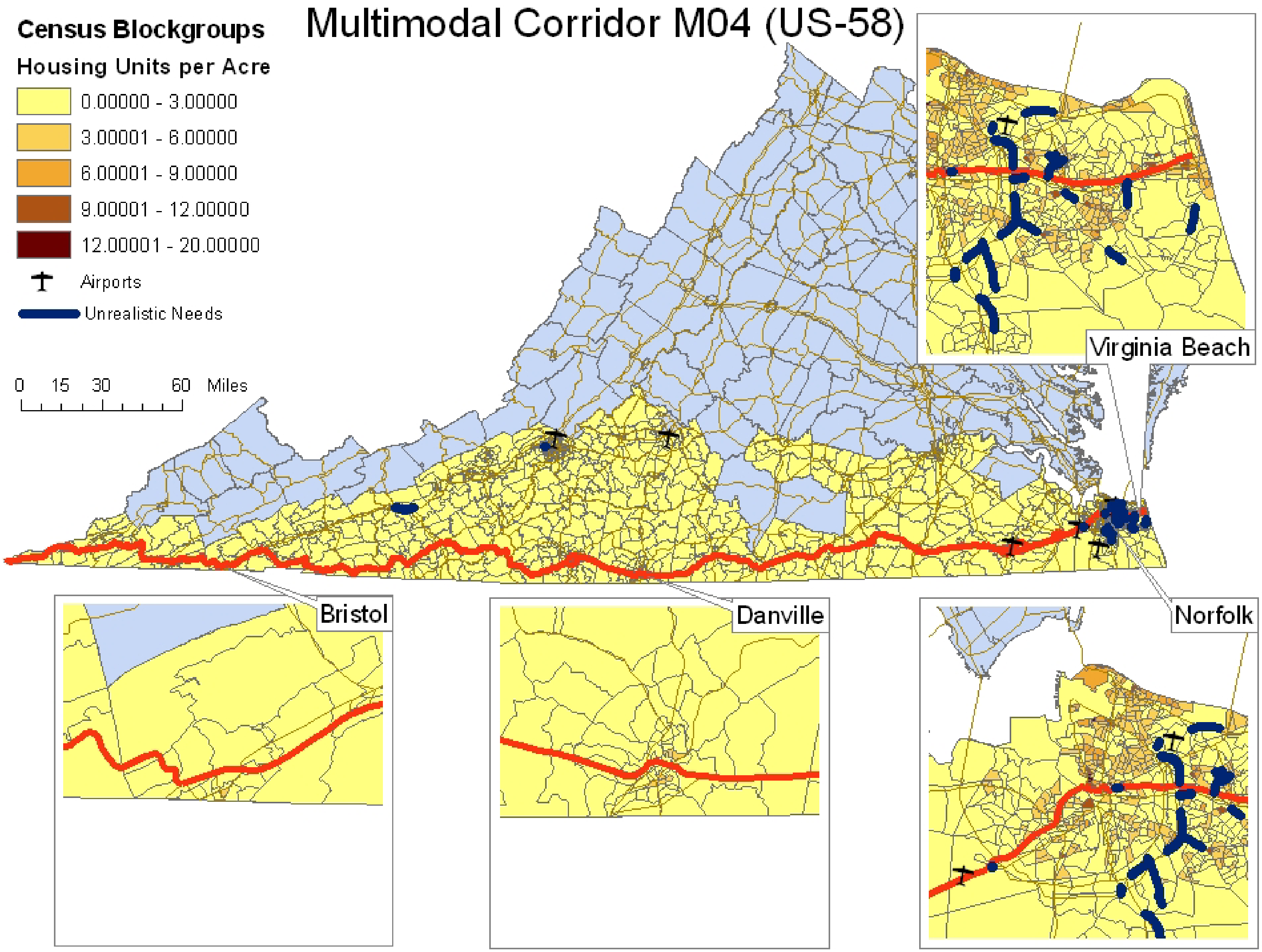
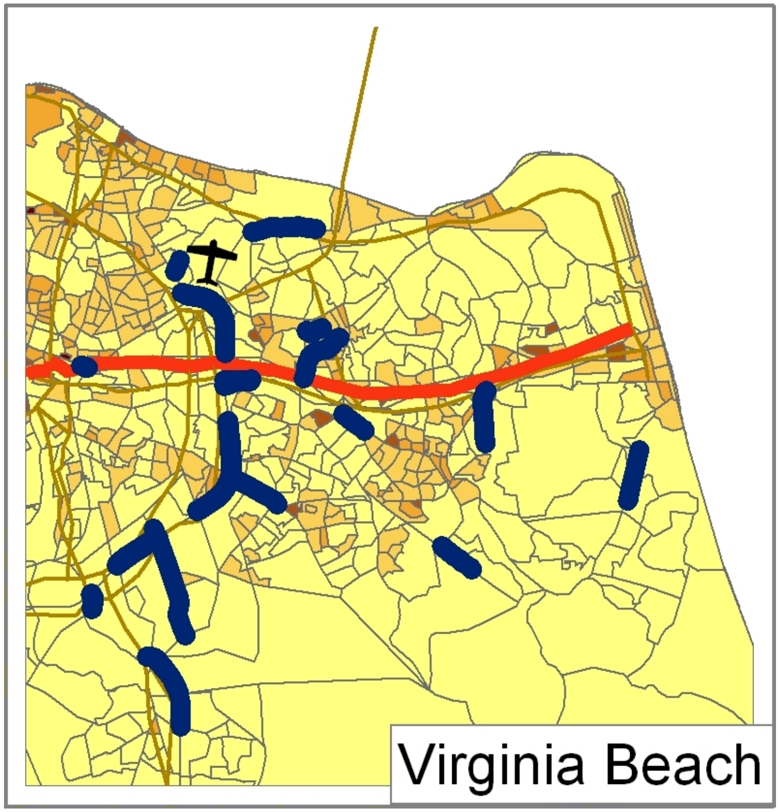
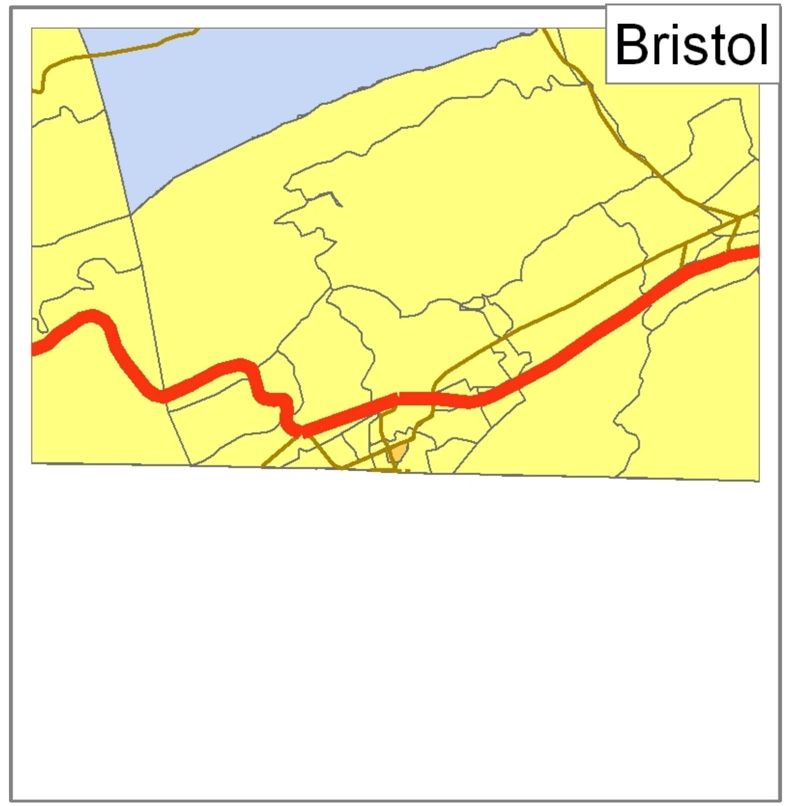
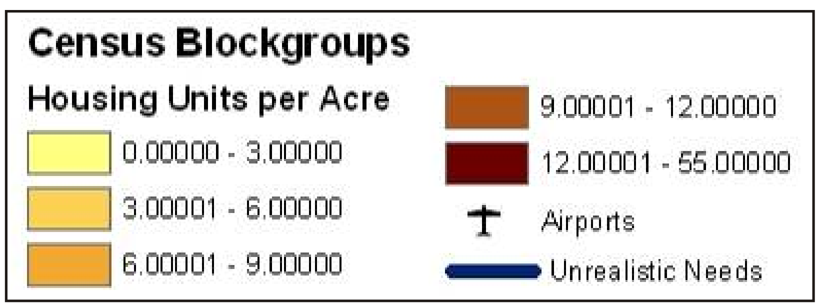
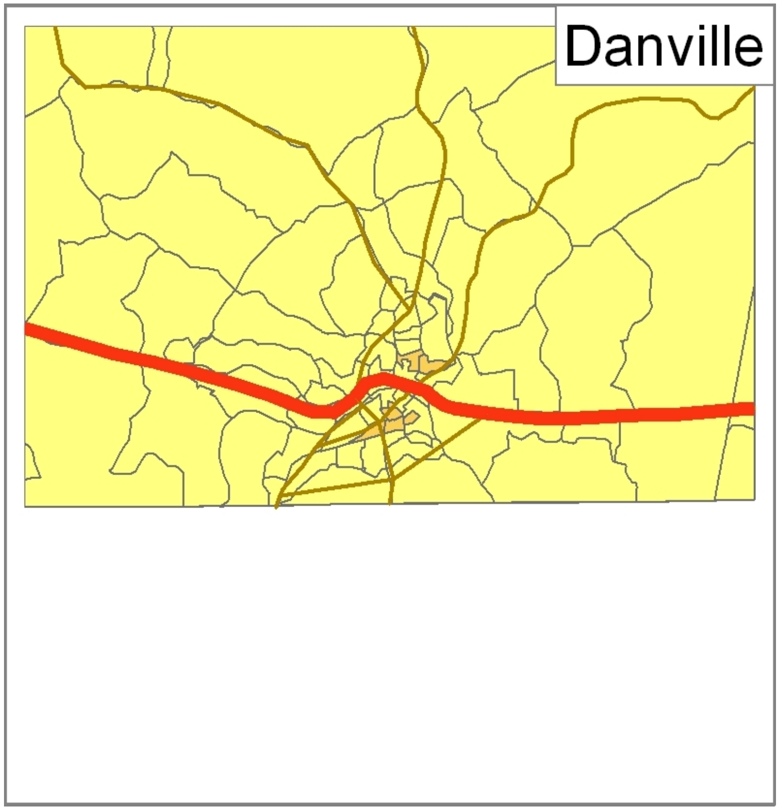
3.00001 - 6.00000
6.00001 - 9.00000
9.00001 - 12.00000
12.00001 - 55.00000
Airports
Unrealistic Needs

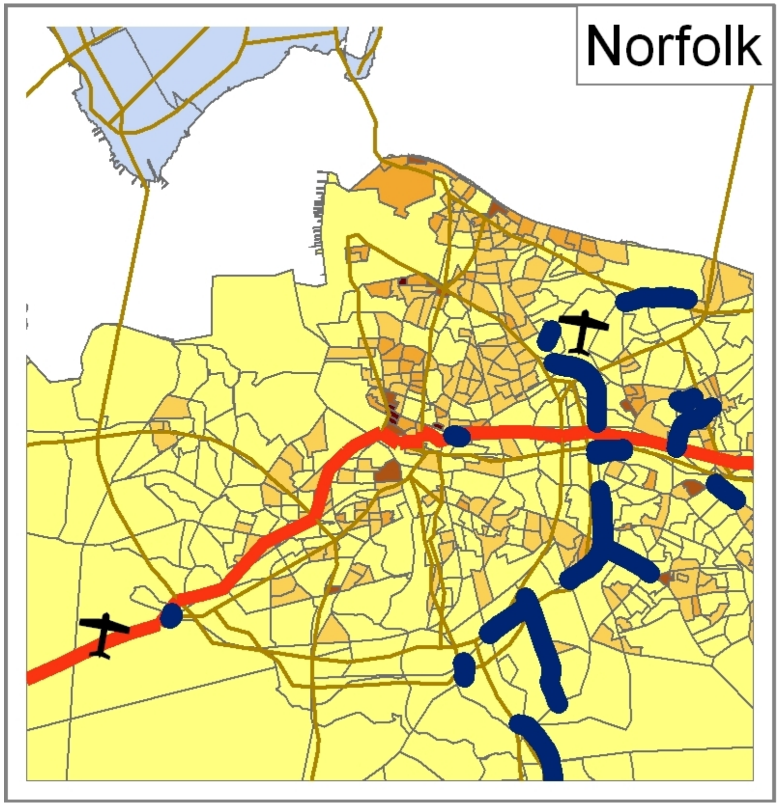

Census Blockgroups
Housing Units per Acre
0.00000 - 3.00000
3.00001 - 6.00000
6.00001 - 9.00000
9.00001 - 12.00000
12.00001 - 20.00000
Airports
Unrealistic Needs
0 15 30 60 Miles
Multimodal Corridor M04 (US-58)
Virginia Beach
Bristol
Danville
Norfolk

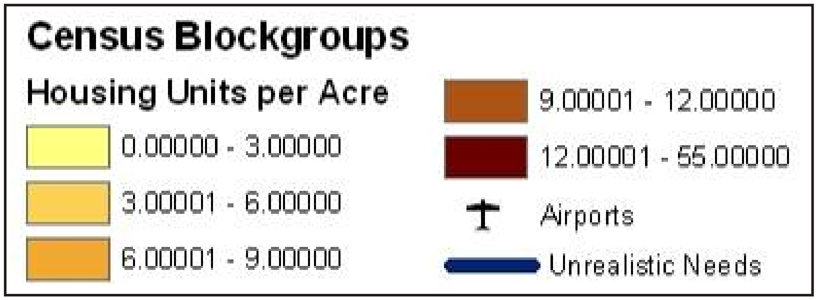

Virginia Beach

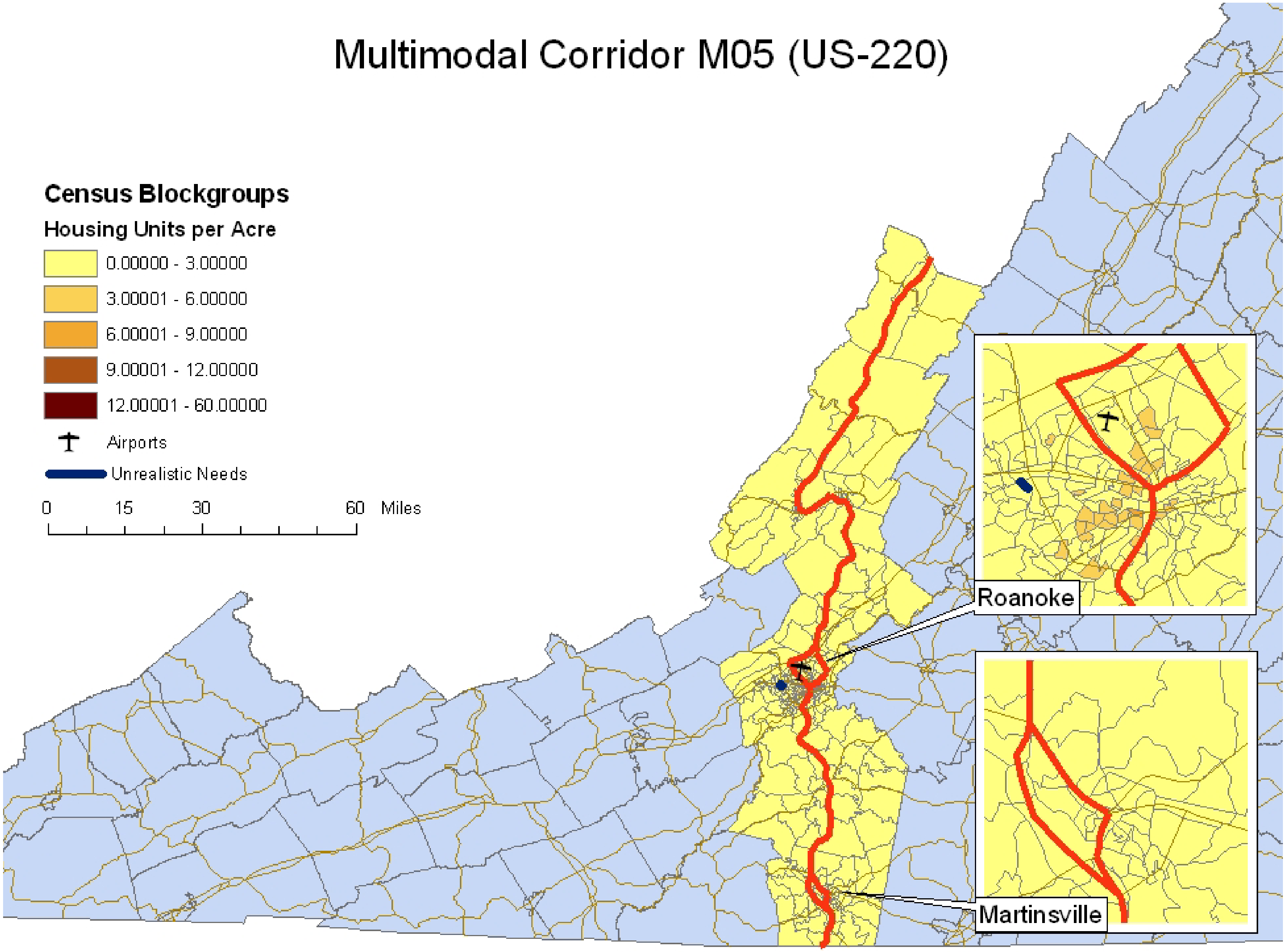

Bristol

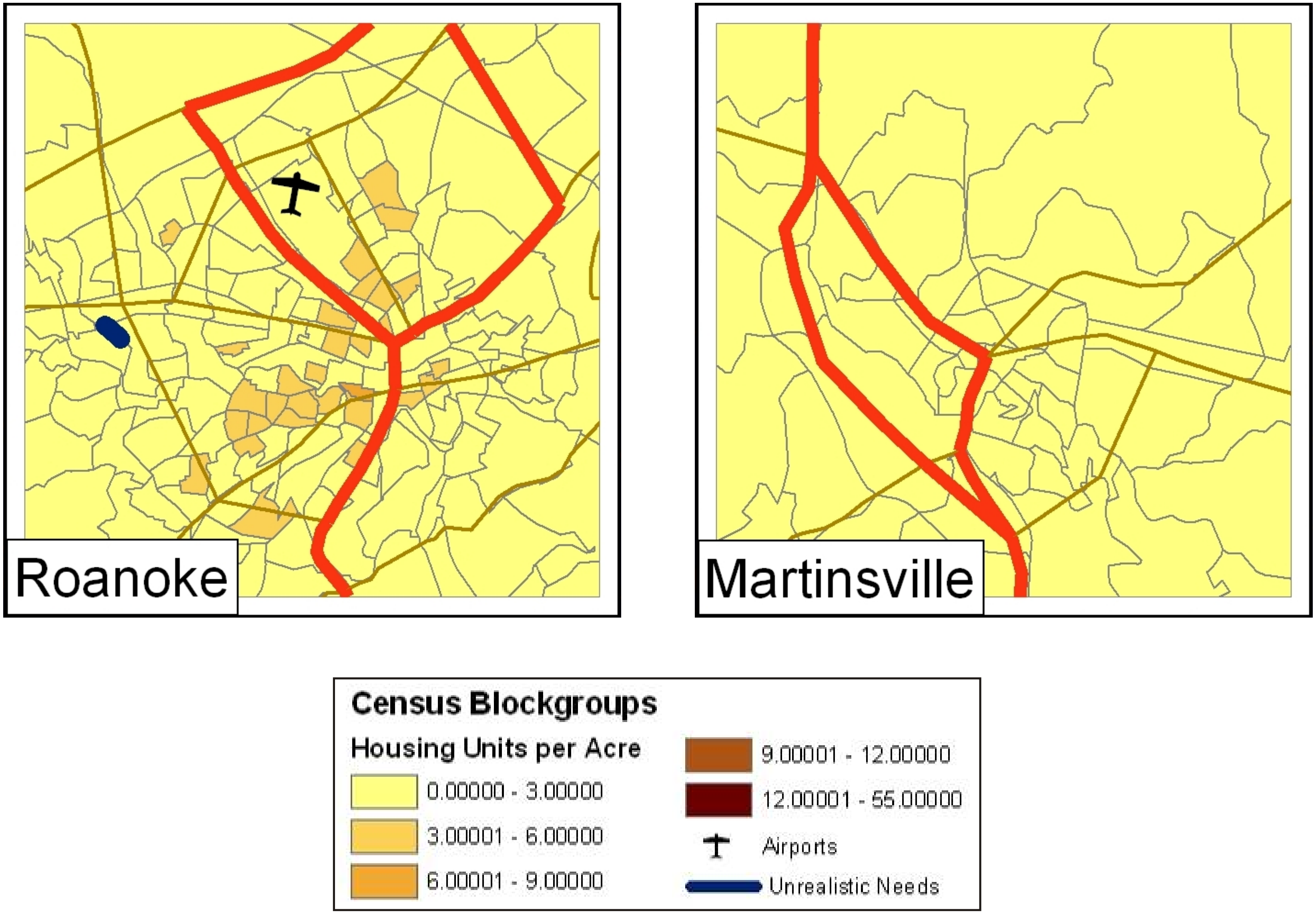

Census Blockgroups
Housing Units per Acre
0.00000 - 3.00000
3.00001 - 6.00000
6.00001 - 9.00000
9.00001 - 12.00000
12.00001 - 55.00000
Airports
Unrealistic Needs


Danville

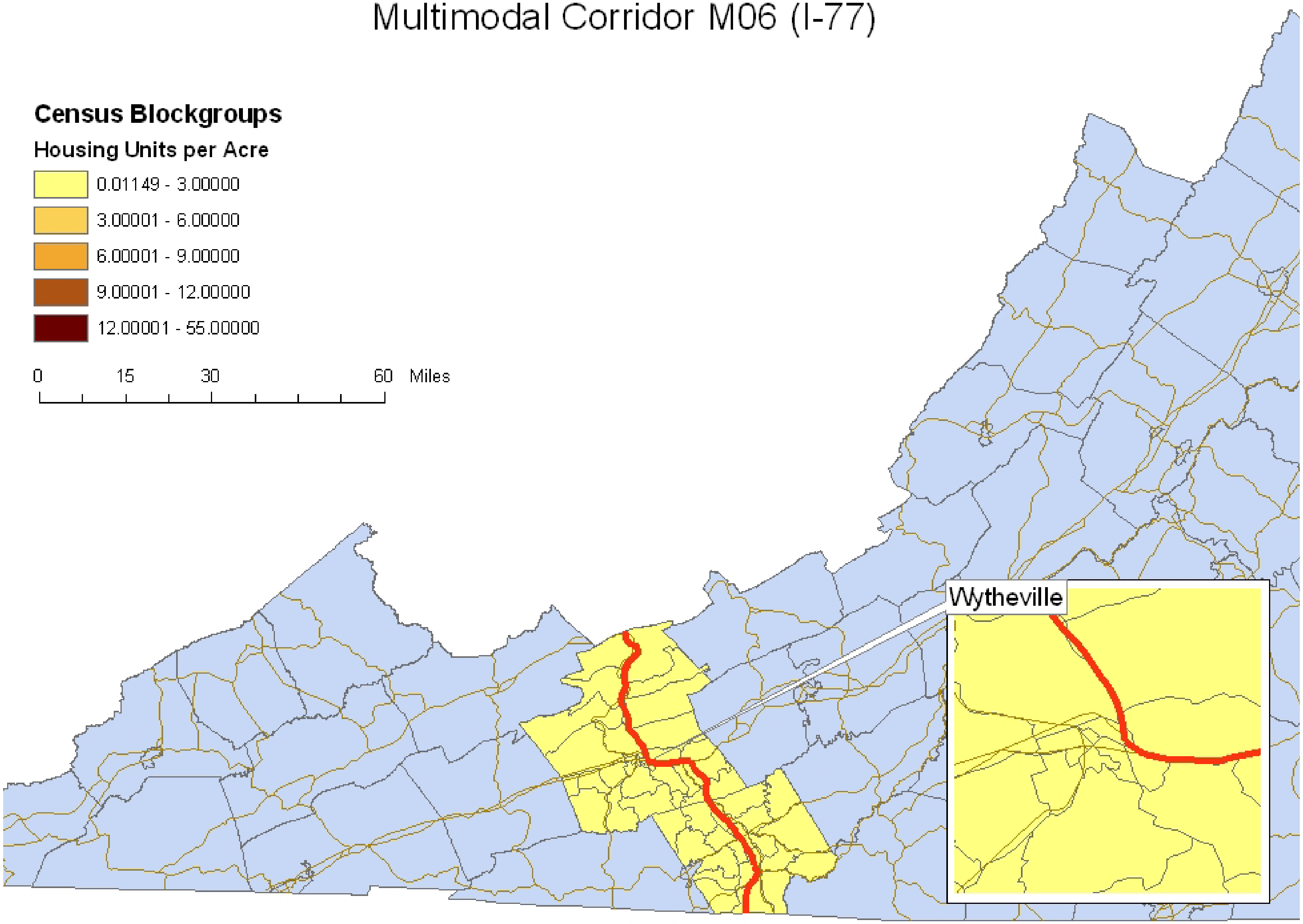

Norfolk

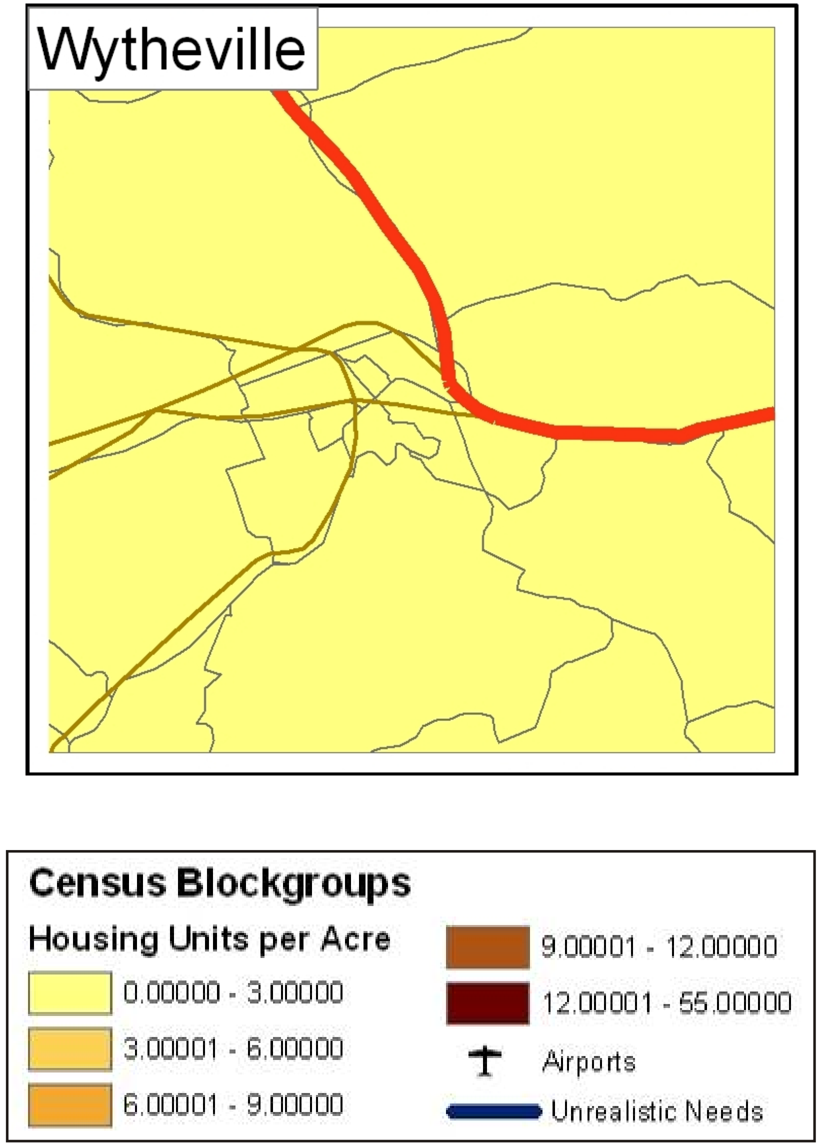

Census Blockgroups
Housing Units per Acre
0.00000 - 3.00000
3.00001 - 6.00000
6.00001 - 9.00000
9.00001 - 12.00000
12.00001 - 55.00000
Airports
Unrealistic Needs

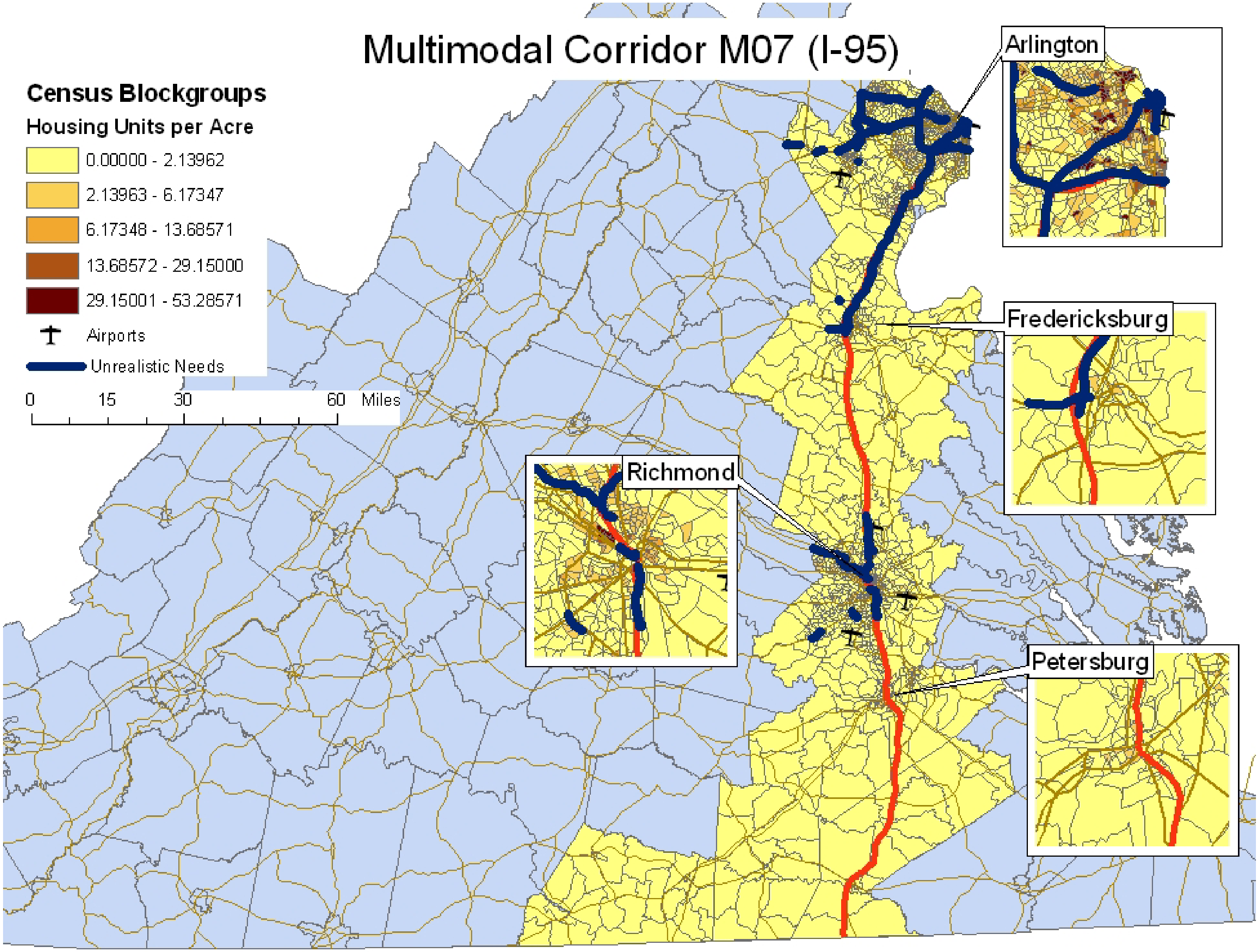

Multimodal Corridor M05 (US-220)
Census Blockgroups
Housing Units per Acre
0.00000 - 3.00000
3.00001 - 6.00000
6.00001 - 9.00000
9.00001 - 12.00000
12.00001 - 60.00000
Airports
Unrealistic Needs
0
15
30
60
Miles
Roanoke
Martinsville

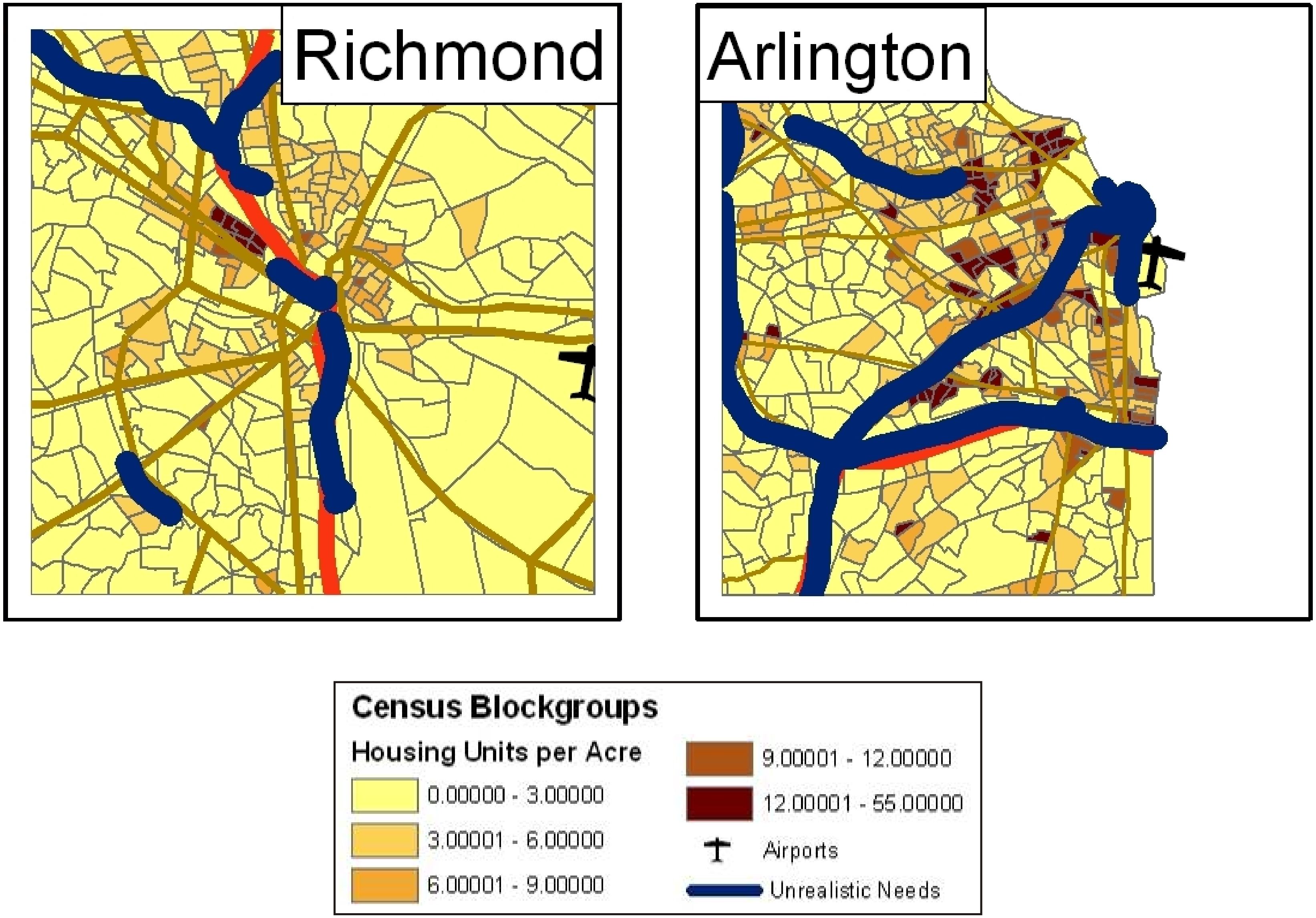

Roanoke
Martinsville
Census Blockgroups
Housing Units per Acre
0.00000 - 3.00000
3.00001 - 6.00000
6.00001 - 9.00000
9.00001 - 12.00000
12.00001 - 55.00000
Airports
Unrealistic Needs

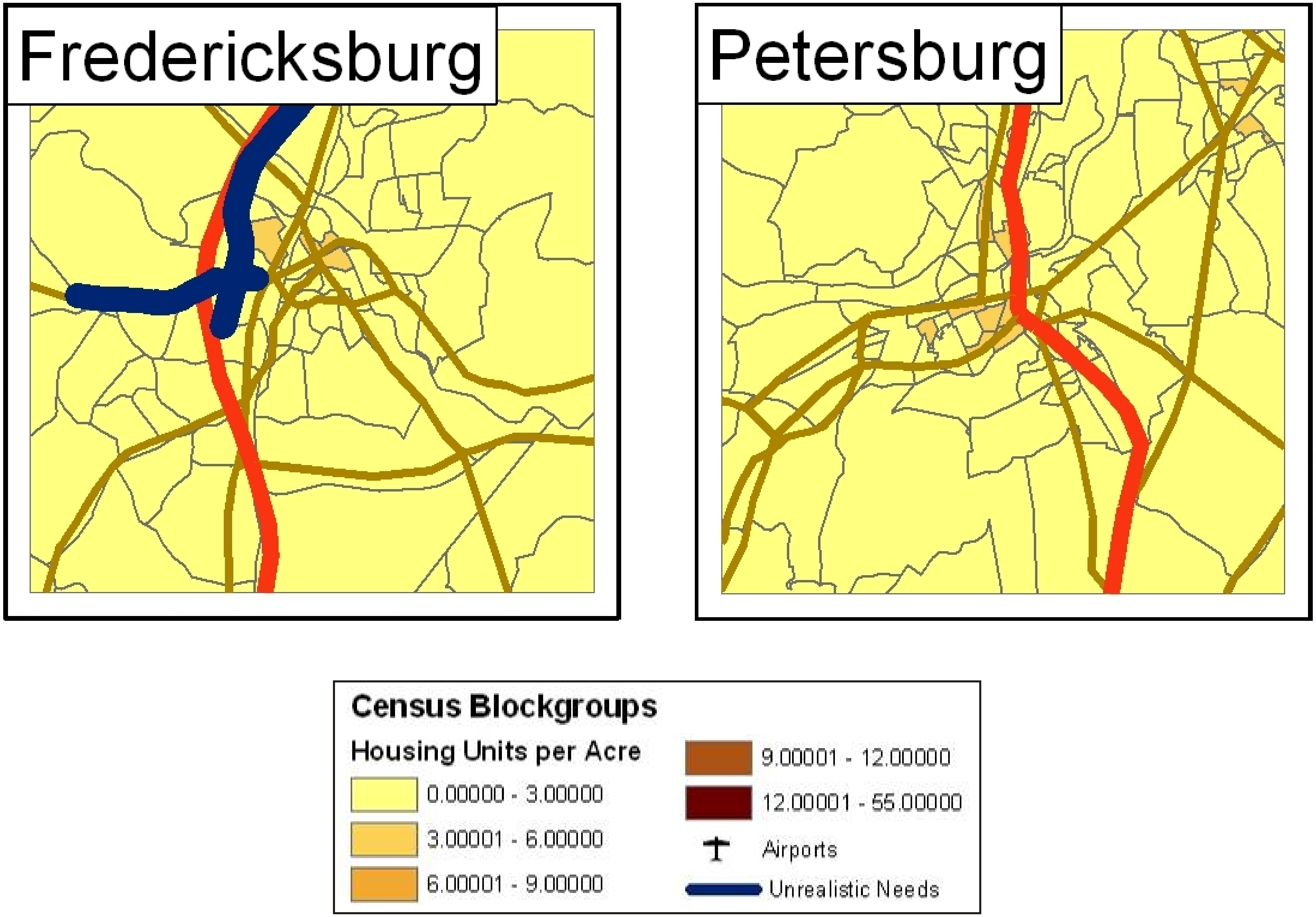
Multimodal Corridor M06 (I-77)

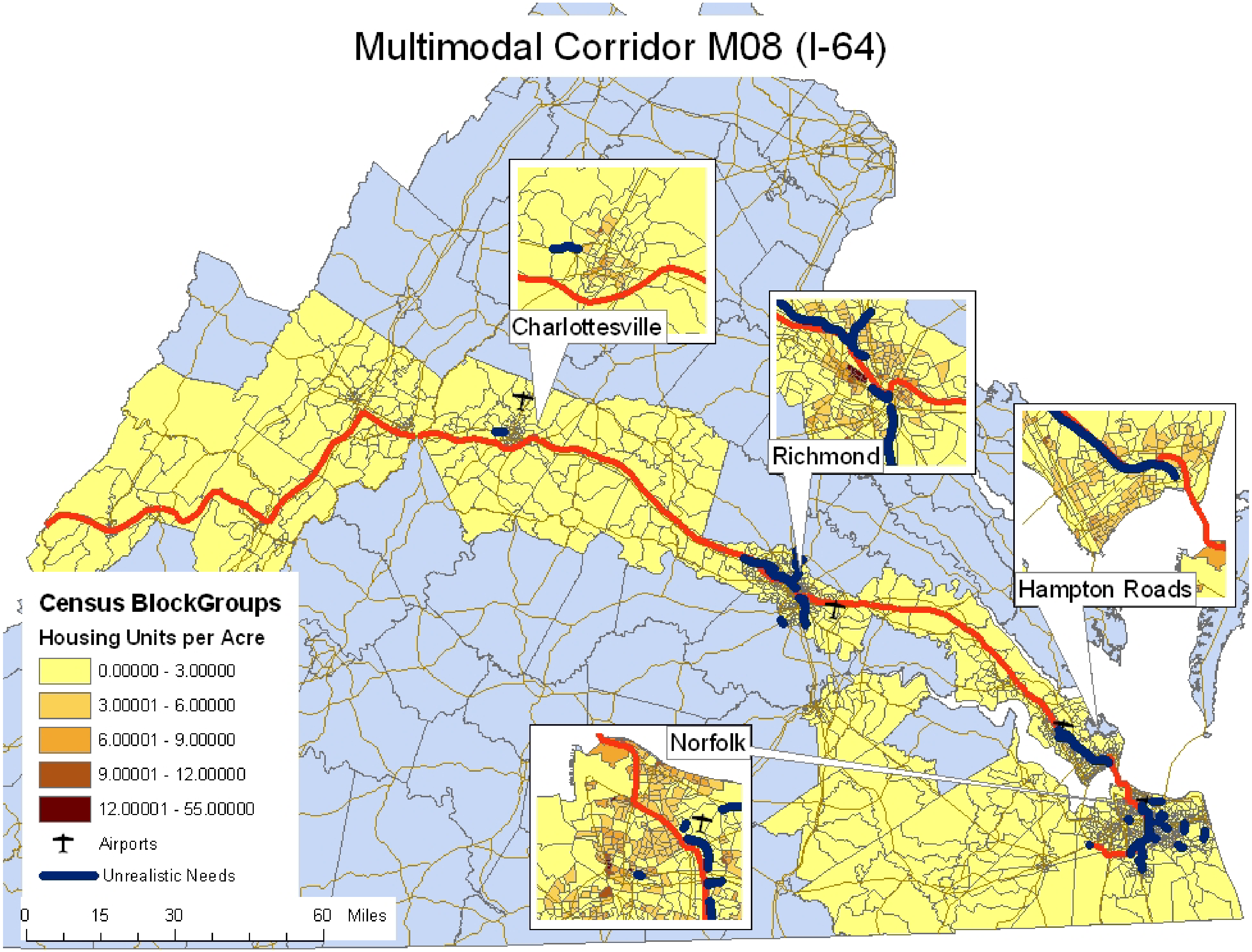


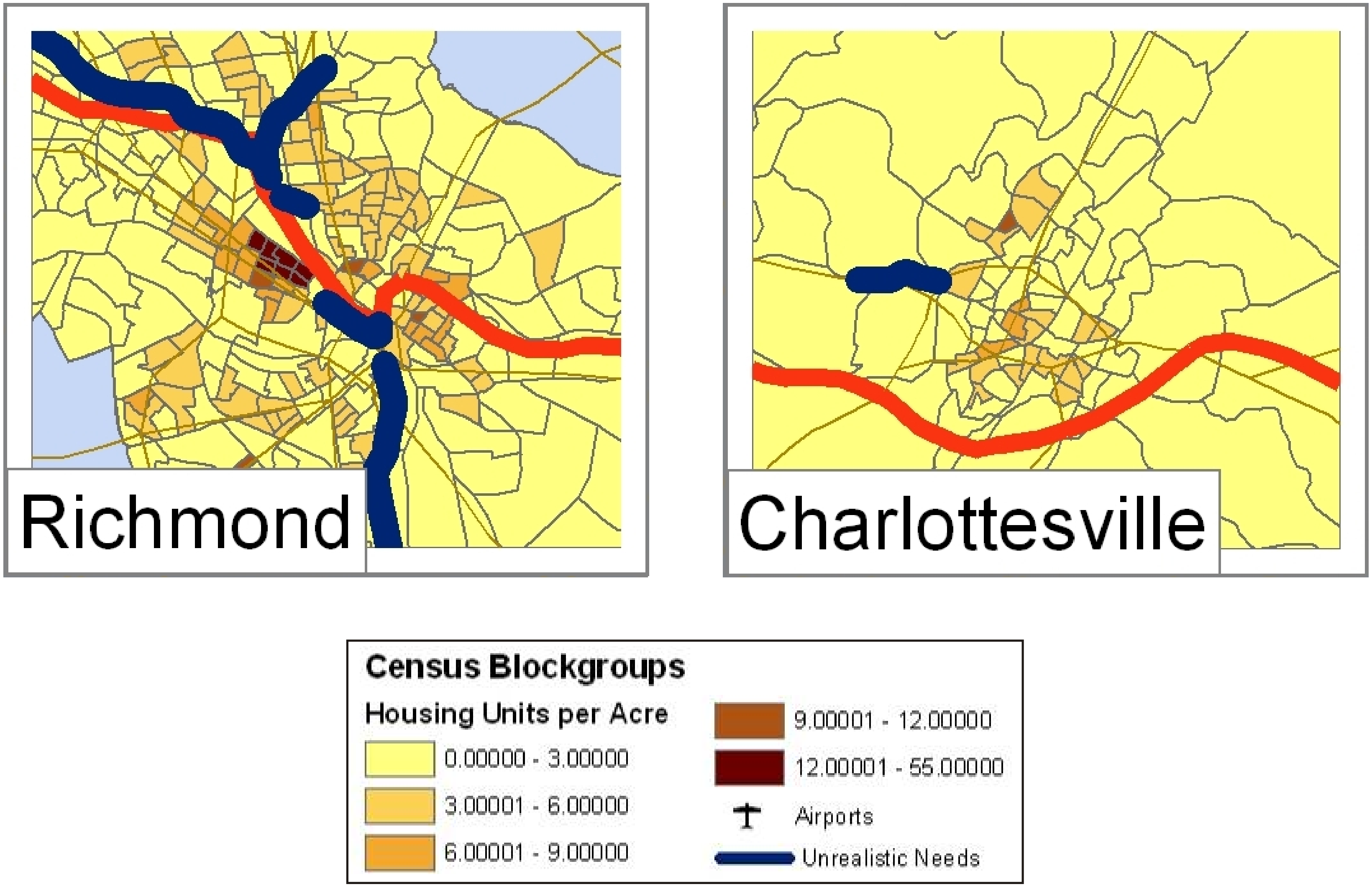

Wytheville
Census Blockgroups
Housing Units per Acre
0.00000 - 3.00000
3.00001 - 6.00000
6.00001 - 9.00000
9.00001 - 12.00000
12.00001 - 55.00000
Airports
Unrealistic Needs

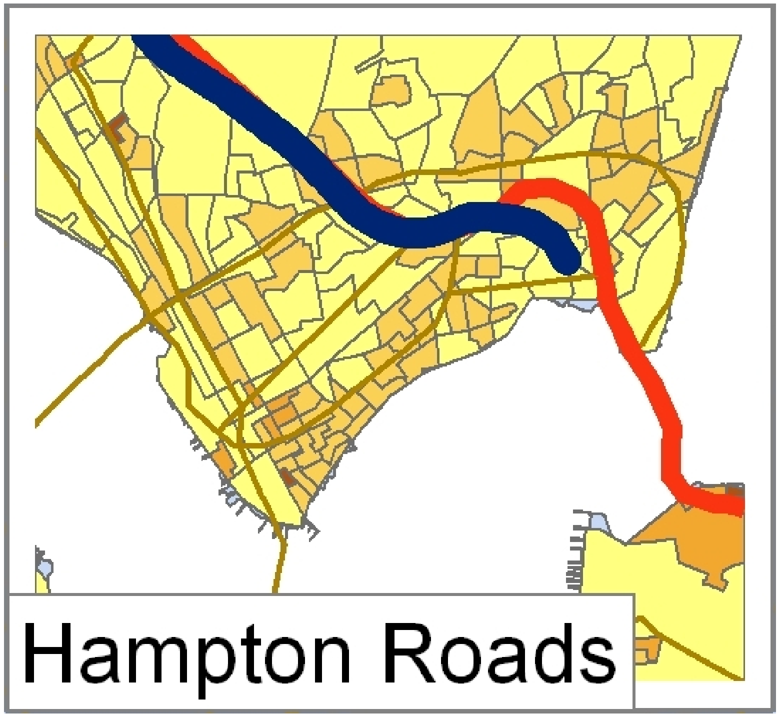

Multimodal Corridor M07 (I-95)
Census Blockgroups
Housing Units per Acre
0.00000 - 2.13962
2.13963 - 6.17347
6.17348 - 13.68571
13.68572 - 29.15000
29.15001 - 53.28571
Airports
Unrealistic Needs
0
15
30
60
Miles
Arlington
Fredericksburg
Richmond
Petersburg

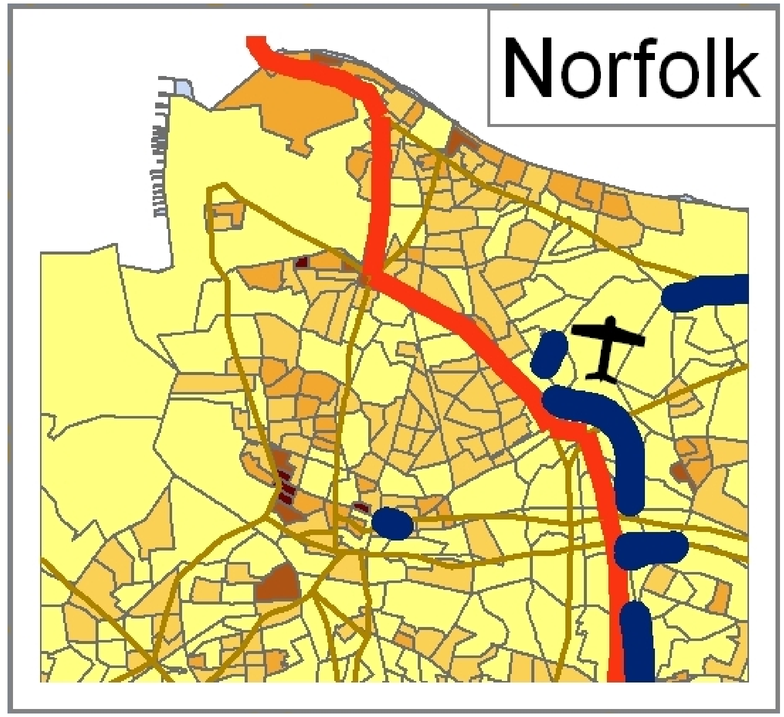

Richmond
Arlington
Census Blockgroups
Housing Units per Acre
0.00000 - 3.00000
3.00001 - 6.00000
6.00001 - 9.00000
9.00001 - 12.00000
12.00001 - 55.00000
Airports
Unrealistic Needs

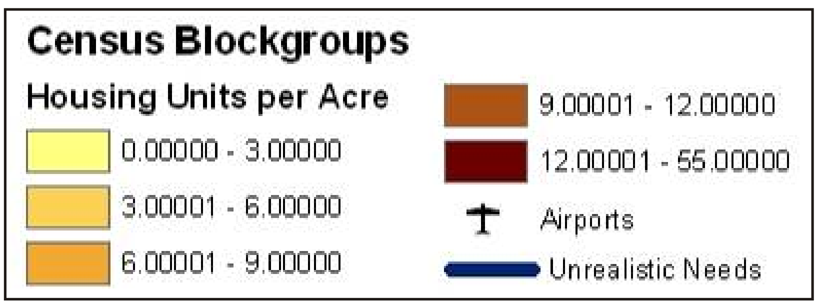

Fredericksburg
Petersburg
Census Blockgroups
Housing Units per Acre
0.00000 - 3.00000
3.00001 - 6.00000
6.00001 - 9.00000
9.00001 - 12.00000
12.00001 - 55.00000
Airports
Unrealistic Needs

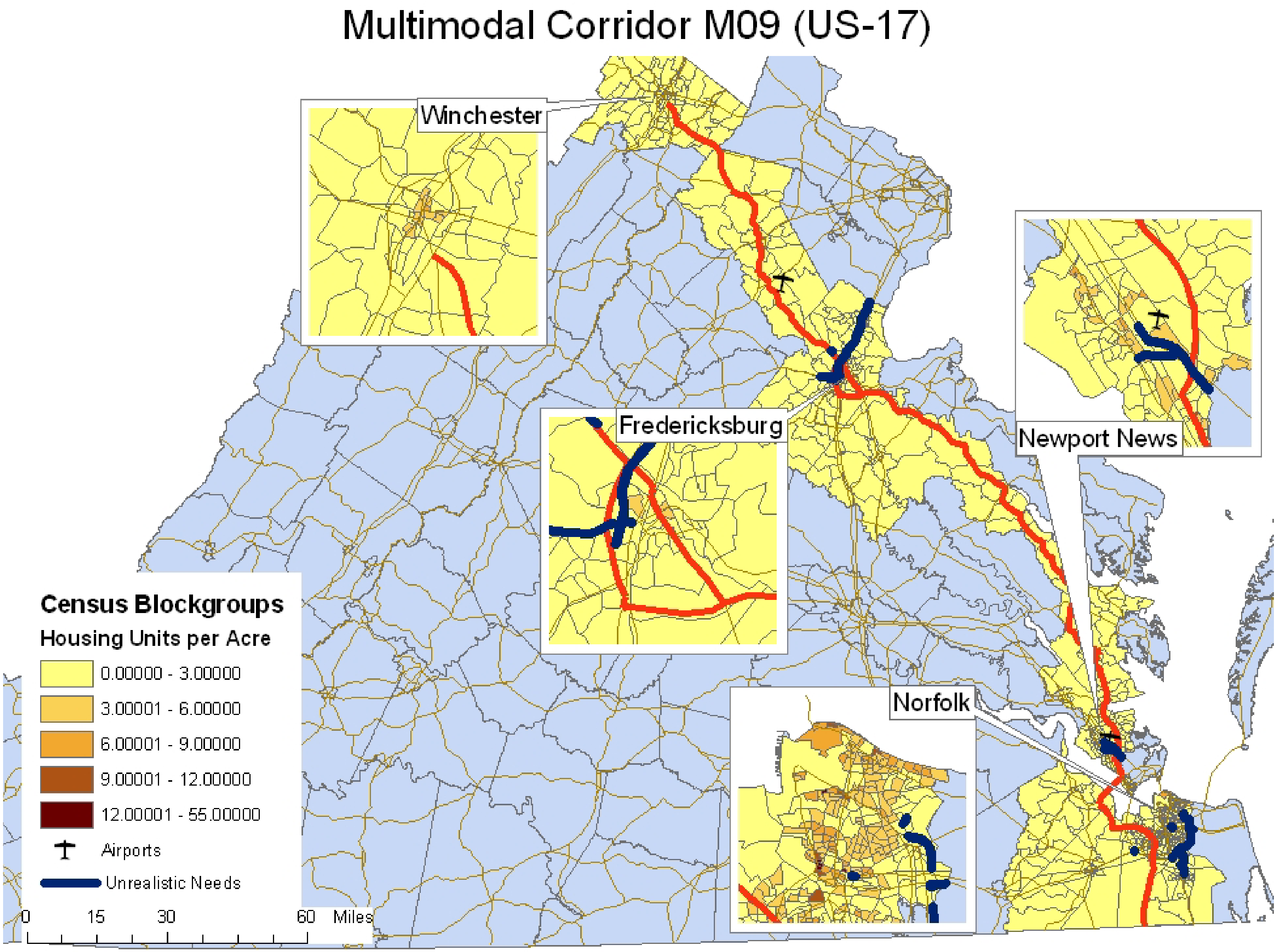

Multimodal Corridor M08 (I-64)
Charlottesville
Richmond
Hampton Roads
Norfolk
Census BlockGroups
Housing Units per Acre
0.00000 - 3.00000
3.00001 - 6.00000
6.00001 - 9.00000
9.00001 - 12.00000
12.00001 - 55.00000
Airports
Unrealistic Needs
0 15 30 60 Miles

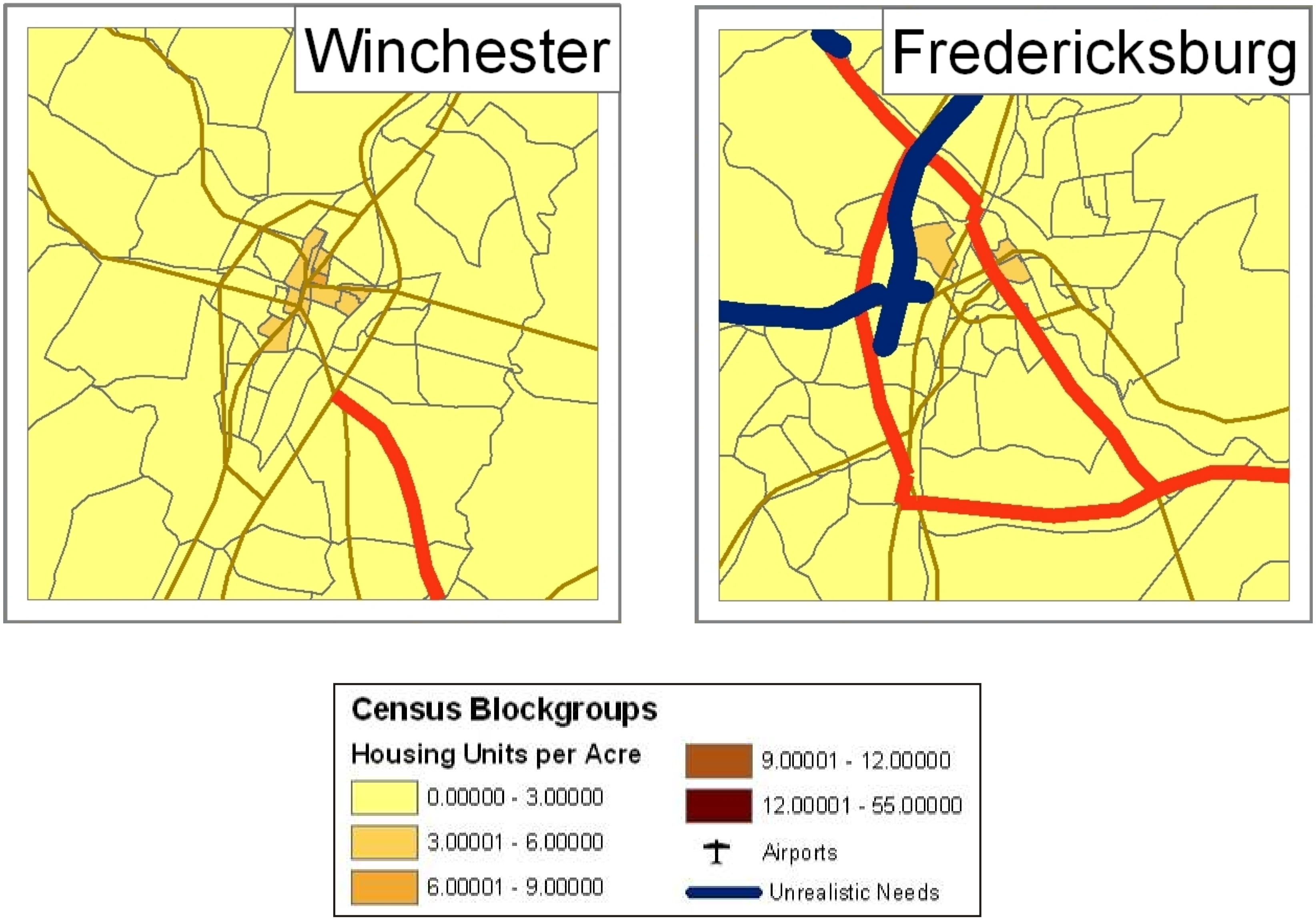

Richmond
Charlottesville
Census Blockgroups
Housing Units per Acre
0.00000 - 3.00000
3.00001 - 6.00000
6.00001 - 9.00000
9.00001 - 12.00000
12.00001 - 55.00000
Airports
Unrealistic Needs

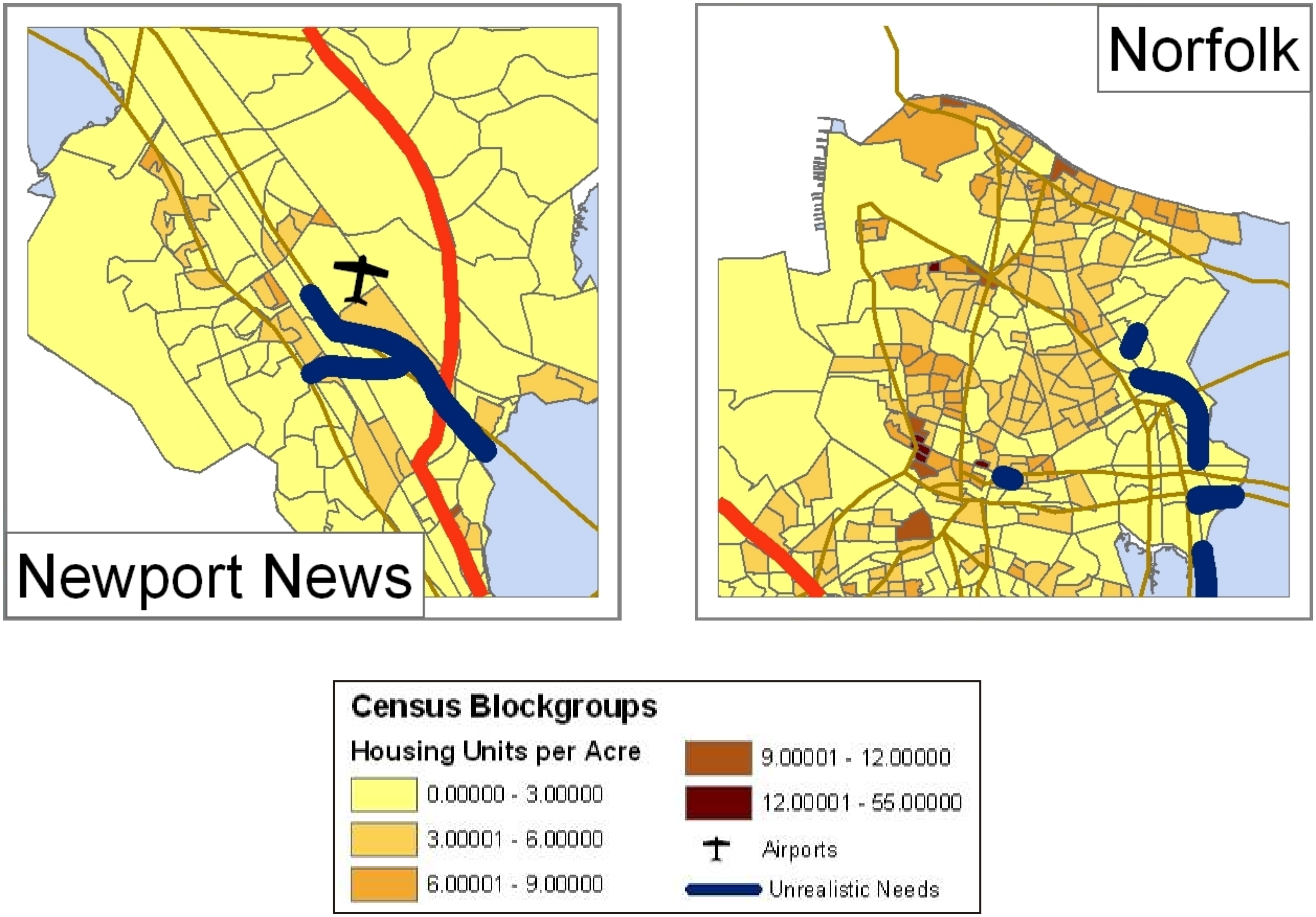

Hampton Roads

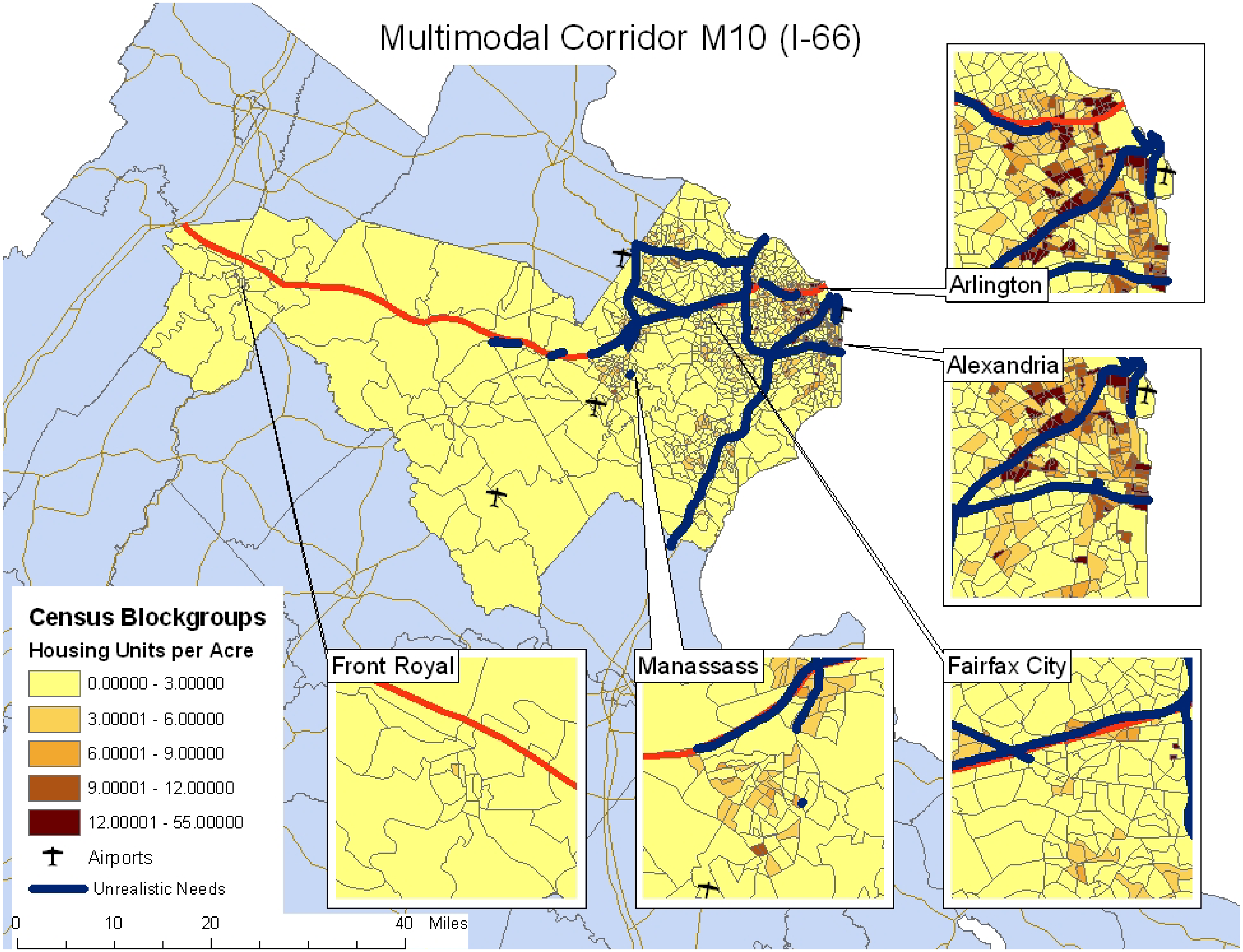

Norfolk

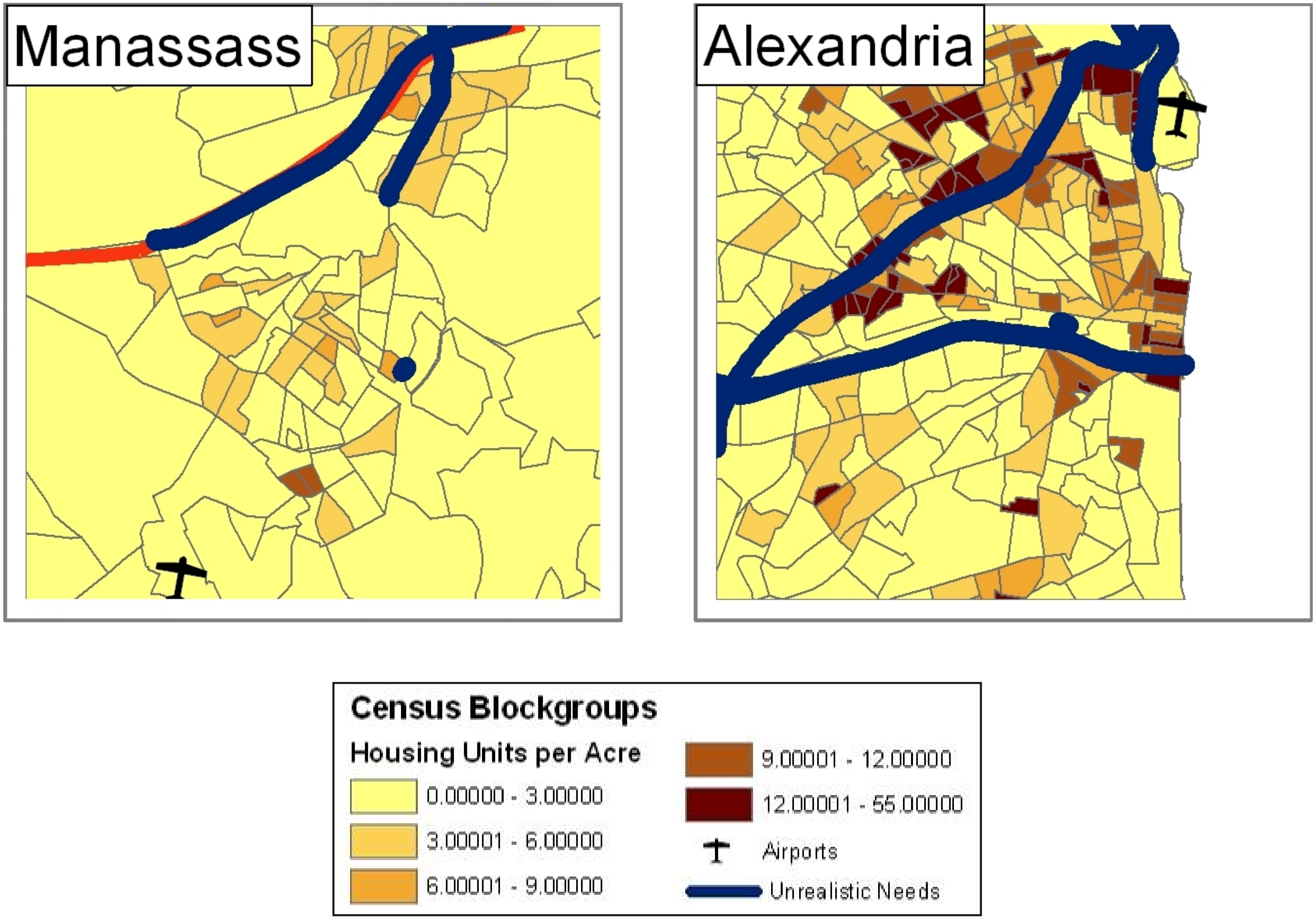

Census Blockgroups
Housing Units per Acre
0.00000 - 3.00000
3.00001 - 6.00000
6.00001 - 9.00000
9.00001 - 12.00000
12.00001 - 55.00000
Airports
Unrealistic Needs

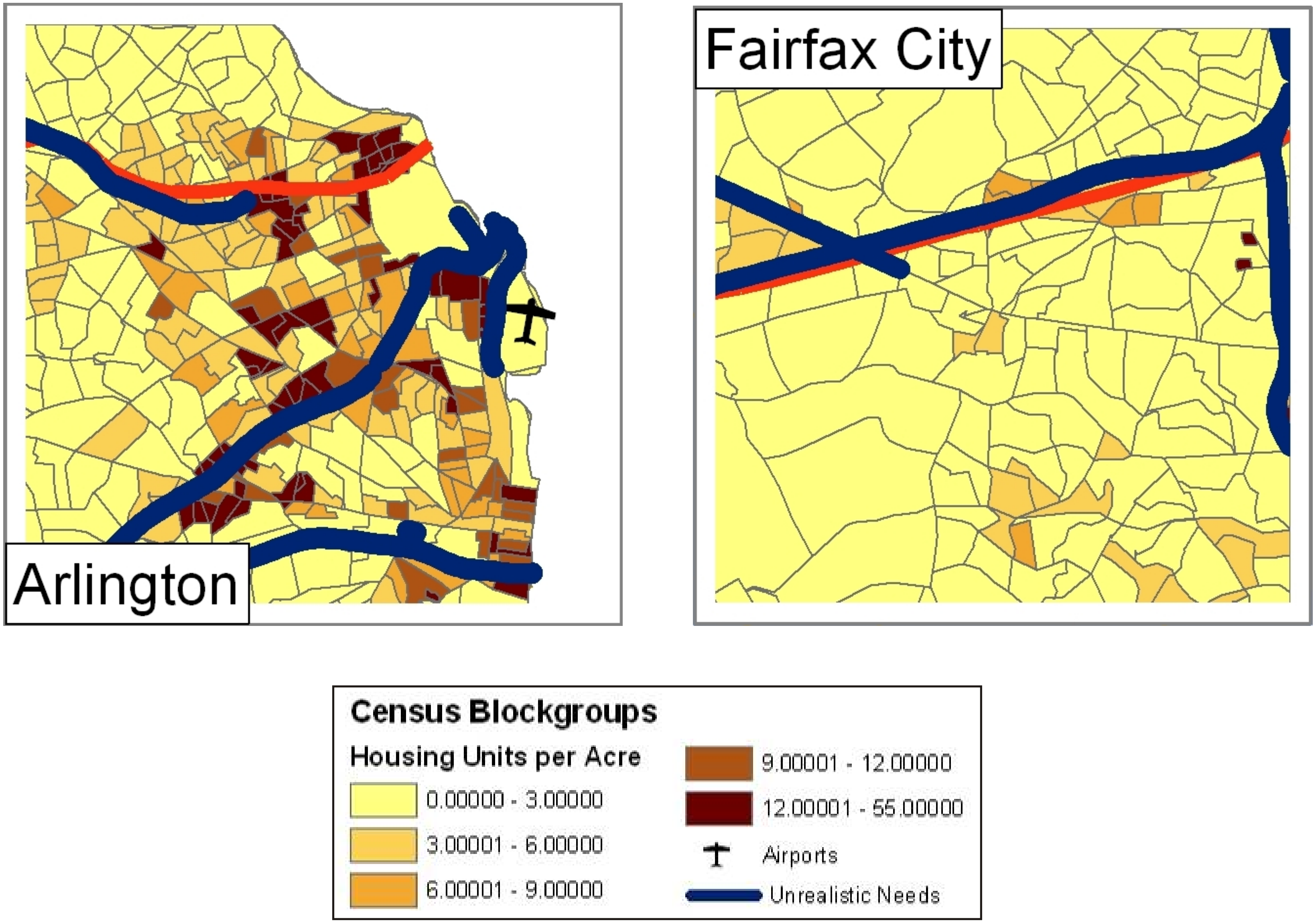

Multimodal Corridor M09 (US-17)
Winchester
Fredericksburg
Newport News
Norfolk
Census Blockgroups
Housing Units per Acre
0.00000 - 3.00000
3.00001 - 6.00000
6.00001 - 9.00000
9.00001 - 12.00000
12.00001 - 55.00000
Airports
Unrealistic Needs
0
15
30
60
Miles

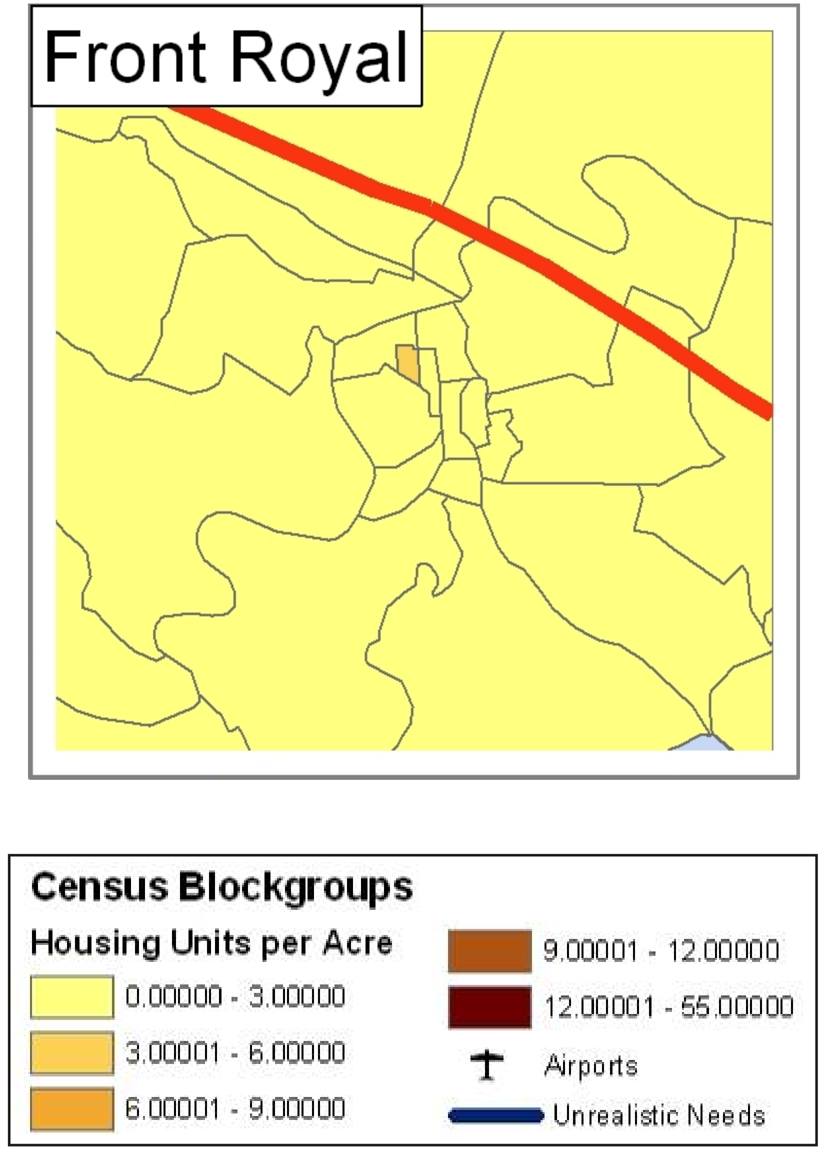

Winchester
Fredericksburg
Census Blockgroups
Housing Units per Acre
0.00000 - 3.00000
3.00001 - 6.00000
6.00001 - 9.00000
9.00001 - 12.00000
12.00001 - 55.00000
Airports
Unrealistic Needs

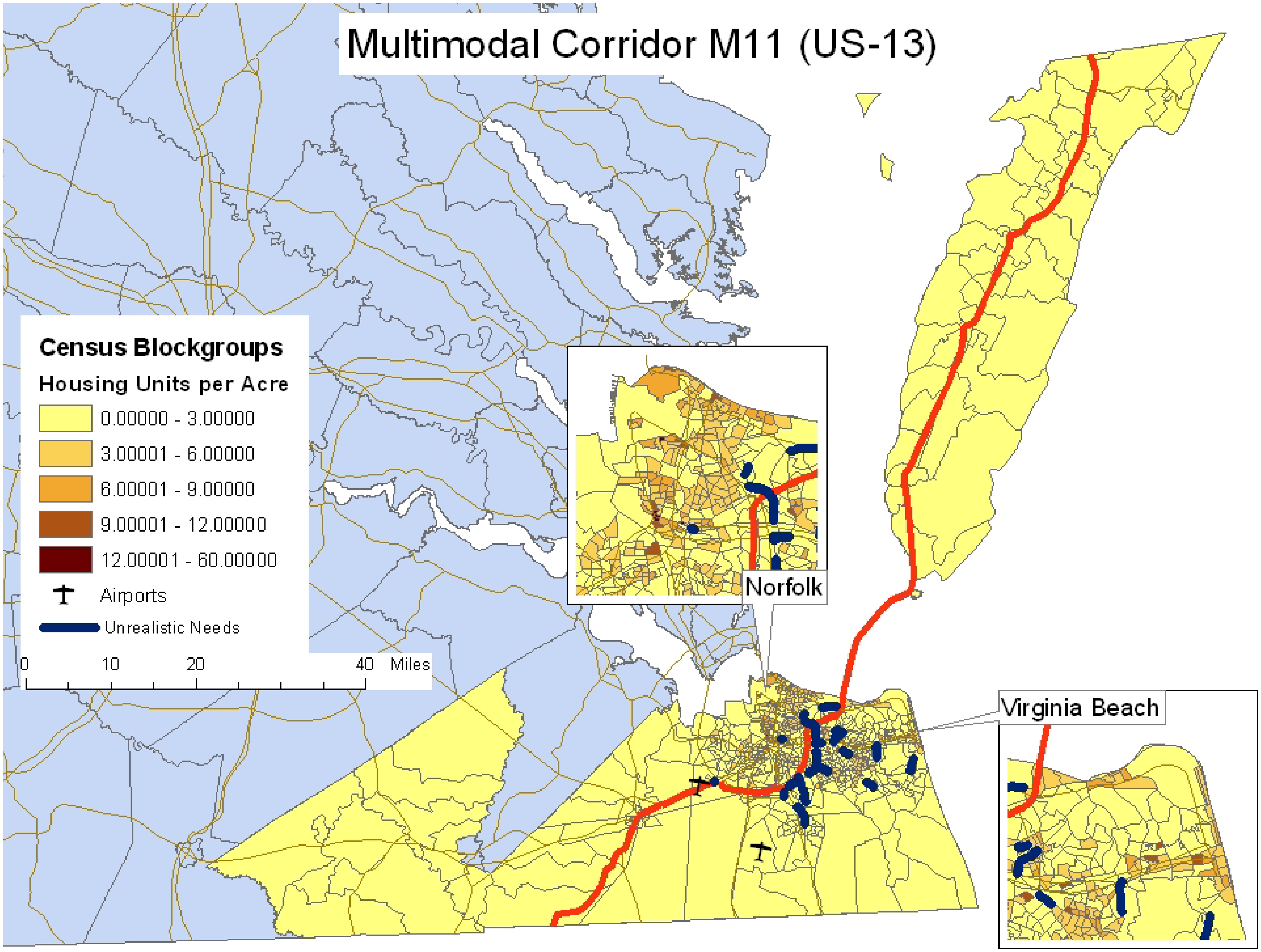

Newport News
Norfolk
Census Blockgroups
Housing Units per Acre
0.00000 - 3.00000
3.00001 - 6.00000
6.00001 - 9.00000
9.00001 - 12.00000
12.00001 - 55.00000
Airports
Unrealistic Needs

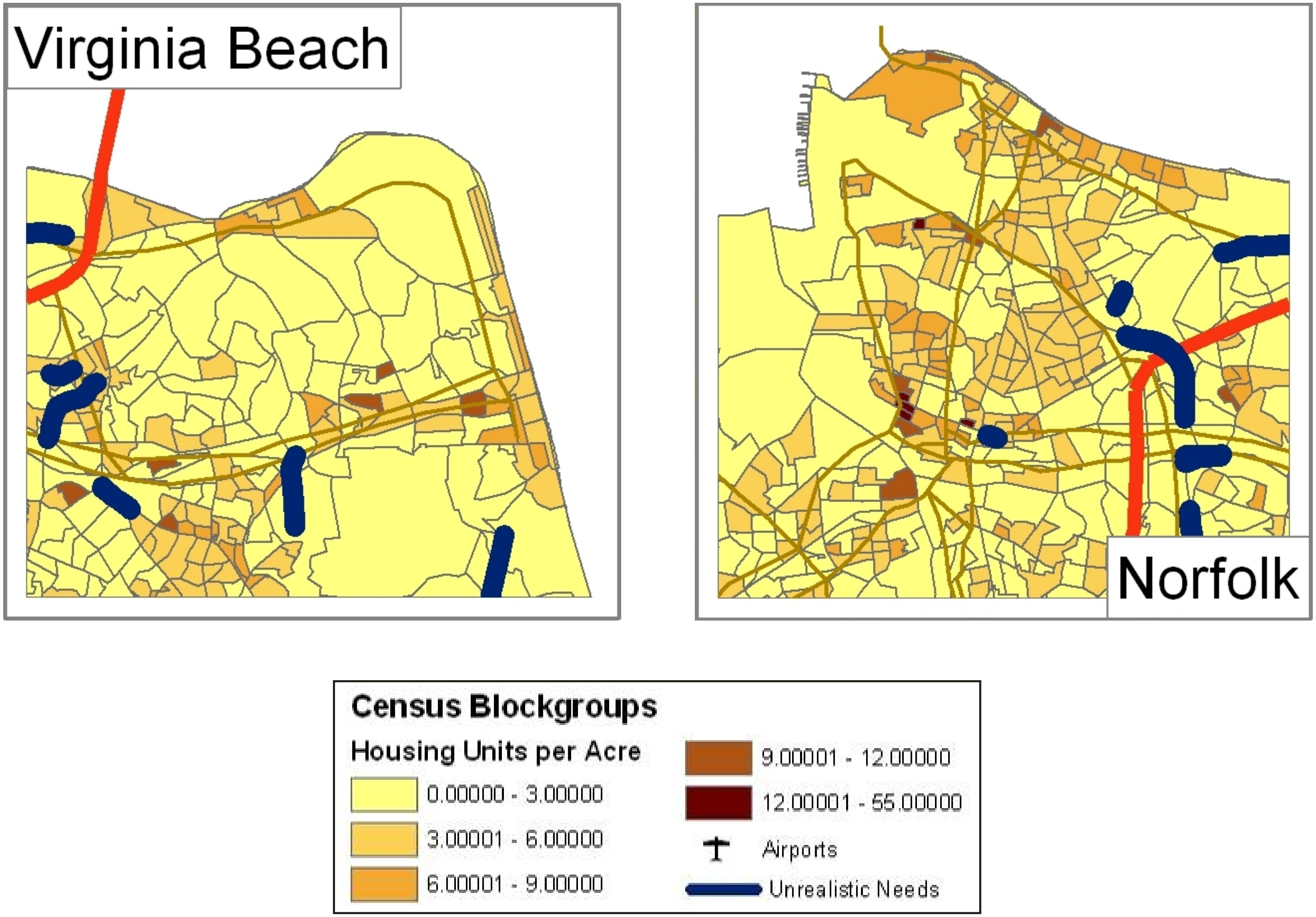

Multimodal Corridor M10 (I-66)
Arlington
Alexandria
Front Royal
Manassass
Fairfax City
Census Blockgroups
Housing Units per Acre
0.00000 - 3.00000
3.00001 - 6.00000
6.00001 - 9.00000
9.00001 - 12.00000
12.00001 - 55.00000
Airports
Unrealistic Needs
0
10
20
40
Miles


Manassass
Alexandria
Census Blockgroups
Housing Units per Acre
0.00000 - 3.00000
3.00001 - 6.00000
6.00001 - 9.00000
9.00001 - 12.00000
12.00001 - 55.00000
Airports
Unrealistic Needs


Arlington
Fairfax City
Census Blockgroups
Housing Units per Acre
0.00000 - 3.00000
3.00001 - 6.00000
6.00001 - 9.00000
9.00001 - 12.00000
12.00001 - 55.00000
Airports
Unrealistic Needs


Front Royal
Census Blockgroups
Housing Units per Acre
0.00000 - 3.00000
3.00001 - 6.00000
6.00001 - 9.00000
9.00001 - 12.00000
12.00001 - 55.00000
Airports
Unrealistic Needs


Multimodal Corridor M11 (US-13)
Census Blockgroups
Housing Units per Acre
0.00000 - 3.00000
3.00001 - 6.00000
6.00001 - 9.00000
9.00001 - 12.00000
12.00001 - 60.00000
Airports
Unrealistic Needs
0 10 20 40 Miles
Norfolk
Virginia Beach


Virginia Beach
Norfolk
Census Blockgroups
Housing Units per Acre
0.00000 - 3.00000
3.00001 - 6.00000
6.00001 - 9.00000
9.00001 - 12.00000
12.00001 - 55.00000
Airports
Unrealistic Needs