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FINAL REPORT

FREIGHT MOVEMENT, PORT FACILITIES, AND ECONOMIC COMPETITIVENESS

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16. Abstract:
This research report examines how the Panama Canal expansion will affect freight at three ports, truck movement between the ports and inland economic hubs and the economic impacts accompanying the shift in cargo shipping patterns. Economic impacts stemming from the Panama Canal expansion are examined with three primary research objectives: to profile the relationship between the Panama Canal and port activities along the East and Gulf Coasts and explore the nature of inland freight movement; to examine the implications for highway infrastructure resulting from a change in freight movement; and to model different scenarios of the Panama Canal expansions' impact on local economic activity.

The analysis begins by examining 14 east and Gulf Coast ports having a combined cargo volume of over one quarter million twenty-foot equivalent units (TEU). The research contains a deeper analysis of the relationship between highway network conditions, port activity and local and regional economies utilizing large seasonal truck GPS samples for three selected ports: the Garden City Terminal at the Port of Savannah, the Norfolk International Terminals in at the Port of Virginia, and the Napoleon Avenue Container Terminal at the Port of New Orleans. GPS truck data showed that congestion around the Port of New Orleans is limiting truck range compared with Savannah or Norfolk. While the Savannah area is not severely congested, main truck routes encounter congestion around major cities and highway interchanges in Georgia, and by 2040 congestion is expected to affect urban and rural interstates in South and North Carolina.

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Civil & Environmental Engineering
Georgia Institute of Technology
O. Lamar Allen Sustainable Education Building
788 Atlantic Drive
Atlanta, GA 30332-0355

Point of Contact: Dr. Michael P. Hunter

Submitted by:
Georgia Tech Research Corporation
(A Non-profit, State Controlled Institution of Higher Education)

Principal Investigator: Dr. Catherine L. Ross (catherine.ross@coa.gatech.edu)

Co-Principal Investigator: Dr. David Jung-Hwi Lee (david.lee@coa.gatech.edu)

Researchers:
Dr. Chelsea C. White III, Dr. Alan L. Erera, Peter Hylton, Fangru Wang, Yun Sang Lee, Sarah Smith

Georgia Institute of Technology
College of Architecture
Center for Quality Growth and Regional Development (CQGRD)
760 Spring Street, Suite 213
Atlanta, GA 30332-0790
Phone: (404) 385-5133, FAX: (404) 385-5127

Freight Movement, Port Facilities, and Economic Competitiveness

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About the Center for Quality Growth and Regional Development

The Center for Quality Growth and Regional Development (CQGRD) is an applied research center of the Georgia Institute of Technology. The Center serves communities by producing, disseminating, and helping to implement new ideas and technologies that improve the theory and practice of quality growth.

For more information visit www.cqgrd.gatech.edu.

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EXECUTIVE SUMMARY

Freight movement supports economic activity, undergirds quality of life, and shapes pollution and energy consumption. Freight connects production and consumption nodes, and provides access for businesses and consumers to a wide array of goods and resources. Freight is integral component to different parts of the production process as raw materials, pre-assembly subcomponents, finished products, and retail goods must all be transported to customers. Customers realize the impact of freight delays in the form of elevated costs and geographically limited access to markets as a result of the highly integrated nature of freight with the supply chain.

The expansive geographical range at which freight routinely operates means that many related issues cannot be fully addressed at the local level alone. A significant amount of cargo movement occurs as a part of globalized supply chains that link natural resources, manufacturers, intermediaries, and consumers throughout the world. Local freight movement depends not just on local conditions, but in large part it also dependent on global economic conditions and transportation infrastructure. A given road's freight volume may depend less on local characteristics than global production and consumption locations, and on its connection with global transportation infrastructure. Thus, a local perspective is necessary but not sufficient to understand freight movements occurring in any one city, county, or even state because the dynamics that drive freight are not local. Moreover, while local planning and engineering is necessary to respond to freight challenges, larger-scale policies are needed to optimize investments and ensure a consistent approach to solving freight issues.

The megaregion is a geographic scale useful to analyze freight movement. Megaregions are areas of continuous development that link cities, peripheries, and rural areas with long-term economic and transportation interactions. As the country's economic drivers, America's 10 megaregions concentrate a majority of its productive and purchasing power on a fraction of its land. The megaregion is the most ideal spatial unit from which multi-jurisdictional freight planning should be conducted. This report examines the potential impacts of freight movement through the lens of the megaregion to provide a clear understanding of the flow of goods at the most appropriate geographic scale.

The volume of freight imported into the United State and exported across the globe has increased exponentially over the past several decades. Much of this growth is related to expanding trade with East Asia. Most cargo between the two regions moves along a limited number of cargo routes. Two of the most travelled routes include a multimodal shipment of goods starting with a water route then offloaded at ports in California, Oregon, or Washington and loaded onto trucks or trains to complete the journey to the eastern United States. Another route, one that is growing in importance to the US economy is an all-water route with ships transiting the Panama Canal on their way to the East Coast and Gulf Coast U.S. ports. In both cases, to achieve economies of scale, ocean carriers are building larger and larger ocean going vessels.

These modern ships strain the capacity of one of the world's transportation network choke points: the Panama Canal. The vessels are much larger than the canal's original engineers could have foreseen; many of the vessels are larger than can be accommodated by the canal's locks. Moreover, the substantial increase demand for travel through the Panama Canal is pushing the current volume of movement towards the capacity. In preparation for forecasted trade growth, the Panama Canal Authority undertook an ambitious expansion project to accommodate modern ships and additional cargo volume. The expansion is scheduled for completion in 2016. The new locks will accommodate modern deep-draft ships with a draft of up to 50 feet, compared to a previous functional capacity of 39.5 feet. The canal offers a more direct—and with a larger ship capacity more economical—route to and from the eastern U.S., compared to the multi-model transcontinental ground shipments that is needed for freight arriving by ship on the west coast. This has the potential to shift a portion of previously West Coast port bound imports to the East Coast and Gulf of Mexico ports.

Cargo rarely stops at the port at which it is imported. Rather, dockworkers transfer cargo from the ship onto another mode that can reach the next destination. Several factors affect whether onward transportation occurs on a truck, train, barge, pipeline, or other mode. Generally, cargo that is time-sensitive, more valuable per weight, and closer to the final destination moves by truck compared with other modes. Moreover, ocean imports from East Asia moves inland by truck at a higher percentage (66% of tonnage) than total ocean imports (35% of tonnage), likely because of their commodity types (FAF3, 2011). Thus, ocean shipping volume and locations affects where, when, and how many trucks travel on American roads. Ocean shipping growth—especially from East Asia—merits examination to understand how it will affect roads

This research report forecasts how the Panama Canal expansion will affect three ports, truck movement between the ports and inland economic hubs, and the economic impacts that may accompany the shift in cargo shipping patterns. The project uniquely examines a broad range of economic impacts stemming from the Panama Canal expansion with three primary research objectives: to profile the relationship between the Panama Canal and port activities along the East and Gulf Coasts and explore the nature of inland freight movement from these ports; to examine the highway infrastructure implications resulting from a change in freight movement; and to model with scenarios the Panama Canal expansion’s impact on local economic activity.

The analysis begins by broadly examining 14 East and Gulf Coast ports with a combined cargo volume of over one quarter million twenty-foot equivalent units (TEU). The research then focuses on a deeper analysis of the relationship between highway network conditions, port activity and land and regional economies utilizing large seasonal truck GPS samples for three selected ports: the Garden City Terminal at the Port of Savannah, the Norfolk International Terminals in at the Port of Virginia, and the Napoleon Avenue Container Terminal at the Port of New Orleans. The research team found that many ports are exploring deepening their harbors to accommodate the largest of the new ‘post-Panamax’ ships that may traverse the expanded canal. However, only a few ports have moved beyond studies, namely Norfolk, Baltimore, New York / New Jersey, and Miami. Savannah is set to begin dredging very soon, and New Orleans is planning the most ambitious deepening project on the Gulf Coast. Therefore, the ports that have the harbor depths and supporting infrastructure in place to accommodate larger ships when the expanded canal opens in 2016 are the most likely to see cargo growth. When freight volumes do grow, they will enter an environment that is already severely congested in key places and getting worse. GPS truck data showed that congestion around the Port of New Orleans is limiting truck range compared with Savannah or Norfolk. While the Savannah area is not severely congested, main truck routes encounter congestion around major cities and highway interchanges in Georgia, and by 2040 congestion is expected to afflict many urban and rural interstates in South and North Carolina as well. Similarly, trucks leaving Norfolk encounter moderate congestion in large cities today, but by 2040 congestion is forecasted to be severe not only in major cities, but also along rural interstate segments as well. Chronic congestion can increase the cost of goods and force trucks to use less efficient routes. Congestion in rural and metro areas far away from a port does matter for port operations because of trucks movement patterns. Additionally, the study team found that truck parking shortages may already exist and will worsen in the future. Truck parking is very important to allow drivers to meet federally required rest periods and to enhance truck safety. However, parking is provided very unevenly around major ports. The literature documents widespread parking shortages, leading some drivers to park on ramps, highway shoulders, and other dangerous locations. A truck parking database analyzed in conjunction with GPS truck data revealed that major truck routes around the Port of Norfolk had fewer truck parking spaces per truck mile traveled than either Savannah or New Orleans. Overall shipping growth and cargo diversion caused by the Panama Canal will require roads around East and Gulf Coast ports to add in some cases hundreds or even thousands of truck parking spaces.

Next a forecast of changes along major freight corridors and potential bottlenecks is developed to measure the impact of the Panama Canal on inland transportation infrastructure. Cargo volumes in Savannah, GA; Norfolk, VA; and New Orleans, LA are examined providing a variety of generalizable results that can inform similar analysis in other East Coast and Gulf Coast ports. It matters for cargo volumes in ports and on roadways how much the canal expansion shifts traffic from West Coast to East and Gulf Coast ports. High rates of diverted shipments will produce a much greater impact on eastern ports and roads than will simply growing the status quo. Imports into the Port of Norfolk are forecasted to produce between 2,667 daily trucks (if the canal expansion has no impact) and 4,000 trucks (if the canal expansion has high impact). The Port of Savannah is likely to generate between 5,530 daily trucks (no impact) and 9,124 trucks (high impact), while New Orleans forecasts the most traffic with between 6,953 daily trucks (no impact) to 12,167 trucks (high impact). GPS data showed that many of these trucks stop at local distribution centers—up to 67.8% around the Port of Savannah. At these distribution centers, shipments are processed and loaded onto different trucks for onward movement. Trucks that do not stop in local distribution centers directly travel to inland customers or warehouses. The research team forecasted that there will be between 278 of these direct trucks per day on I-75 between Macon and Atlanta (if the canal expansion has no impact) to 458 direct trucks (if the canal expansion has a significant impact). When port cargo from distribution centers is added, the actual number of port-related trucks is much higher although difficult to estimate. Similarly, trucks leaving from the Port of New Orleans will significantly impact roads in Louisiana and surrounding states. Effects are projected to be greatest on interstates north and east of the port. I-55 south of Jackson, MS may see a between 509 (no impact) and 890 daily port-related trucks (high impact). I-10 around Gulfport could see between 371 (no impact) and 649 daily port-related trucks (high impact), and even I-20 as far away as western Birmingham, AL could see between 296 (no impact) and 518 (high impact) daily port-related trucks. A particularly important segment for New Orleans is the I-10 bridge across Lake Pontchartrain because it is a natural bottleneck. The bridge could see upwards of 2,469 (no impact) to 4,321 (high impact) daily port-related trucks. While Norfolk's geography creates fewer bottlenecks than New Orleans, cargo growth will still concentrate truck traffic a several important roadways. Direct shipments from the port alone (without counting trucks that have already stopped in local distribution centers) will add between 455 (no impact) and 682 (high impact) daily port-related trucks to the Hampton Roads Bridge Tunnel on I-64. The Monitor-Merrimack Bridge Tunnel on I-664 is forecasted to see between 172 (no impact) and 278 (high impact) daily port-related trucks, while the Chesapeake Bay Bridge Tunnel on US 13 could see 125 (low impact) to 187 (high impact) daily port-related trucks. Large impacts are also felt farther away. I-64 west of Richmond could see from 280 (no impact) to 421 (high impact) daily port-related trucks, while I-95 just south of the VA-NC border could see between 234 (no impact) and 351 (high impact) daily trucks.

The focus of the study narrows once more to the state of Georgia developing a model of economic activity in each county that depends on port-related imports yielding important information on direct and indirect industry and freight linkages. These linkages are used to estimate the economic impact of the Panama Canal on Georgia's 159 counties. Through 2040, the canal expansion is expected to generate between $21 billion and $57 billion dollars in economic activity equating to between $5.4 billion and $36 billion dollars in economic growth compared with 2013 port activity. The Port of Savannah is expected to sustain between 38 thousand and 66 thousand jobs. The exact amount of growth depends on the extent to which the canal expansion diverts ships from competing routes. The greatest monetary impacts will be felt in Fulton, Gwinnett, Chatham, Troup, and Cobb Counties in decreasing order, while the most jobs will be felt in Gwinnett, Fulton, Chatham, Troup, and DeKalb Counties. Moreover, the economic impacts are much larger than the approximately $652 million necessary to deepen the Savannah harbor. If the Panama Canal expansion diverts a small amount of cargo from West Coast ports, the impact on Georgia of that small diversion alone is estimated at $10 billion, and a large diversion could affect $31 billion in Georgian economic activity.

The research provides decision makers with insights to improve regional and statewide transportation planning and support economic development. The project addresses the emerging topic of freight planning at a megaregion scale; an issue that is important for effectively and efficiently capturing the economic benefits canal expansion will generate. Responding to the cargo growth at the Port of Savannah or any other large port will large depend on coordination across silos, organizations, and states. The Georgia Department of Transportation (GDOT) should continue coordinating with other states, such as through their membership in the Institute for Trade & Transportation Studies, to ensure continuous freight flows across the megaregion serviced by the Port of Savannah. Many of the greatest impacts will be on interstate highways, which will require federal agency support. Local governments can help freight flow smoothly in the state by aligning their land use regulations with Georgia's designated freight corridors. In particular, land use regulations should encourage the distribution centers that will accompany port cargo growth to locate along existing designated freight corridors and discourage incompatible land uses. It may also be helpful to continue strengthening the existing working relationships with the Georgia Ports Authority to ensure that the state's transportation planners remain aware of changes to ocean carrier operations that may affect the frequency, amount, or cargo types transported to and from the Port of Savannah. Finally, other modal operators—particularly railroads—should play a role in accommodating freight growth. Using alternative modes may allow cargo to bypass congested roadways. Without a doubt, capacity is important to solving the challenges and realizing the opportunities presented by port cargo growth. However, using existing capacity as fully as possible, encouraging land uses that minimize redundant investment, and fully exploring all modes should allow the state to effectively manage and support port-related trucking.

The Georgia Department of Transportation (GDOT) and the U.S. Department of Transportation (USDOT) supported this research, conducted under the auspices of the National Center for Transportation System Productivity and Management (NCTSPM) at the Georgia Institute of Technology.

The research team drew the following major findings from its analysis:

Shipping Volumes

- Finding 1: Cargo throughput at any individual port depends on a myriad of local national, and global factors.

Truck Volumes

- Finding 1: Several scenarios of freight demand show the Panama Canal expansion will likely have a significant impact on truck traffic.
- Finding 2: Rail will be most competitive with trucks on corridors with a high levels of congestion.

Bottlenecks

- Finding 1: Highways around the Savannah port are better prepared for canal-related growth than either Norfolk or New Orleans.
- Finding 2: Bottlenecks exist around all three ports with increased levels of congestion expected.
- Finding 3: Most major Georgia freight routes are currently designated freight corridors; others may need to be added.

Parking Needs and Safety

- Finding 1: The availability of truck parking may be a safety concern as freight traffic grows.
- Finding 2: Georgia is least equipped with truck parking compared to surrounding states.
- Finding 3: Each corridor in each megaregion will require additional parking to maintain the current level of service.
- Finding 4: Growing freight volumes may affect truck-related accident rates far from the port generating the traffic.

Economic Impact

- Finding 1: Primary benefactors are counties surrounding the Port of Savannah and major population centers.

- Finding 2: Panama Canal expansion will potentially have an economic impact of over $35 billion by 2040 in Georgia.

The research team recommend the followings:

Address Bottlenecks

1. Expand capacity on some key roadways.
2. Partner with other states in the Piedmont Atlantic Megaregion to address bottlenecks on primary port-related corridors outside the state.
3. Leverage data and information technologies to optimize roadway operations.

Strengthen Coordination between Port Operators and State Department of Transportation

1. Maintain a close working relationship with the Georgia Ports Authority.
2. Build partnerships with other state departments of transportation and port operators in megaregions to explore how cooperation can maximize megaregion attractiveness to ocean carriers.

Leverage Designated Freight Corridors

1. Align freight corridors with import truck traffic. The analysis has confirmed that most major port-related routes are already state freight routes.
2. Coordinate freight corridors with surrounding states in megaregion to ensure continuity across state lines.
3. Work with local governments to align zoning with designated freight corridors.

SECTION I. INTRODUCTION

Research Background

To many Americans, global supply chains seem understandably distant from daily life. The transactions that connect suppliers, factories, stores, and consumers all over the world can appear abstract in a way that make its effects on quality of life hard to see. In reality, logistics are deeply interwoven into nearly everyone's life. Americans buy globally produced goods in stores, businesses transform imported materials into finished products, and companies sell their goods on a global market. Interlinking each of these myriad activities is an army of companies and individuals operating trucks, trains, and pipelines within the United States, and ships and airplanes between overseas destinations. Ever-active freight movement links each organization in countless production activities that allow the complex global economy to function. As such, even local freight movements carry a global component. Local, intra-state, and inter-state freight are all at times responsible for transporting goods the first or last miles to or from an overseas destination.

Global supply chains are now an integral part of many economic sectors. To be sure, globalization has been controversial because of its connections with offshore production and reduced regulatory oversight. However, today global supply chains are a reality deeply imbedded in American consumption and economic patterns. Significant amounts of America's economic activity depend on globally sourced goods. Transportation costs are built into products that are produced overseas in part or in full, as well as American goods and services that use imported goods as inputs. Economic wellbeing has come to depend on reliable and inexpensive transportation. Congestion at any point along the supply chain raises costs passed on to consumers and ultimately discourages overseas trade.

A major change to the global cargo transportation network will occur in 2016 when new oversized locks at the Panama Canal are opened. The Panama Canal is one of the most important passageways linking East Asian and Eastern American ports. The Panama Canal expansion will allow larger, more efficient ships to transit between the Pacific Ocean and the Caribbean Sea in a way that will change the Panama Canal's benefits relative to competing routes. Many have projected that the expansion will lower the cost of shipping directly from Asia to U.S. East and Gulf Coast ports, in the process shifting cargo away from West Coast ports. East and Gulf Coast ports are preparing accordingly. Many are buying larger cranes and deepening their harbors to welcome the larger ships, knowing that with cargo come jobs and corporate transportation investment. However, by focusing attention on just the ports themselves, more macro-level megaregion planning activities may not be receiving enough attention. Moreover, cargo does not stop once it leaves a ship. From there it is transported usually by truck or train to consumers from a few miles offsite to thousands of miles away. If these last important links in the supply chain are not ready to accommodate the new freight, then congestion will raise costs for consumers around the country, force cargo into less ideal ports, and sap trade's economic benefits. Moreover, high truck volumes would tend to raise roadway accident rates if growth is not accompanied by strategies to enhance safety, such as driver rest areas and appropriate roadway geometry.

The danger of congested roads is even greater because port-related freight will increase at the same time that nationwide freight is projected to grow independently of the canal expansion. Major trucking corridors support 75% of total commodity flows by value, but freight already strains existing roads. Moreover, the Freight Analysis Framework (FAF3) projects that truck ton-miles will grow from over 2.18 trillion ton miles in 2015 to over 3.31 trillion in 2040, an increase of 52%. The Panama Canal expansion will reconfigure global supply chains, shifting trucks away from some ports and towards others. As a result, congestion risks spreading to the nation's most import freight arteries, which directly affects economic competitiveness.

This report presents findings of a multiyear study of roadways and counties around three case study ports under several ocean shipping scenarios. The Port of Savannah (Garden City Terminal), the Port of Hampton Roads (the Norfolk International Terminals), and Port of New Orleans (Napoleon Avenue Container Terminal) were chosen for analysis because they each are investing to be ready for more and larger ships. The study examines how the Panama Canal expansion will likely affect each port's cargo volume, if and where bottlenecks might occur in the port's operating region, and how much cargo increases will stimulate the state economy.

The ports were selected because of the contrasts that they provide. The ports differ in size, commodity types, and primary trade partners, but each is investing in infrastructure and projects to accommodate larger ships related to the Panama Canal expansion. The ports are at different points in readiness for post-Panamax ships; the Port of Virginia at Norfolk is naturally one of the deepest harbors on the East Coast with a depth of at least 50 feet. By contrast, the Port of Savannah is set to begin dredging to deepen the harbor to 47 feet, and the Port of New Orleans is conducting studies. Moreover, each port presents a different commodity. Savannah and Norfolk import large quantities of consumer goods, while New Orleans' largest shipment categories are mostly energy resources and industrial products. The ports are linked differently with inland transportation networks. Most imports into Savannah move inland by truck, while Norfolk has a larger rail presence, and New Orleans is nearly evenly split among truck, rail, pipelines, and water movement. Finally, the three ports' areas of influence cover a significant portion of the eastern United States with minimal overlap. These characteristics make study findings most transferrable to other settings in the eastern United States, including the 11 other large container ports that are presented in Figure 1.

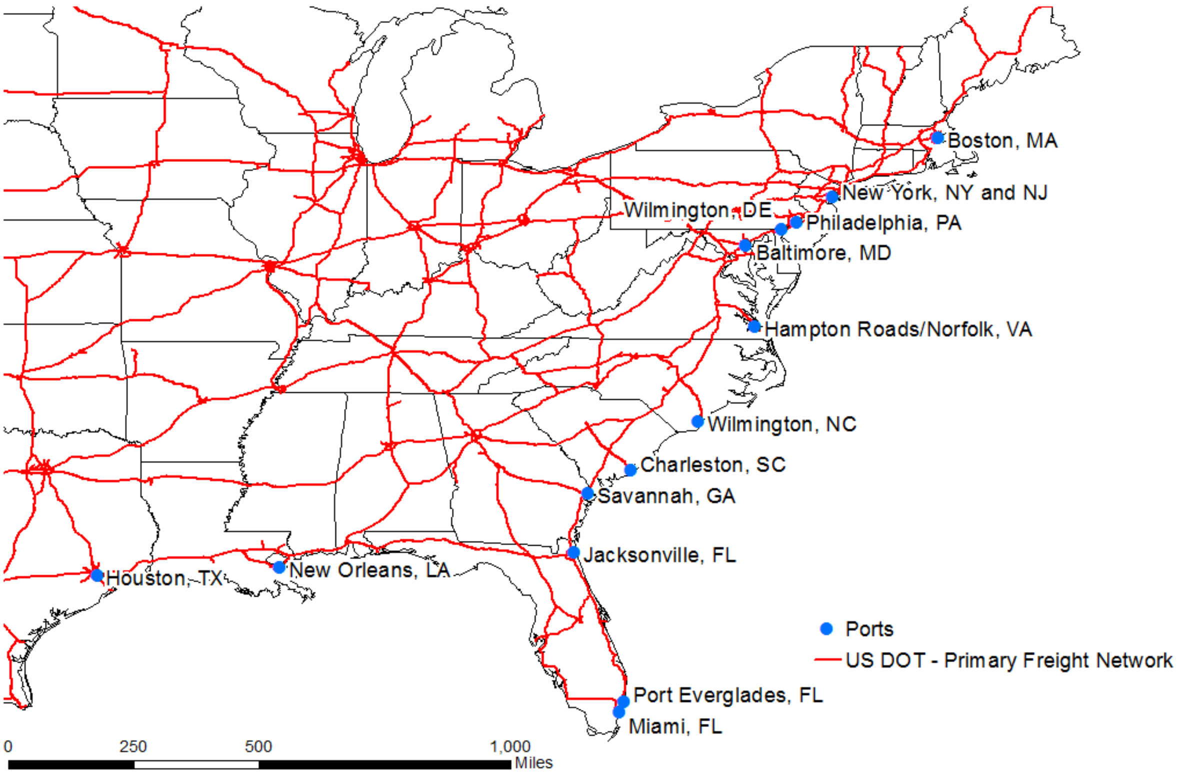


Figure 1: Major Port Locations

Source: Center for Quality Growth and Regional Development, modified from U.S. Army Corps of Engineers Navigation Data Center (2014) and ESRI GIS data (2010)

The study also builds on years of research findings by the Center for Quality Growth and Regional Development (CQGRD), which have shown that freight connections should be addressed at the megaregion scale. Megaregions have the distinct advantage of following functional rather than purely political boundaries. The megaregion framework aligns closely with the system-wide, multijurisdictional scale needed to analyze global supply chains. A number of studies have established megaregions' importance. In 2005, approximately two-thirds of all U.S. trade took place in the 50 largest metropolitan areas (Puentes, 2008). International trade's place in most megaregions continues to grow (Ross et al., 2008). As economic centers, megaregions also serve as freight nodes connecting origins and destinations. Megaregion's central role underscores the importance of considering freight movement at the scale of the megaregion (Gifford et al., 2010; Ross et al., 2008; Seedah & Harrison, 2011). Megaregion planning allows regions, cities and towns to compete globally as cohesive regions connected by efficient and reliable transportation links.

This study concentrates on three megaregions that are partially contained in the three case study ports' operating area. Figure 2 below shows the locations for the Texas Triangle Megaregion, the Piedmont Atlantic Megaregion, and the DC-Virginia Megaregion relative to the ports of New Orleans, Savannah, and Norfolk. The megaregions' different economic and commodity profiles are mirrored to a large extent in the ports' commodity imports. The existing truck movements also attest to the links between the ports and megaregion economies. Each megaregion highlights the ports' large area of influences.

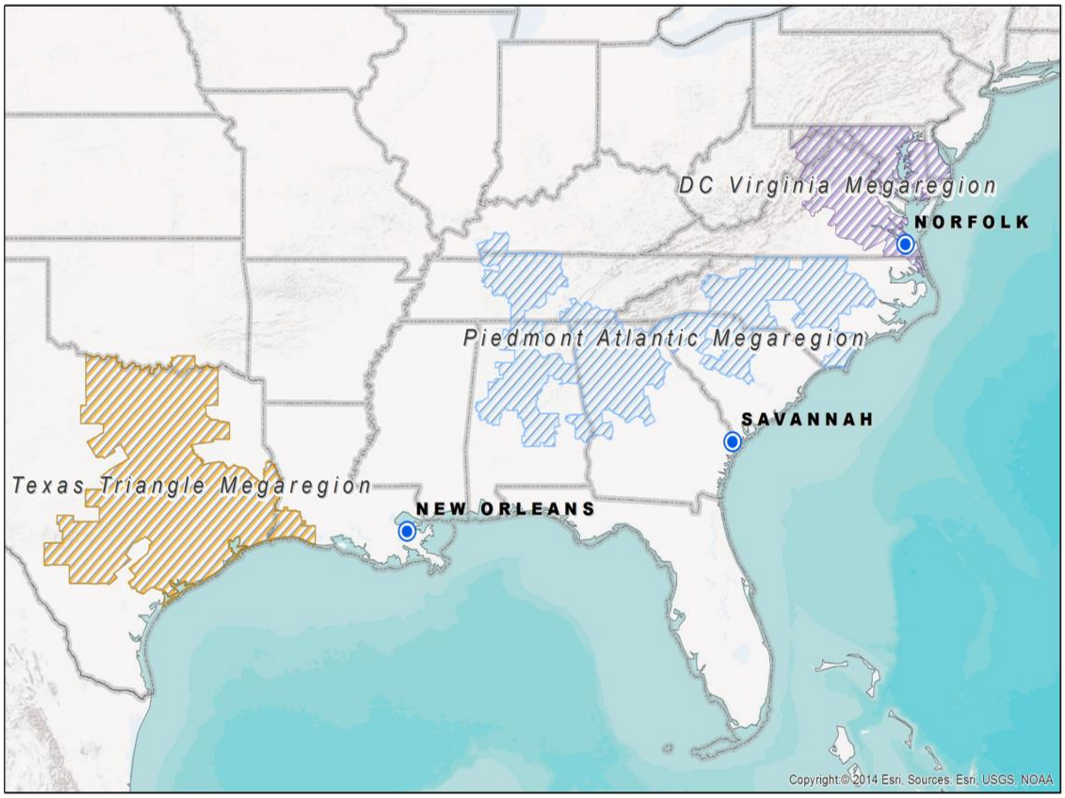


Figure 2. Three Ports and Megaregions of Study

Source: Center for Quality Growth and Regional Development (2009) and U.S. Army Corps of Engineers Navigation Data Center (2014)

A key data source for this study is a disaggregate truck movement database generated by the American Transportation Research Institute (ATRI). This database, which is generated from location readings collected from several hundred thousand trucks equipped with advanced global positioning system-based (GPS) technology, contains several billion position reads annually. The Federal Highway Administration has used ATRI's truck data as part of its Freight Performance Measures program, as have numerous states and metropolitan regions for freight planning purposes. Many other data sources support the freight analysis presented in the report. The Freight Analysis Framework, version 3 (FAF3) documents freight movement among 123 regions throughout the United States. FAF3 also forecasts future freight movement and overseas imports through year 2040. The research team also called on economic analysis tools. One is called IMPLAN. IMPLAN quantifies economic relationships among industrial sectors and identifies county-level demand for different commodities. The research team merged these primary datasets and other secondary data to build and supports its analysis and conclusions.

In the end, the study connects macroeconomic changes and the Panama Canal expansion with specific roadway volumes, the project allows planners to prepare in a way that avoids or minimizes congestion, infrastructure degradation, and safety degradation. The research team found that forecasted freight increases are likely to strain selected road segments around the three study ports. Planning will be important for effectively and efficiently capturing the economic benefits that the expansion will generate. Effective planning must go beyond individual jurisdictions and bring governments together to address freight movement at the regional and the megaregion scale. Inter-jurisdictional cooperation is important for each ports region’s economic competitiveness and indeed for the entire national economy, which depends on reliable and economical freight movement.

Report Organization

The report begins broadly and narrows its focus until it identifies specific corridors at risk for bottlenecks and economic impact. Early report sections (namely Sections II and III) are both geographically broad and topically diverse. They describe current and forecasted states of transoceanic shipping and nationwide trucking, while also raising a series of related safety and economic issues. Subsequent Sections IV, V, and VI hone the focus onto the three case study ports and associated megaregions. The report documents current truck movements that originate at the three case study ports by analyzing a sample of GPS data and identifies how the Panama Canal expansion is likely to affect trucking patterns. Finally Section VII describes an economic analysis approach that could be used in any state but is concretely applied to Georgia's 159 counties. Section VIII reviews key report findings and draws policy implications. The following paragraphs address each section's purpose.

Section II – Literature Review: The literature review grounds the report in the most advanced knowledge on (1) freight characteristics and previous Panama Canal studies, (2) freight regulations and safety, and (3) economic impact analysis methodologies. A significant portion of the literature review focuses on trucking because of the need to address inland port-related freight corridors. Moreover, trucking accounts for 69% of freight movement by tonnage and 75% of freight movement by value in the United States (American Trucking Associations, 2013a), making it essential to economic health. The literature review also uncovers important freight and regulatory issues. Federal regulations require that truck drivers rest after a certain period of on-duty time. Truck traffic growth will accentuate the need for rest areas for truck drivers to operate safely and legally.

Section III – Baseline Conditions: Baseline conditions are the context through which the research explains the trends and forecasts developed in latter sections. This section identifies existing conditions and statistics on the relationship between the Panama Canal and the eastern ports. The section details port characteristics, freight volumes, commodity breakdowns, and improvement plans, as well as current and forecasted Panama Canal volumes.

Section IV – Freight Movement from a Megaregions Perspective: Megaregions are an important framework for understanding multi-jurisdictional issues like freight. Section IV profiles freight and freight-generating activity in each of the three megaregions corresponding with the case study ports. Specifically, the section describes the status of port facilities, major truck corridors, the spatial structure of industry clusters and functional relationships, warehousing hub, and megaregion import commodities.

Section V – Truck Network Analysis: Advanced global positioning system (GPS) data for thousands of trucks allowed the research team to study current truck movement from each of the three ports. To understand how increased port activity will affect regional transportation networks in the future, it is first important to understand how the network is currently behaving. This section also establishes the operating range for the trucks, which defines the freight-shed for each port. Three characteristics have been determined for each freight-shed: (1) size of the region and extent of the trucking transportation network; (2) ease of trucking mobility in the region, and (3) availability of truck parking.

Section VI – Impacts of the Panama Canal Expansion on Freight Movement: One of the report's major contributions is its growth scenarios that quantify potential Panama Canal expansion impacts on the three case study ports. The forecasts implicitly account for changes in the canal's relative competitiveness vis-à-vis other trade routes and for economic growth in destination counties. The port forecasts provide inputs for Section VII's economic analysis.

Section VII – Regional Economic Impact Analysis. Section VII propose and implements a methodology for estimating county-level economic impacts related to forecasted freight increases in the state of Georgia. This will provide transportation planners with guidance on the important transportation corridors that will need the most investment.

Section VIII – Conclusions: The final section draws together all report section and information from the Georgia Statewide Freight and Logistics Plan into concise findings and recommendations for future action.

SECTION II. LITERATURE REVIEW

Expected Impacts of Canal Expansion

Introduction

The Panama Canal expansion is expected to support growth in shipping tonnage between the Atlantic and Pacific Oceans, with larger post-Panamax ships comprising much of the fleet. Post-Panamax ships are too wide or deep to fit through the Panama Canal (whose present locks are 110 feet wide, 1,050 feet long, and approximately 41 feet deep), but will be able to traverse the newly built Panama Canal locks, (which will be 180 feet wide, 1,400 feet long, and 60 feet deep). The expansion is expected to open new opportunities for U.S. East Coast and Gulf Coast ports, which will likely see growth in maritime cargo diverted from West Coast ports. There is a general consensus that the expanded Panama Canal will be a boon for East Coast and Gulf Coast ports because of potential traffic diversion, increasing ship size, and export opportunities.

Traffic Diversion

While cargo volume between East Asia and the eastern United States are the Panama Canal's largest single trade route, the Panama Canal competes with two other routes for freight between East Asian and the eastern United States. One route is called the intermodal route. The intermodal route transports cargo from Asian ports to western U.S. and Canadian ports. From there, the cargo is loaded onto trucks or trains to complete the journey on land. The intermodal route is normally a few days faster than the all water route through the Panama Canal, though it is also more expensive.

The second competing route is through the Suez Canal. Cargo is loaded onto ships in Asia and travels westward to ports on America's East and Gulf Coasts through the Strait of Malacca, the Suez Canal, and the Mediterranean Sea. The Suez route is longer than the Panama Canal route for origins east of Singapore. However, the Suez Canal is much larger than the Panama Canal and therefore can accommodate much larger ships.

The Panama Canal's ability to compete with the intermodal route and the Suez route is a function of several factors, including ship size and energy costs. Drewry (2008) predicts that cargo from Asia would increasingly divert from West Coast ports to East Coast and Gulf Coast ports because of rising intermodal costs and falling all-water costs. The expanded Panama Canal lowers costs for the Panama route, even as high demand for rail transport has pushed up intermodal route costs. CanagaRetna (2010) highlights the shift from West Coast ports to East Coast and Gulf Coast ports facilitated by the expanded canal.

Jones Lang LaSalle (2011) believes that the highest value cargo from Northeast Asia to the eastern U.S. will continue to use the intermodal route even as lower value cargo follows the lowest cost shipment option, which is the all-water route. A "demarcation line" (Jones Lang LaSalle, 2011) or "line of cost equivalence" (Rodrigue & Notteboom, 2010) divides the United States according to the coast that is most cost-effective for receiving shipments from East Asia:

areas east of the line can most economically receive shipments from the Gulf Coast or East Coast, whereas areas west of the line could receive shipments from the West Coast at the lowest price. The Canal expansion will likely move the old line of cost equivalence westward, increasing the territory that can economically receive lower-value Asian cargo through East and Gulf Coast ports. Table 3**Error! Reference source not found.** below shows the approximate old (black) and new (red) locations of the line of cost equivalence (Jones Lang LaSalle, 2011).

Figure 3: Movement of Line of Cost Equivalence Before and After Canal Expansion

Source: Jones Lang LaSalle, 2011

Other factors favoring the Panama Canal route over the intermodal route include a series of expensive strikes and work slowdowns along the West Coast ports and more available land for supply chain functions near East Coast and Gulf Coast ports. Already the canal is performing strongly compared with its competition. Between 1999 and 2007, the Panama Canal Authority reports that the Panama Canal's share of freight between Northeast Asia and the U.S. East Coast increased from 11.3% to 43.0% at the expense of the intermodal route (Rodrigue, 2010).

The Panama Canal's strong performance combined with global cargo volume growth has caused many East and Gulf Coast ports to plan for growth. The global economy and the shipping industry continues to recover from the recent economic recession (De Monie, Rodrigue, & Notteboom, 2009). The Port of Hampton Roads / Norfolk forecasts an increase in demand from 2.1 million TEUs to a minimum of 4 million TEUs by 2028 based on the Global Insights forecast for the East Coast (The Port of Virginia, 2013). The Georgia Port Authority projects increases in vessel calls between 5% and 7% annually at the Port of Savannah through 2022 (Institute for Water Resources, 2012). The Port of New Orleans is also expecting significant cargo increases (Masson, 2013). The expanded Panama Canal may divert significant freight volume from West Coast ports to East and Gulf Coast ports.

On a regional scale, IHS Global Insights (2009) predicts growth in East Coast and Gulf Coast ports due to trade with Europe and Latin America without apparently accounting for trade diversion due to the Panama Canal. If there is significant diversion, the effects could be dramatic, as IHS Global Insights (2009) predicts that TEUs from China and Taiwan to the U.S. to increase by about 375% between 2013 and 2037. Moreover, Global Insights estimates that the Panama Canal cargo tonnage throughput will increase by 3% per year (Knight, 2008).

Vessel Size

Many analysts expect the expanded Panama Canal to lead to larger ships frequenting East Coast and Gulf Coast ports. Marginal decreases in per unit shipping costs have encouraged shipping companies to order post-Panamax ships. It has been especially important to reduce shipping costs in light of fuel prices and industry overcapacity in recent years, which have led some shipping companies to reduce ship speeds and pass on savings to clients, a practice referred to as “slow steaming” (Jones Lang LaSalle, 2011).

Today 30% of the world fleet is post-Panamax, as are most ships on order (Bank of America Merrill Lynch, 2013). Ashar (2010) argues that shippers in recent years have favored the longer transit times and lower costs of an all water route compared with the faster times and higher costs of the intermodal route. This has contributed to the Panama Canal’s steadily increasing market share on the Asia-eastern U.S. route. The Panama Canal is likely to continue increasing its market share, especially for low-value commodities, as the expanded Canal increases shipment reliability and decreases shipping cost (Rodrigue, 2010; Salin, 2010).

Export Potential

The Panama Canal expansion also offers East Coast ports an opportunity to expand their exports to Asia. There is already extra export capacity compared with imports in East Coast and Gulf Coast ports (Rodrigue, 2010). However, the canal expansion will offer more reliable and faster transit times that may make it more advantageous for exports to leave from East Coast and Gulf Coast ports, especially for low-value commodities. Presently, it is common practice for ships loaded with low-value commodities to not purchase a canal reservation and instead to wait for an available transit time (Institute for Water Resources, 2012). Canal congestion increases wait time.

Baird, Bittner, Gollnik, and Gardner (2011) describe the potential for decreased costs and increasing reliability for the all-water route for exporting Midwestern grain to Asia. Similarly, Costa and Rosson (2012) modelled U.S. cotton exports under different scenarios and predict that lowered shipment costs associated with the Panama Canal expansion will dramatically increase cotton exports through the canal. The U.S. Army Corps of Engineers also expects the Panama Canal expansion “to significantly lower the delivery cost of U.S. agricultural exports to Asia and other foreign markets” (Institute for Water Resources, 2012).

However, Baird et al. (2011) believe that short-term export increases from Gulf Coast ports will depend heavily on Panama Canal Authority's operating and pricing policies. Significant increases in Canal transit fees could mitigate the all-water route's savings. Even if high canal transit fees discourage agricultural products from diverting to Gulf Coast ports in the short-run, Baird et al. (2011) argue that Gulf Coast ports are likely to accommodate additional grain exports to Asia in the long-run.

Other Opinions

While it is generally viewed that the Panama Canal will increase cargo volumes to East Coast and Gulf Coast ports, there remain some questions. Ashar (2010) argues that the savings of post-Panamax ships over Panamax ships is too minor to divert large amounts of cargo from the intermodal route. Moreover, Mitchell (2011) asserts that freight volumes on the intermodal route are not significant enough for a small diversion to have a major impact on East Coast and Gulf Coast ports. For these authors, growth in port volumes will come largely through total cargo volume increases between Asia and the eastern United States.

Uncertainties

The extent to which East and Gulf Coast ports experience cargo growth depends on macroeconomic conditions and business strategies that cannot be accurately predicted. Among the macroeconomic conditions are the strength and locations of manufacturer and consumer demand. The Panama Canal Authority's fee structure, ocean carriers' operational decisions, and West Coast ports' responses will also affect canal traffic. Finally, there is a possibility that new routes may emerge to compete with the Panama Canal, either in the form of a Nicaraguan Canal or an Artic passage. Each uncertainty is reviewed below.

Location of Production Centers

Economic dynamics in Asia and the United States could affect short- or long-term supply or demand. Rodrigue (2010) discusses the possibility of production leaving China—where labor costs are rising—for less expensive countries in South Asia, Southeast Asia, or Latin America. If supply does shift to Southeast or South Asia, the westbound-route through the Suez Canal might attract shipping companies. Southeast Asia is near the point at which ships can reach the U.S. East Coast by the same distance either eastward (through the Panama Canal) or westward (through the Suez Canal). This is called the "indifference point," located near Singapore. Production occurring east of Singapore would favor the Panama Canal and production occurring west of Singapore would favor the Suez Canal. However, this shift does not threaten East Coast and Gulf Coast port volumes. In fact, it might likely increase them. It could also imply a decreased reliance on the Panama Canal to reach the American market. Figure 4 below shows the competing westbound and eastbound routes as they relate to the indifference point.

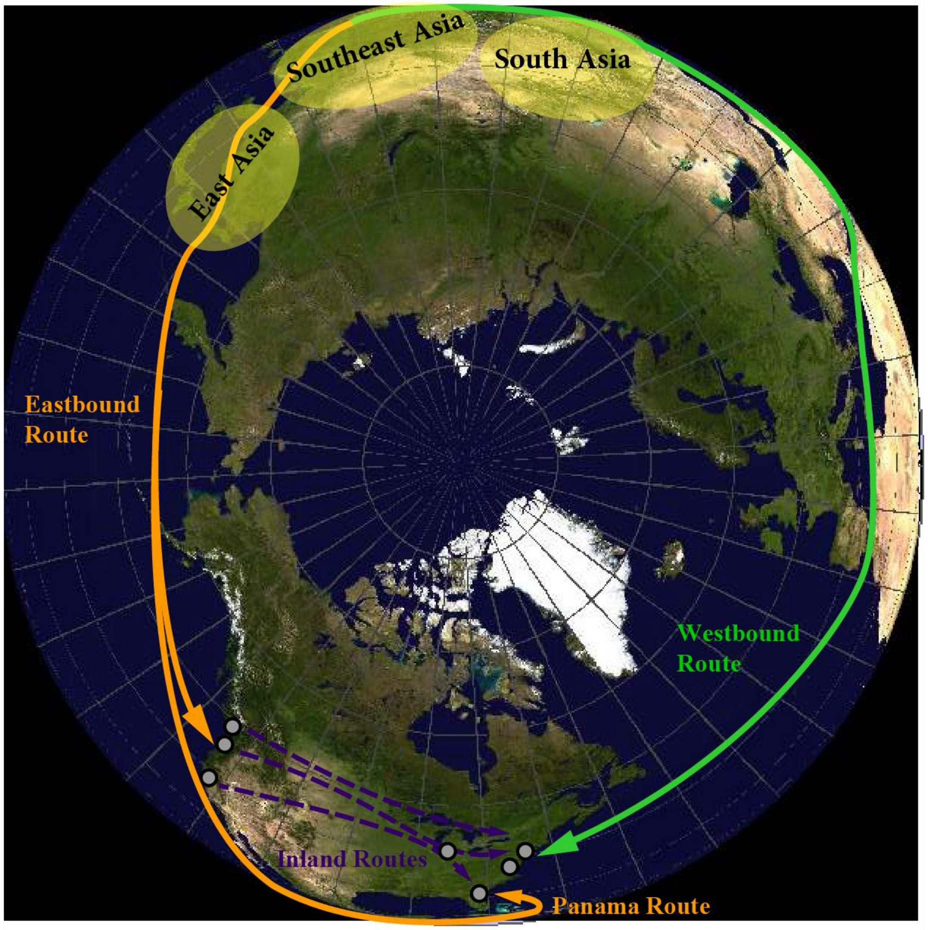


Figure 4: Competing Routes to the U.S. East Coast from Asia through the Suez Canal ("Westbound"), the Panama Canal ("Eastbound"), and Ship and Truck/Rail ("Land Bridge")

Source: Center for Quality Growth and Regional Development, modified from Rodrigue (2010)

High oil prices, rising labor costs, and supply chain uncertainty might also drive production to Latin America or even back to the United States itself (Harrington, 2012; The Economist, 2013). Most origins in Latin America would still rely on ocean shipment that might or might not use the Panama Canal but would use East Coast and Gulf Coast ports. Fossey (2010) and Drewry (2008) assert that shifts in production from East Asia to South America may also drive growth in Gulf and East Coast ports.

Consumer Demand

Rodrigue (2010) addresses consumer demand since stagnant consumer demand could affect shipping demand. America's aging population will likely devote a higher portion of the gross domestic product to healthcare rather than other economic sectors that drive shipments from East Asia. Rodrigue and Notteboom (2010) also contend that high levels of government debt may result in spending cuts that depress American consumer demand. Traffic into and out of American East Coast and Gulf Coast ports will depend heavily on American and foreign economics.

Strategies from West Coast Ports

Another uncertainty is the success of improvements to the intermodal route. According to Salin (2010), Mexican and Canadian western ports are growing and coordinating with railroads to accommodate east-bound cargo shipments diverted from U.S. West Coast ports. Some, such as Prince Rupert, offer additional time savings over U.S. West Coast ports. Simultaneously, Ashar (2010) notes that West Coast ports are expanding capacity and collaborating with railroads to improve service.

Panama Canal Tolling

The all-water route through the Panama Canal must maintain a lower cost structure than the intermodal route to justify the extra transit time. While the expanded Panama Canal will enable ocean carriers to employ larger ships and greater economies of scale to reduce shipping cost, the Panama Canal Authority's tolls must not increase too much to undo the efficiency gains. Rodrigue and Notteboom (2010) note that tolls between 2006 and 2011 increased 80%, which captures "about 40% of the potential cost savings of the expansion." IHS Global Insight agrees that the flow of freight into East Coast and Gulf Coast ports from Asia will depend heavily on the Panama Canal's rate of tolls and American railroad companies' operations (IHS Global Insights, 2009).

Supply Chain Configurations

It is unclear how ocean carriers will respond to the new routing options that the expanded Canal allows. As Rodrigue (2010) explains, the Panama Canal expansion's "consequences are multidimensional and prone with feedback effects, some of which may even be unintended." The complexity of global shipping and supply chain management undermines the predictability of shipping outcomes even in cases of known and studied changes. Nonetheless, most of the possible ocean carrier reactions still provide for tonnage increases to East Coast and Gulf Coast ports.

Several authors document the possibility of a Caribbean transshipment hub. Transshipment involves the transfer of cargo between vessels, usually to obtain supply chain efficiencies. Rodrigue (2010) documents three dynamics that might support the development of a transshipment hub in the Caribbean Sea: (1) optimized utilization of post-Panamax ships into a circum-equatorial route rather than transoceanic pendulum connectors between the U.S. and Asia, (2) the ability to accommodate multiple cargo destinations along the coast, and (3) the use of larger and more efficient feeder ships between East and Gulf Coast ports, and the Caribbean transshipment hub. While Rodrigue (2010) supposes that transshipping would decrease the size of ships frequenting East Coast ports and might spread cargo over more ports, it would not directly impact total cargo volumes to East Coast and Gulf Coast ports. The U.S. Army Corps of Engineers concurs that a transshipment hub would allow shipping companies to take greatest advantage of the expanded Canal within an environment in which many East Coast ports cannot accommodate post-Panamax vessels, even while acknowledging extra delays and handling costs involved in transshipment (Institute for Water Resources, 2012).

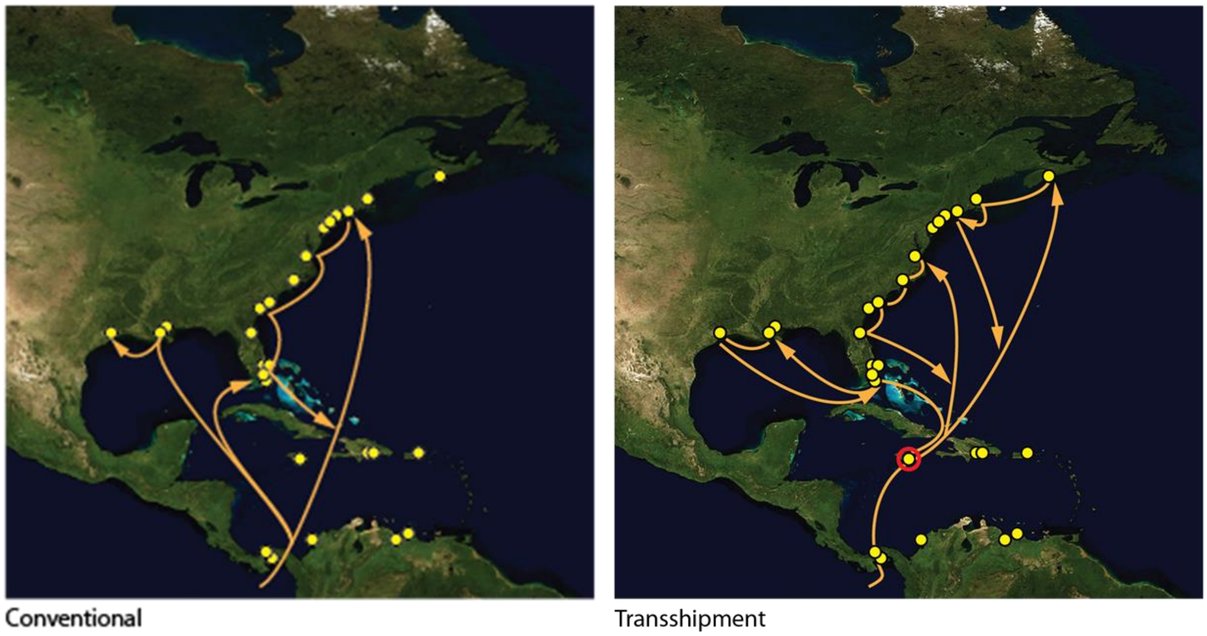


Figure 5: Contrast Between a Conventional Route to U.S. East and Gulf Coasts and a Proposed Routing Involving a Caribbean Transshipment Hub

Source: Center for Quality Growth and Regional Development, modified from Ashar (2006)

New Water Routes

Finally, there is a chance in the medium- to long-term that alternate routes to the Panama Canal could make it easier to transport cargo to East Asia to East Coast and Gulf Coast ports. A Chinese company recently proposed a canal through Nicaragua to compete with the Panama Canal (Moore, 2013). The Nicaraguan canal could be operational as soon as 2019. By 2050, it may also be possible for ships to navigate Canada's Northwest Passage in summer due to global warming. This could provide another connection between East Coast ports and Asia, although there are no known shipping forecasts that far into the future (Smith & Stephenson, 2013).

Economic, Safety, and Policy Considerations

Economic Impact Analysis and Methodologies

The Panama Canal expansion is expected to bring significant regional economic impacts by creating more shipping capacity through the canal and new opportunities for East Coast and Gulf Coast ports. Freight shipments occur because of underlying economic supply and demand relationships between producers and consumers, but freight movement itself generates new economic activity. According to the Bureau of Labor Statistics (2014), truck transportation employs approximately 1.3 million people nationwide, and freight contributes hundreds of billions of dollars of economic activity into the national economy (Bureau of Transportation Statistics, n.d.).

Freight may stimulate new economic activity in several ways. First, it may change a local area's relative accessibility to markets by changing the time or cost incurred by goods moving between the locality and other consumer and production markets. High relative freight accessibility may make a county more attractive for production and intermediate freight processing activity. Second, increasing freight accessibility may reduce the local cost imported goods, which would increasing consumption and potentially spurring in-migration. Moreover, the freight industry pays drivers, consumes fuel, and pays for vehicle maintenance. These trucking industry outlays stimulate the economy. Finally, there are indirect effects to the extent that the increased freight movement requires new warehouses to process flows or that freight employees spend income on other goods. Measuring and evaluating the economic impacts of the additional freight movement requires a regional economic model to convert the direct economic activities to broader regional economic impacts with specific indicators like employment, gross regional/state product, and personal income. Section VII develops and applies an economic model to assess county-level economic impacts of increased ocean shipping and port throughput.

Freight Safety

As policymakers consider cargo's economic impacts on their regions and how the infrastructure must be updated to stay competitive, one major consideration that must not be overlooked is truck safety. Truck volume on roads is expected to increase dramatically in the future, raising the potential for severe crashes which can cause fatalities and roadway congestion. Providing truck facilities such as increased parking spaces to prevent driver fatigue will be essential to reduce accidents.

Based on the published data, accidents involving trucks are on average more severe than non-truck accidents. In 2012, there were 111,784 large truck crashes in the United States, causing 3,878 deaths and 61,153 injuries (Federal Motor Carrier Safety Administration, 2013). According to a report by the Federal Motor Carrier Safety Administration (2006), fatigue is a major factor in 13.0% of large truck crashes. Other common factors include prescription drug use , over-the-counter drug use, lack of familiarity with the roadway, and various forms of driver error (Federal Motor Carrier Safety Administration, 2006). The most common factors contributing to an accident are related to driving management (i.e., driver-related factors) and environmental factors rather than vehicle failures. Traffic flow interruption is the single most common environmental factor (24.6% of accidents), and vehicle-related failure is a factor in no more than 3% of major accidents.

Accidents involving trucks can occur in rural, urban, and semi-urban areas. The Georgia Department of Transportation (2011) found that over half of Georgia's truck accidents occur in the Atlanta region. However, rural accidents can still be very significant from a safety perspective even when they are a small percentage of total crashes because they may be more severe. In this case, the Georgia Department of Transportation found that truck accidents in rural areas have a high percentage of head-on collisions, which are more deadly than other accident types. Thus, 57% of Georgia's truck-related fatal crashes are in rural areas even though only a quarter of all truck related accidents are in rural areas. Georgia's truck-related crash characteristics may be indicative of accident characteristics elsewhere.

Federal regulations on driver hours of service (HOS) exist to minimize driver fatigue and increase roadway safety for large trucks. Until July 1, 2013, HOS regulations allowed drivers to work for up to 11 hours after 10 hours off-duty. In July 2013, the HOS changed to help drivers to remain on regular circadian sleep schedules. Driver 'restart' period (a 36-hour period off-duty reoccurring up to every seven days) are now required to contain two consecutive periods from 1:00 AM to 5:00 AM (Federal Motor Carrier Safety Administration, n.d.; National Association of Truck Stop Owners, 2013b). According to research by Van Dongen, Jackson, and Belenky (2010), aligning extended rest periods with circadian rhythms improves driver alertness compared with rests of similar lengths not aligned with normal day-night wake and sleep times. Thus, the updated HOS regulations are likely to improve driver rest and truck safety, even though Belenky, Wu, Zaslona, and Hodges (2012) found that many drivers already obtained adequate sleep aligned with circadian rhythms.

Even with rest, driver errors become more likely with longer working days and driver times. Blanco et al.'s (2011) study of 97 drivers and driving behavior found that drives made more severe errors as work days became longer. However, driving breaks "significantly reduced the risk of being involved in a [safety critical event] during the 1-hour window after the break" (Blanco et al., 2011). Thus, it appears that regular breaks like those provided by public rest stops can improve safety, at least for the several hours after the break. Knipling et al. (2004) reviewed the general categories affecting truck safety and suggested improvements in programs directed at driver fatigue, driver licensing and enforcement, non-commercial driver instruction on sharing the road with trucks, truck maintenance, infrastructure design and maintenance, and private safety initiatives.

The federal HOS regulations require that drivers take rests of defined times after given lengths of time driving. The requirement to rest on the road necessitates that parking be available for drivers. There are nationwide networks of state-managed welcome centers and rest stops providing truck parking as well as privately owned truck stops near highways that provide truck parking in addition to commercial services.

There are no known nationwide studies to quantify existing truck parking capacity. However, several researchers have quantified parking at the state or corridor level. Chatterjee and

Wegmann (2000) found 31 rest areas with spaces for 472 large trucks along Tennessee's interstates. The researchers also documented 16 "pull-out" areas that were commonly used for truck parking with approximately 240 truck spaces. ConnDOT (2008) analyzed its state-owned truck parking facilities at 23 service plazas (which include commercial activity) and 8 rest areas. Georgia has 17 rest areas and 9 welcome centers, most of which include truck parking (Georgia Department of Transportation, 2012).

Many studies have shown private truck stop parking to outnumber public rest stop parking for trucks by a ratio ten to one. Chatterjee and Wegmann (2000) documented truck parking in truck stops visible from Tennessee interstates, finding approximately 5,240 private truck parking spaces, compared with approximately 712 official and unofficial publicly owned spaces. Truck stops also outnumber rest areas in Georgia. Georgia has 26 rest stops and welcome centers, about a quarter of the 100 truck stops with overnight parking (TruckStopGuide.com, 2013). The Georgia Statewide Freight and Logistics Plan documented 10,040 truck parking spots in Georgia at private truck stops, public rest areas, and public weigh stations (Georgia Department of Transportation, 2013c). The parking spots are very unevenly distributed along interstate corridors. The interstates with the most truck parking spaces per miles are I-20 west of Atlanta, I-75 north of Atlanta, and I-75 south of Macon. Each of these corridors has over 15 truck parking spaces per interstate mile. By comparison, I-16 between Savannah and Macon only has two truck parking spaces per mile. The Georgia Statewide Freight and Logistics Plan also compared peak demand for truck parking with supply and finds that some interstates severely undersupply parking. The corridors where parking supply is inadequate are I-16 (52% below peak demand), I-75 south of Macon (42% below peak demand), I-85 south of Atlanta (7% below peak demand), and I-85 north of Atlanta (3% below peak demand).

Truck parking shortages have been documented around the country for decades, especially at rest stops. In 1997, Davis's survey of 48 states showed that "8 in 10 [public] rest areas reported truck parking areas as either full or overflowing onto the ramps at night," and half were full during the day. Chatterjee and Wegmann (2000) also documented truck parking shortages in several states, including Tennessee, Georgia, and Virginia. More recently, ConnDOT (2008) observed illegal truck parking due to parking shortages, estimating with the Federal Highway Administration Truck Parking Demand Model that demand surpassed supply by 65%, the equivalent of about 700 additional truck parking spaces. According to Chatterjee and Wegmann (2000), the shortfall was most severe Monday through Thursday and very late at night (e.g., after 2:00 AM). The result is many trucks parking on ramps or highway shoulders rather than in official spaces (Chatterjee & Wegmann, 2000; ConnDOT, 2008; Davis, 1997), which can be a safety hazard for passing traffic. According to a comment made by a GDOT official (Chatterjee & Wegmann, 2000), some of the shortage near Atlanta was due to trucks using public parking as a staging facilities for deliveries in metro Atlanta.

State decisions make a difference in the use of truck parking. According to Davis (1997), and Chatterjee and Wegmann (2000), drivers most often used spaces allowing trucks to pull through, even sometimes parking illegally rather than using a space requiring back-up. Several states also have at various times implemented truck parking limits, though many have been weakly enforced for fear of sending tired drivers onto the roads (Davis, 1997; Trombly, 2003).

When enforced, limits appeared to push drivers taking longer breaks to stop at truck stops or other locations without time limits (Garber & Wang, 2004). Georgia also instituted a no parking policy on ramps and at some shoulders, and both Georgia and Virginia have increased truck parking supply (Chatterjee & Wegmann, 2000).

Private truck stops are not generally as full as rest stops, though there are still capacity problems (Garber & Wang, 2004). Fleger et al. (2002) found that nationwide 48% of drivers said that parking was seldom available at rest stops vs. 16% citing unavailability at truck stops. Drivers use truck stops and rest stops for different purposes. Rest stops tend to accommodate shorter breaks than truck stops, which are used for extended rest (Chatterjee & Wegmann, 2000; Fleger et al., 2002). On the whole, the aggregate capacity of truck stops and rest stops is frequently insufficient to reliably meet trucker demand (Fleger et al., 2002; Martin & Shaheen, 2013).

Carson, Pezoldt, Koncz, and Obeng-Boampong (2011) compared the benefits and costs of Texas rest areas as they apply to both passenger and freight traffic. Benefits accrue to road users, public agencies (e.g., Texas Department of Transportation), and external entities, like businesses along the highways. The primary benefits to highway users were in safety, convenience, reduction of excess travel to reach off-interstate facilities, and by providing an area for commercial vehicle staging. Users typically bear few costs except for a marginal safety risk when merging back onto the highway. Public agencies may gain direct monetary benefit by leasing or franchising services, though commercial activity at rest stops is heavily limited and regulated. Public agencies may also gain some monetary benefit from a reduction in stops on shoulders, reducing stops on shoulders would increase road safety and decrease maintenance requirements. By contrast, public agencies must pay for the rest area construction, operations, and maintenance. According to Carson et al. (2011), the overall benefits outweighed costs by a ratio of between 8.7:1 and 29.5:1 depending on the corridor. However, most of the costs were borne by the public agencies while benefits accrued to highway users and external organizations.

Part of the parking problem comes from drivers not knowing where to find parking. Several organizations have created programs to help truck drivers find parking. One such effort is by Travel Centers of America, which has a new program called “Reserve It” to allow drivers to reserve truck parking at its truck stops. “Reserve It” employs a smartphone app to communicate with drivers (National Association of Truck Stop Owners, 2013a). Travel Centers of America is also working with the State of Michigan to investigate using interstate signs to communicate parking information (National Association of Truck Stop Owners, 2013a). Providing information to truck drivers is one of the solutions listed by Knipling et al. (2004), others include expanding rest stop parking, creating alternative parking at sites such as weigh stations and government facilities, and changing enforcement practices.

The Georgia Statewide Freight and Logistics Plan

Freight has a major impact on economic performance. Investment in transportation assets for freight supports not only freight-related sectors, but also the entire economy. Several states in the DC-Virginia, Piedmont Atlantic, and Texas Triangle Megaregions have created freight plans to leverage the link between economic performance and freight movement. The Virginia Department of Transportation completed a draft Multimodal Freight Plan in 2013 in conjunction with Cambridge Systematics. The plan concentrates on freight strategies, freight performance measures, and corridors (Virginia Department of Transportation, 2013). Maryland's freight plan dates from even a few years before 2009 (Maryland Department of Transportation, 2009). In the Texas Triangle, neither Texas nor adjacent Louisiana have a complete and distinct freight plan. However, the Texas Department of Transportation (2014) is developing a freight plan, and Louisiana's statewide transportation plans includes a freight chapter (Louisiana Department of Transportation and Development, 2003). Several states have freight plans or reports in the Piedmont Atlantic Megaregion, including Tennessee (Tennessee Department of Transportation, 2014), Georgia (Georgia Department of Transportation, 2013c), Alabama (Alabama Department of Transportation, 2010), and North Carolina (North Carolina Department of Transportation, 2008). South Carolina is developing a freight plan (South Carolina Department of Transportation, 2013).

The Georgia Statewide Freight and Logistics Plan is one of the most extensive freight plans in the country. The plan was led by the Office of Planning at the Georgia Department of Transportation with technical assistance from Cambridge Systematics. The plan has earned recognition in several forums including the Federal Highway Administration's 2012 Transportation Planning Excellence Award co-sponsored by the Federal Transit Administration and the Transportation Research Board. The plan's analysis results and methods serve as a benchmark to guide this study's megaregion-scale freight and economic analysis. It also informs research on the Savannah case study. This section summarizes several of the Statewide Freight and Logistics Plan's findings related to the nature of freight movement, future freight transportation projections, and economic impacts.

The Georgia Statewide Freight and Logistics Plan builds on the deep, bidirectional connection between freight and the state's economy in order to guide state infrastructure investment. The plan outlines transportation investments importance for the state's population and economic growth. The plan found reasons to be concerned about underinvestment. Over the past decade the state's transportation funding has decreased below the nationwide transportation investment baseline. Increasingly deteriorating performance may threaten economic growth. The Statewide Strategic Transportation Plan calls for new transportation investment to add over $480 billion to the gross state product and almost half a million jobs by 2040.

The plan establishes a series of baseline business as usual, high, and low forecasts for the state's economy, and land, air, and sea cargo. The Statewide Freight and Logistics Plan's baseline estimate for the Port of Savannah cargo volume is 6.5 million TEU by 2050. The low estimate assumes that the port will lose market share to other East Coast ports and handle only 3.5 million TEUs, while the high estimate assumes that the port will dramatically gain vessel call share to handle up to 15 million TEUs by 2050. The report describes the role that the Panama Canal expansion is likely to play in shaping east coast ports' maritime cargo growth.

The Georgia Statewide Freight and Logistics Plan analyzes cargo characteristics in detail. Most Georgia trucking happens on interstate highways even though they account for less than 1% of the state's road mileage.. The most intensive truck movement centers on the Atlanta and

Savannah regions. Some corridors oversupply truck parking, while others—notably I-16 between Savannah and Macon—undersupply parking. Sea and air gateways also have a close relationship with freight movement. The Port of Savannah has increased throughput by 1,857% since 1996, which spurred freight volumes and nearby logistics activity. Simultaneously, the $500 million dollar investment to expand Hartsfield-Jackson Atlanta International Airport in the 1970s has continued to pay dividends. Atlanta's air cargo facilities directly and indirectly generate over 31 thousand jobs and $7.5 billion in economic activity annually in the Atlanta metro area.

The Statewide Freight and Logistics Plan highlights several industries with exceptionally strong links to the freight industry. One is warehousing and distribution, which has grown due to Georgia's high quality transportation infrastructure and the state's central "keystone" location in the Southeast, which make it an advantageous distribution hub. The agriculture and food processing industries also rely heavily on truck transportation, particularly for shorter trips for which intermodal rail-truck is less efficient. Mining produces bulk commodities requiring low-cost transportation for use and export. Similarly, lumber and wood production generate $15.1 billion annually in Georgia. Since lumber and wood are spread throughout the state, they rely on efficient transportation to connect production and processing facilities.

The Statewide Freight and Logistics Plan forecasts commodity movement changes through 2050 for different commodity types from IHS Global Insight's Transearch database. Transearch includes commodity-specific forecasts, which allowed the Office of Planning to produce commodity specific estimates to complement GPS-based truck movement data from the American Transportation Research Institute (ATRI). The truck-borne commodity movement for which Transearch forecasts the highest growth rate are instruments, photo equipment, or optical equipment (6.7% annual growth through 2050); ordnance or accessories (4.1%); and fresh fish or marine products (4.0%). However, each of these are among the smallest commodity categories. The large categories grow more modestly. Nonmetallic minerals, which accounts for over a quarter of today's Georgia commodity truck movement tonnage, is forecasted to grow by 1.7% annually, while traffic to and from warehouses and distribution centers (i.e., "secondary traffic") is forecasted to grow by 2.4% annually. The Statewide Freight and Logistics Plan also includes present and 2050 forecasted volume versus capacity analysis for Georgia interstates. Atlanta-area highways are expected to operate at more than twice capacity by 2050, causing significant deterioration in level of service. Congestion decreases as distance from Atlanta increases. By contrast, I-16 connecting the Port of Savannah with inland Georgia is projected to remain well under capacity. I-95, which primarily serves pass-through traffic, expected to face congestion in the Savannah area prior to 2050.

The Georgia Statewide Freight and Logistics Plan grounds the present research's methods and expands and validates its findings in the Piedmont Atlantic Megaregion. The present study undertakes complementary work of analyzing truck movements, parking facilities, economic connections, and growth projections at a larger megaregion scale.

SECTION III. BASELINE CONDITIONS

Characterizing the Nature of Freight Movement

Status of the Panama Canal

The Panama Canal is the 50 mile-long waterway that cuts through the isthmus joining North and South America and enables ships to cross between the Pacific Ocean to the Caribbean Sea. In 2011, about 222 million long tons of cargo transited the Panama Canal, which is about 3% of world seaborne trade cargo volume (Panama Canal Authority, 2013b). The Panama Canal became a bottleneck in all water freight movement and was on the path to obsolescence. At present the largest ships that can transit the canal carry approximately 5,000 TEU (twenty foot equivalent). This led to the decision of expansion of the canal by the introduction of a third set of locks. Post expansion, the New Panama capacity as specified by the Panama Canal Authorities, is going to be 12,000 TEU.

The trade to and from the east coast of the U.S. is the most important in the Panama Canal's cargo volume. Among the 13 principal trade routes identified by the Panama Canal Authority (ACP), the trade between the east coast of the U.S. and Asia accounted for about 40% of all trades in 2011. There are four more trade routes involving the east coast of the U.S.: East Coast U.S. – West Coast South America; East Coast U.S. – West Coast Central America; U.S. Inter-coastal; and East Coast U.S./Canada – Oceania. The cargo volume of all five trade routes accounted for about 60% of the total cargo volume (Panama Canal Authority, 2013b)**Error! Reference source not found.**.

Table 1: Cargo Volume by Trade Route in 2011

Trade Route	Cargo Volume (Thousands of Long Tons)	Percentage
East Coast U.S. - Asia	87,210	39.2%
East Coast U.S. - West Coast South America	26,202	11.8%
Round the World	202	0.1%
Europe - West Coast South America	15,175	6.8%
Europe - Asia	1,555	0.7%
Europe - West Coast U.S./Canada	9,919	4.5%
East Coast U.S. - West Coast Central America	11,742	5.3%
South America Inter-coastal	13,233	6.0%
West Indices - West Coast Central America	1,626	0.7%
U.S. Inter-coastal (including Alaska and Hawaii)	5,777	2.6%
East Coast U.S./Canada - Oceania	1,653	0.7%
East Coast South America - West Coast U.S./Canada	3,825	1.7%
All Other Routes	44,235	19.9%
Total	**222,355**	**100.0%**

Source: Statistics and Models Administration Unit, Panama Canal Authority

Bulk carriers are the most important vessel type in terms of total cargo volume as seen in Table 2**Error! Reference source not found.**. Bulk cargo volume accounted for 46% of the total cargo. Bulk cargo includes petroleum, natural gas, coal, metallic ores, grains, and other high-weight, low-value commodities which are transported by rail, pipeline, and inland waterways more frequently than truck. Container ships and tankers are next to bulk carriers, accounting for

28% and 21% of cargo volume respectively. Most containers travel inland by truck, although rail intermodal has steadily increased its container volume (Association of American Railroads, 2013). The bulk carriers' share of cargo traveling from the Atlantic Ocean to the Pacific Ocean is even larger, at approximately 50%. This is likely reflective of the large amount of export cargo of agricultural and petroleum products from the East and Gulf Coast of the U.S. Also, tankers' share increases to 27%, while container ships' share decreases to 20%. Looking at just the cargo from the Pacific Ocean to the Atlantic Ocean, the patterns change again. The share of bulk carriers and cargo carriers is almost the same, roughly 40% and 39% respectively. Meanwhile, the share of tankers decreases to about 13%. This reflects the importance of manufactured products from Asia traveling to the East Coast of the U.S.

Table 2: Vessel Types in 2011

	Total		Atlantic to Pacific		Pacific to Atlantic	
	Volume	**Percentage**	**Volume**	**Percentage**	**Volume**	**Percentage**
Bulk Carriers	102,403	46.0%	67,145	50.1%	35,259	39.8%
Container Cargo	61,039	27.4%	26,847	20.0%	34,192	38.6%
General Cargo	7,447	3.3%	3,733	2.8%	3,714	4.2%
Passenger	0	0.0%	0	0.0%	0	0.0%
Refrigerated Cargo	4,487	2.0%	560	0.4%	3,927	4.4%
Tank	46,923	21.1%	35,562	26.6%	11,360	12.8%
Other	135	0.1%	66	0.0%	68	0.1%
Total	**222,433**	**100.0%**	**133,914**	**100.0%**	**88,518**	**100.0%**

Source: Statistics and Models Administration Unit, Panama Canal Authority
Volume in thousands of long tons

The pattern found in commodity types passing through the canal is consistent with that of vessel types as seen in Table 3**Error! Reference source not found.**. The share of container cargo is about 25%. Most other commodities, except canned and refrigerated foods and petroleum and petroleum products, are likely to be transported by bulk carriers. Grains and petroleum and petroleum products account for about 18% and 16% respectively. Looking at grains and petroleum products passing from the Atlantic Ocean to the Pacific Ocean, the shares increase to 30% and 21% respectively, signifying the U.S. export of agricultural and petroleum products. If we look at the cargo from Pacific Ocean to Atlantic Ocean, the share of container cargo increases to about 36% and the share of grains and petroleum products decreases to about 2% and 9%.

Table 3: Commodity Types in 2011 (Long Tons)

	Total		Atlantic to Pacific		Pacific to Atlantic	
	Volume	**Percentage**	**Volume**	**Percentage**	**Volume**	**Percentage**
Canned And Refrigerated Foods	3,630	1.6%	79	0.1%	3,551	4.0%
Chemicals And Petroleum Chemicals	13,057	5.9%	8,627	6.4%	4,430	5.0%

	Total		Atlantic to Pacific		Pacific to Atlantic	
	Volume	Percentage	Volume	Percentage	Volume	Percentage
Coal And Coke (Excluding Petroleum Coke)	14,209	6.4%	10,463	7.8%	3,746	4.2%
Grains	40,246	18.1%	38,261	28.6%	1,985	2.2%
Lumber And Products	3,188	1.4%	1,166	0.9%	2,022	2.3%
Machinery And Equipment	4,034	1.8%	1,493	1.1%	2,541	2.9%
Manufactures Of Iron And Steel	6,475	2.9%	2,902	2.2%	3,573	4.0%
Minerals, Miscellaneous	8,553	3.8%	198	0.1%	8,355	9.4%
Nitrates, Phosphates And Potash	6,384	2.9%	4,157	3.1%	2,227	2.5%
Ores And Metals	17,371	7.8%	9,035	6.8%	8,336	9.4%
Other Agricultural Commodities	1,524	0.7%	399	0.3%	1,125	1.3%
Petroleum And Petroleum Products	35,686	16.0%	28,041	21.0%	7,645	8.6%
Miscellaneous	7,490	3.4%	3,068	2.3%	4,422	5.0%
Container Cargo	54,639	24.6%	23,163	17.3%	31,476	35.6%
Total	**222,355**	**100.0%**	**133,836**	**100.0%**	**88,518**	**100.0%**

Source: Statistics and Models Administration Unit, Panama Canal Authority
Volume in thousands of long tons

Table 4**Error! Reference source not found.** compares the cargo volume headed to the U.S. eastern ports transiting the canal to the total imported cargo volume of U.S. eastern ports. The total share of cargo passing through the canal is 6.6%. However, the importance of the canal varies for different ports. For example, the Panama Canal's share of import cargo is 23.3% in the south Atlantic ports, but the share is only 4.1% in the Gulf ports.

In 2011, the cargo volume passing through the canal going to the U.S. eastern ports was about 40 million long tons, about 50% of the cargo volume transiting from the Pacific Ocean to the Atlantic Ocean. About 39% and 58% of the cargo bound for eastern ports went to ports in the Gulf coast and the Atlantic coasts. Only 3% of the cargo went to the ports in the Great Lakes. Among the cargo to the Atlantic coasts, 54% went to ports in the northern Atlantic coast. Asia and South America were most important origins of cargo, accounting for about 65% and 26% respectively.

Table 4: Cargo Volume through the Panama Canal in 2011 (Long Tons)

	To East Coast United States					
From	**North Atlantic Ports**	**South Atlantic Ports**	**Great Lakes Ports**	**Gulf Ports**	**Total**	**Percentage**
U.S.	36,123	90,550	0	547,235	673,908	**1.7%**
Canada	2,015	42,643	52,266	195,271	292,195	**0.7%**
Central America	1,082,044	228,371	2,848	470,787	1,784,049	**4.4%**
South America	5,052,952	1,795,607	411,400	3,518,416	10,778,376	**26.4%**
Oceania	91,317	108,450	295,123	307,295	802,186	**2.0%**
Asia	6,470,205	8,663,088	520,775	10,853,646	26,507,714	**64.9%**
Imports from P.C. to East Coast U.S.	12,734,656	10,928,709	1,282,412	15,892,650	40,838,428	**100.0%**
Percentage	**31.2%**	**26.8%**	**3.1%**	**38.9%**	**100.0%**	

Source: Panama Canal Authority, 2013

Table 5**Error! Reference source not found.** compares the total imports to each port region with the total imports passing through the canal to each port region. Although the cargo volumes to north Atlantic ports and south Atlantic ports are not very different, the share of cargo via the canal among the south Atlantic ports is larger than that among the north Atlantic ports. This is because of the much larger scale of imported cargo in the north Atlantic ports. We might interpret this to mean that the Panama Canal's role is more important in the south Atlantic ports.

Table 5: Cargo Volume through the Panama Canal in 2011 (Long Tons)

	To East Coast United States					
From	**North Atlantic Ports**	**South Atlantic Ports**	**Great Lakes Ports**	**Gulf Ports**	**Other Ports**	**Total**
Imports from P.C. to East Coast U.S.	12,734,656	10,928,709	1,282,412	15,892,650	0	**40,838,428**
Total Imports to East Coast U.S.	146,094,983	46,977,410	15,470,793	385,921,772	26,844,081	**621,309,039**
Share of Imports via P.C.	8.7%	23.3%	8.3%	4.1%	0.0%	**6.6%**

Source: Panama Canal Authority and USDOT Maritime Administration

Panama Canal Expansion

The Panama Canal Authority (Autoridad del Canal de Panamá - ACP) started the expansion project of the canal in September 2007 and is expected to complete it by 2016. The capacity of the canal will be expanded by constructing lock facilities, excavating new access channels, and widening and deepening existing channels and the Gatun Lake (Panama Canal Authority, 2006). In the expansion proposal, the ACP predicts that the canal's annual cargo volume will nearly double in the next 20 years from 279 million Panama Canal Universal Metric System (PCUMS) tons to 508 million PCUMS tons, assuming the expansion. Without the expansion, the ACP predicts that the canal would lose the potential of 178 million PCUMS tons per year in demand growth. Among various market segments the containerized cargo growth, from 98 PCUMS tons to 296 PCUMS tons, is expected to drive this increase owing to the trade growth between Northeast Asia, especially China, and the U.S. east coast (Panama Canal Authority, 2006).

The new set of locks will be able to accommodate larger vessels. The existing locks' chambers are 1,000 feet long, 110 feet wide, and 41.5 feet deep and serve up to the "Panamax" size container vessels with dimensions of 965 feet in length, 106 feet in width, and a 39.5 feet in draft in tropical fresh water (Payer, 2005). The new locks' chambers are 1,400 feet long, 180 feet wide, and 60 feet deep. The new chambers will accommodate vessels larger than Panamax vessels known as post-Panamax containerships with dimensions of 1,200 feet in length, 160 feet in width, and 50 feet in draft in tropical fresh water (Panama Canal Authority, 2006). According to their capacity simulation model, the current capacity of the canal is determined to be between 330 and 340 million PCUMS tons per year (Panama Canal Authority, 2006). The same model suggests the new set of locks will add a capacity of 300 PCUMS tons per year, resulting in the total capacity of over 600 million tons with forecasted mix of various types of vessels.

Several years have passed since the 2007 proposal, and they included a global economic slowdown, so the demand growth of the canal's throughput is not likely to occur at the level the proposal predicted. Figure 6 shows the trend of annual cargo volume from 1999 and 2012. The cargo volume growth was the largest when the proposal was made, but after 2007 the cargo volume decreased until 2010 due to the global recession. However, the cargo volume began increasing again in 2010 with a growth rate similar to that of the middle 2000s. In 2007 when the proposal was written, it was expected that the cargo volume would reach the maximum capacity of between 330 and 340 million PCUMS tons per year by 2009 or 2010. Despite the years of delay caused by the global economic slowdown, the maximum capacity was reached in 2012 with cargo volume of about 333 million PCUMS tons (Panama Canal Authority, 2012).

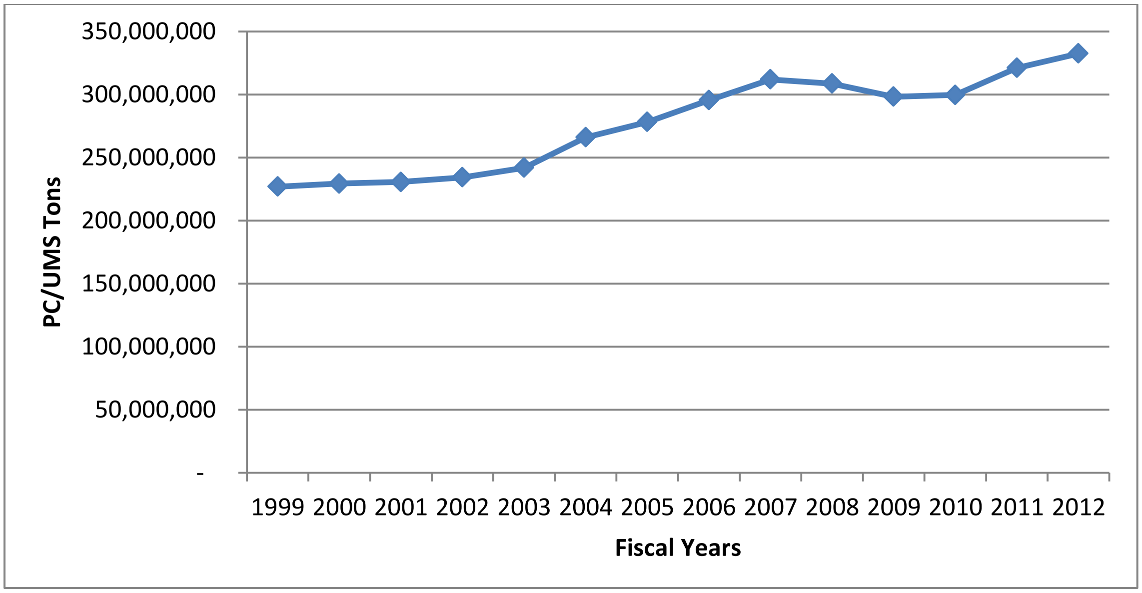


Figure 6: Cargo Volume Trend

Source: Panama Canal Authority (2013b), Panama Canal Authority Announces by Fiscal Year

The Canal Waters Time (CWT), the sum of waiting time and transit time, is an indicator of reliability of the canal's transit service. The average CWTs in the 2000s fluctuated around 25 hours, with the longest CWTs seen in the middle-2000s, as seen in Figure 7**Error! Reference source not found.**. The average CWT dropped significantly in 2009 and 2010 and then started to increase again, consistent with the cargo volume movement. This chart does not indicate extreme levels of congestion, possibly because smaller-scale improvement projects were completed in the late 2000s (Panama Canal Authority, 2014).

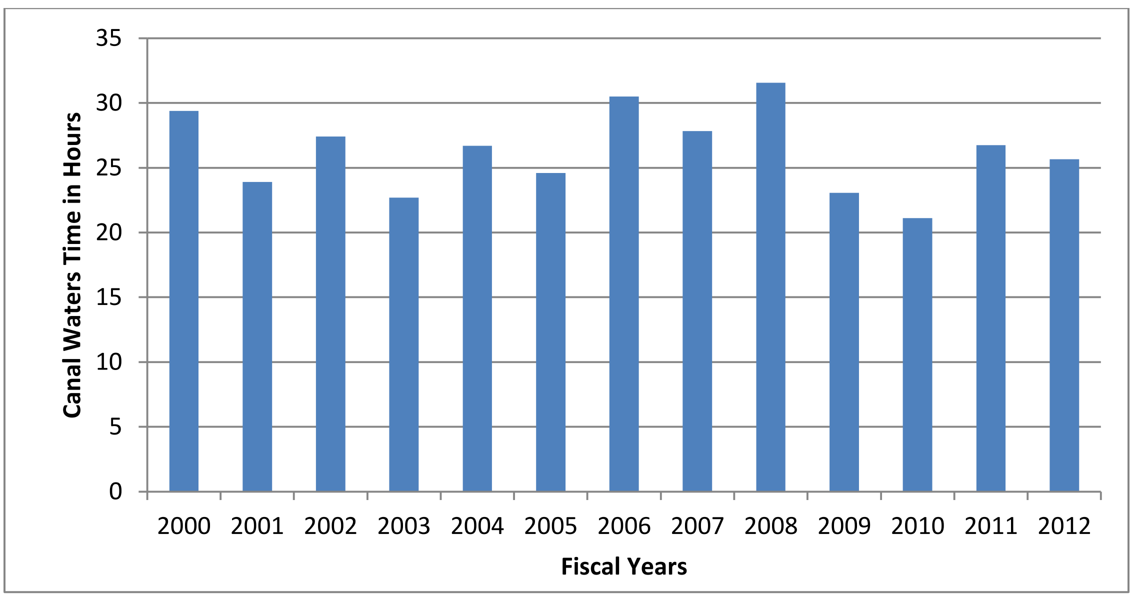


Figure 7: Canal Waters Time

Source: Panama Canal Authority (2013b), Panama Canal Authority Announces by Fiscal Year

Figure 8 and Figure 9**Error! Reference source not found. Error! Reference source not found.**show the cargo volume trends by principal trade route. Over the year, the East Coast U.S. – Asia route has been the route with the highest cargo volume. Its proportion was between 30% and 40% in the early 2000s, but it increased up to 45% in middle 2000s. After the global recession, the share of the East Coast – Asia route decreased to about 40%. The East Coast U.S. – West Coast South and Central Americas comprises over 10% of the cargo volume and their size and share slightly increased in recent years. The share of routes involving the West Coast U.S. is less than 5%. The share of routes involving Europe has decreased from about 19% in the early 2000s to about 10% in the late 2000s. Some routes such as Europe-Asia, West Indies-West Coast Central America, and Round-the-World are virtually disappearing in the Panama Canal's share of throughput. All other routes with unknown origin-destination information comprise about 20% of the cargo volume (Panama Canal Authority, 2013b).

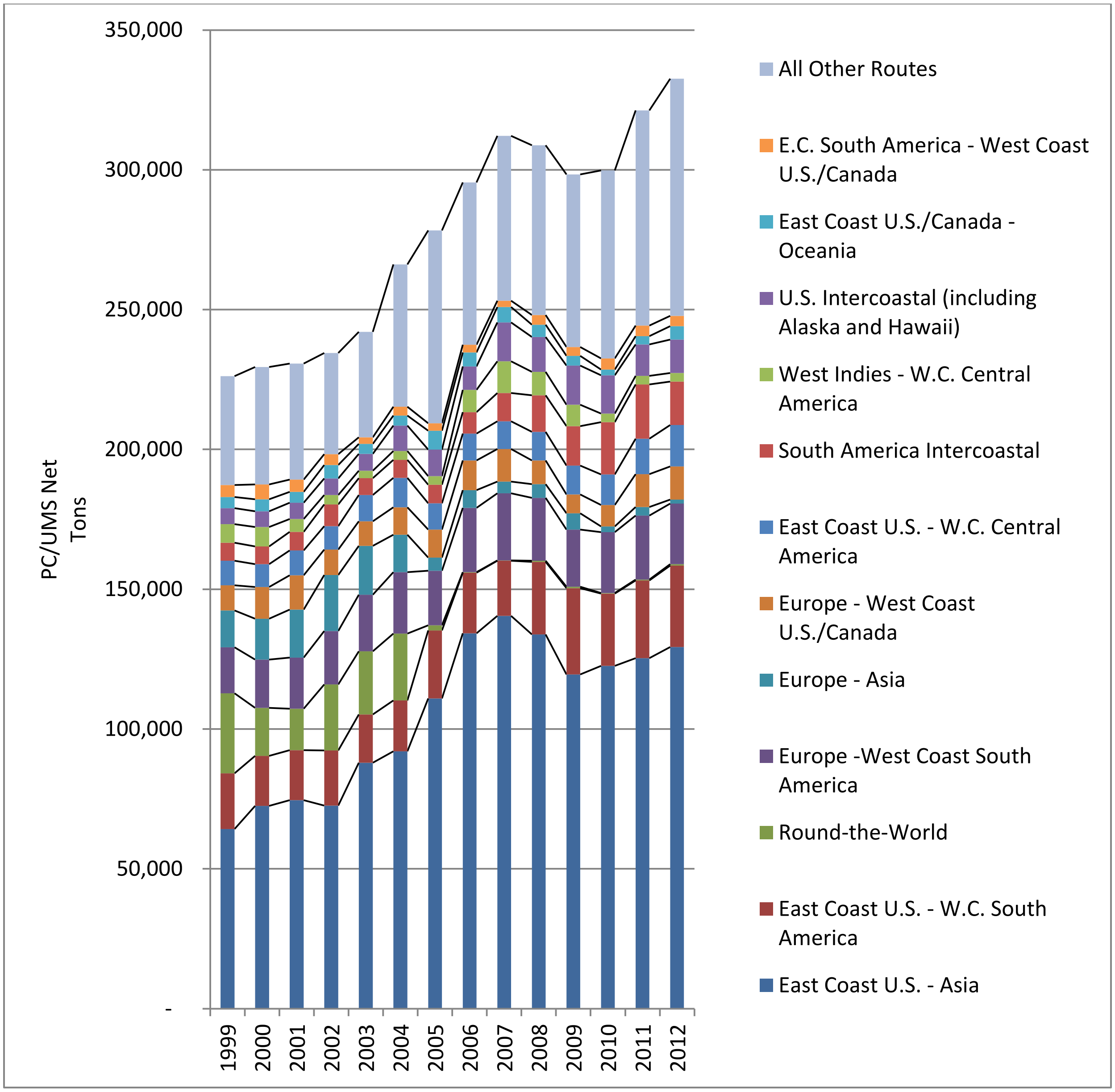


Figure 8: Cargo Volume by Trade Route

Source:Panama Canal Authority (2013b), Panama Canal Traffic along Principal Trade Routes

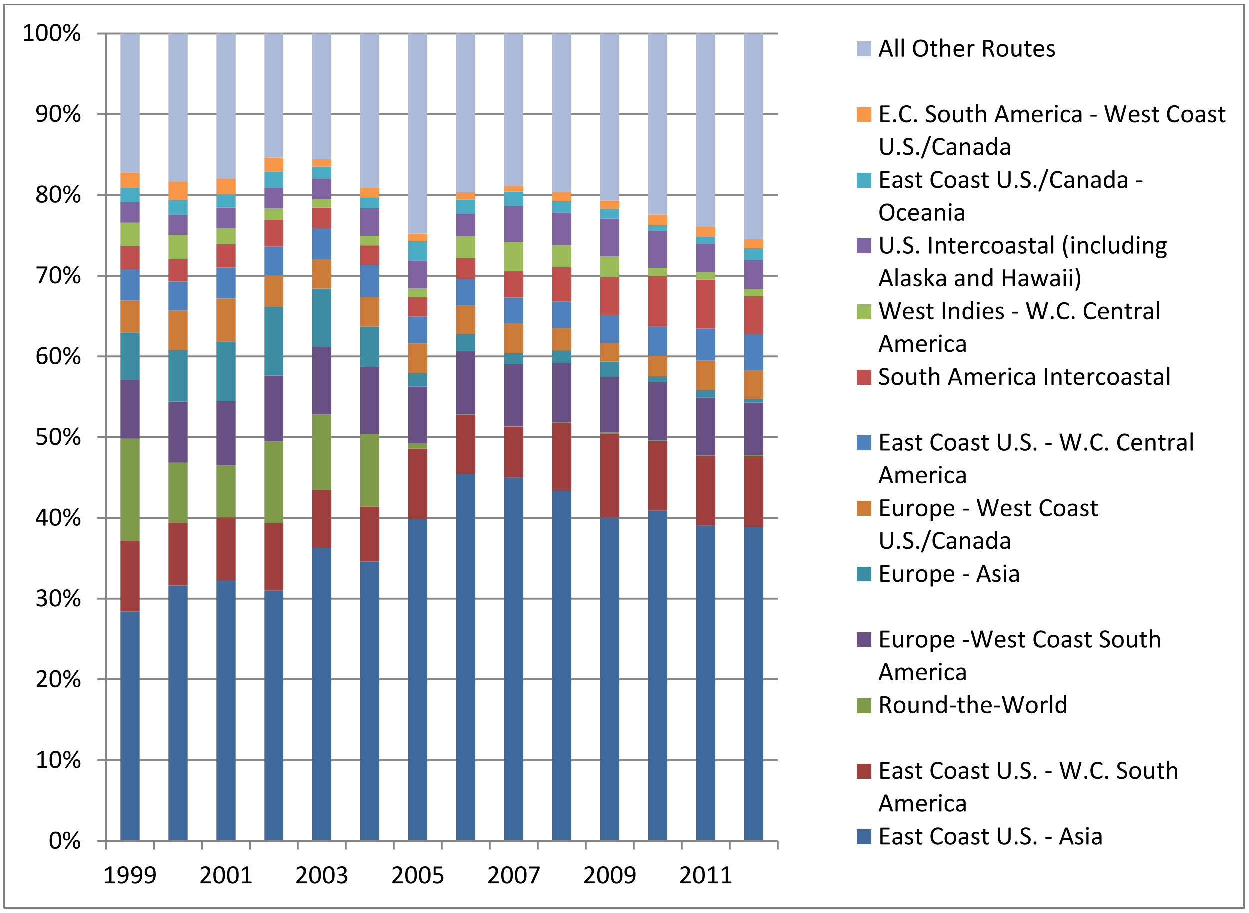


Figure 9: The Proportion of Cargo Volume by Trade Route

Source: Panama Canal Authority (2013b) Panama Canal Traffic along Principal Trade Routes

Asian – American Trade Routes

The largest single trade route through the Panama Canal connects East Asia and the Eastern United States. Many major shipping companies offer competing service on this route. Oftentimes, ships will stop at several Asian ports and several American ports for one or two days each to load and offload cargo. Stopping at multiple ports allows ocean carriers to economically broaden their geographical coverage. Figure 10 illustrates a conventional Northeast Asia to Eastern U.S. routing operated by Hapag-Llyod, the sixth largest ocean carrier worldwide (Burnson, 2012). City pairs are separated by between 23 and 37 days depending on the order of port calls (Table 6).

Figure 10: NYE / SCE Combo Service - Trade Route

Source: Hapag-Lloyd (2014)

Table 6: Transit Time in Days (Latest update: 29 Oct 2013)

From/To	Savannah	Charleston	New York	Norfolk
Arrival Day	**MON**	**TUE**	**THU**	**SUN**
Xiamen	31	32	34	37
Kaohsiung	30	31	33	36
Hong Kong	29	30	32	35
Yantian	28	29	31	34
Shanghai (Yan)	25	26	28	31
Busan	23	24	26	29

Source: Hapag-Lloyd (2014)

Other ocean carriers offer similar routes, including Maersk, the largest ocean carrier by volume. Maersk is known for its large, fuel efficient container ships, many of which are too large to pass through the existing Panama Canal (referred to as “post-Panamax” in this report and as “new Panamax” in Figure 11 below). Already, Maersk’s route between East Asia and the Eastern U.S. travels via the Suez Canal rather than the Panama Canal, ostensibly to benefit from the Suez Canal’s larger dimensions compared with the unexpanded Panama Canal (Figure 12). Maersk’s service stops in the Ports of New York and New Jersey, Norfolk, and Savannah, as well as several Chinese, Japanese, and Malaysian ports. Carriers have had to balance per-unit cost savings with the largest ships against the added time of using the longer Suez Canal route. The expanded Panama Canal will reduce the trade-off, allowing larger ships to take the shorter route between East Asia and the Eastern United States (Figure 13).

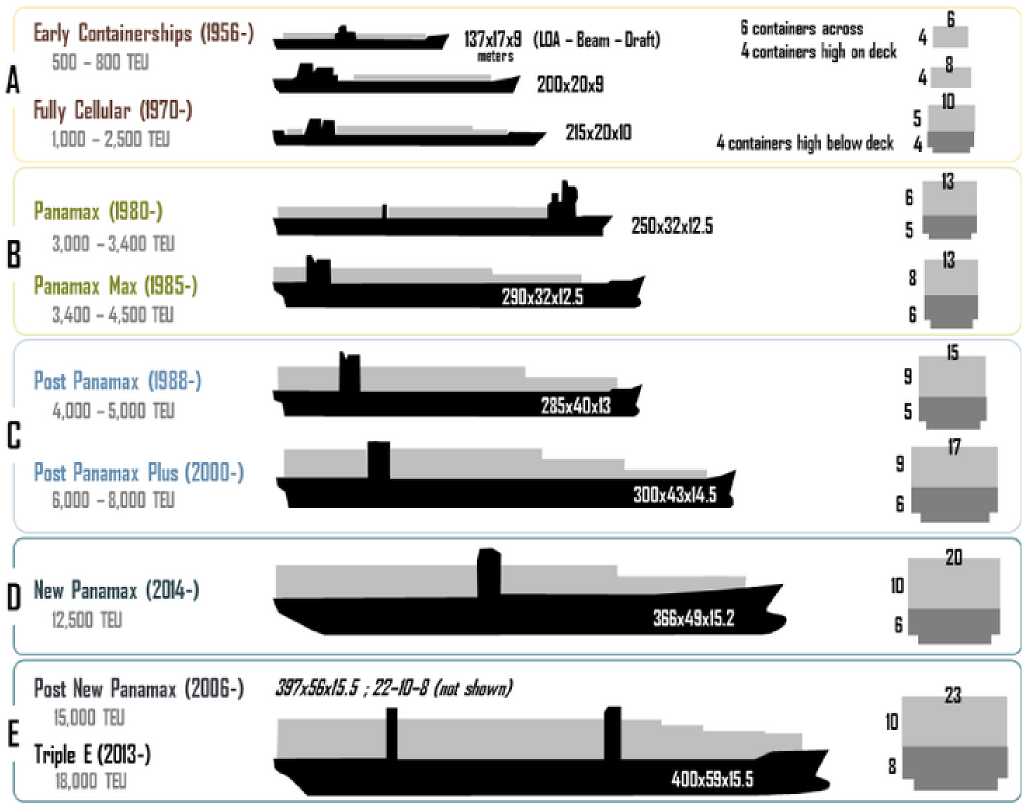


Figure 11: Vessel Size Categories

Source: Rodigue and Ashar (2012)

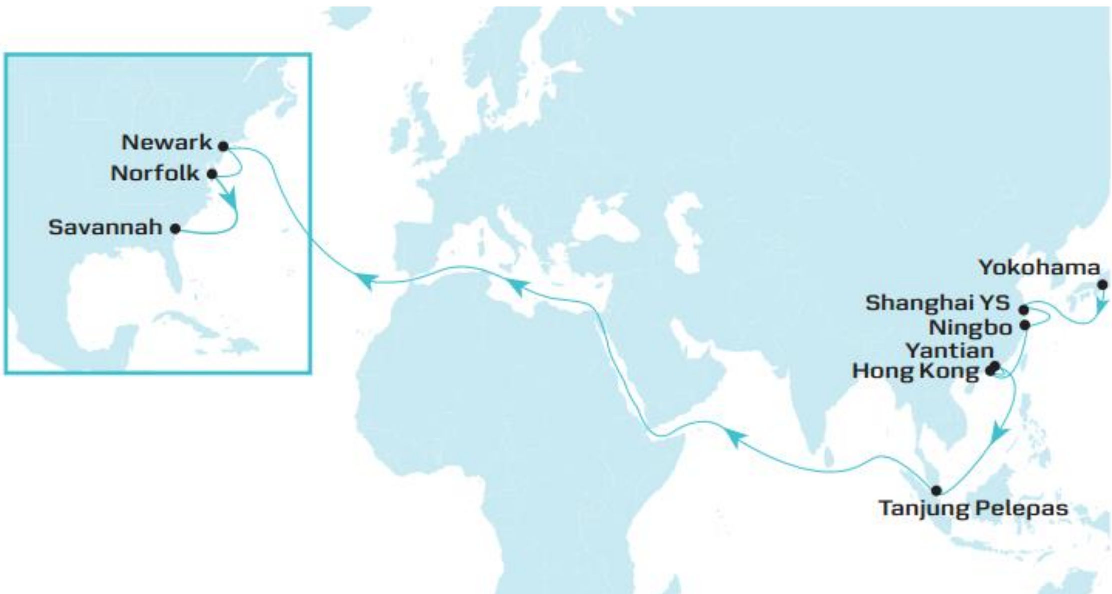


Figure 12: Maersk Transpacific 3 Route

Source: Maersk Lines (2012)

Figure 13: Panama Canal Route vs. Suez Canal Route between East Asia and the Eastern United States

Status of East and Gulf Coast Ports with Over a Quarter Million Container Volume Annually

Current Pattern of North American Inland Freight Movement Pattern

Examining overall volume, current projects, and existing import volumes of each of the major U.S. ports provides a context for understanding ocean shipping trends and projections. East and Gulf Coast ports have been preparing for new cargo that many have forecasted will arrive from Asia—bypassing traditional West Coast ports—after the Panama Canal expansion. Many of these ports hope to process cargo that has traditionally been offloaded in West Coast ports and transported by land to eastern markets. This section presents a brief overview of the East, and Gulf Coast ports with over 250,000 annual TEU throughput annually (shown in Figure 14). It describes major commodities and capacity enhancing projects to show each port's potential to absorb future ocean cargo.

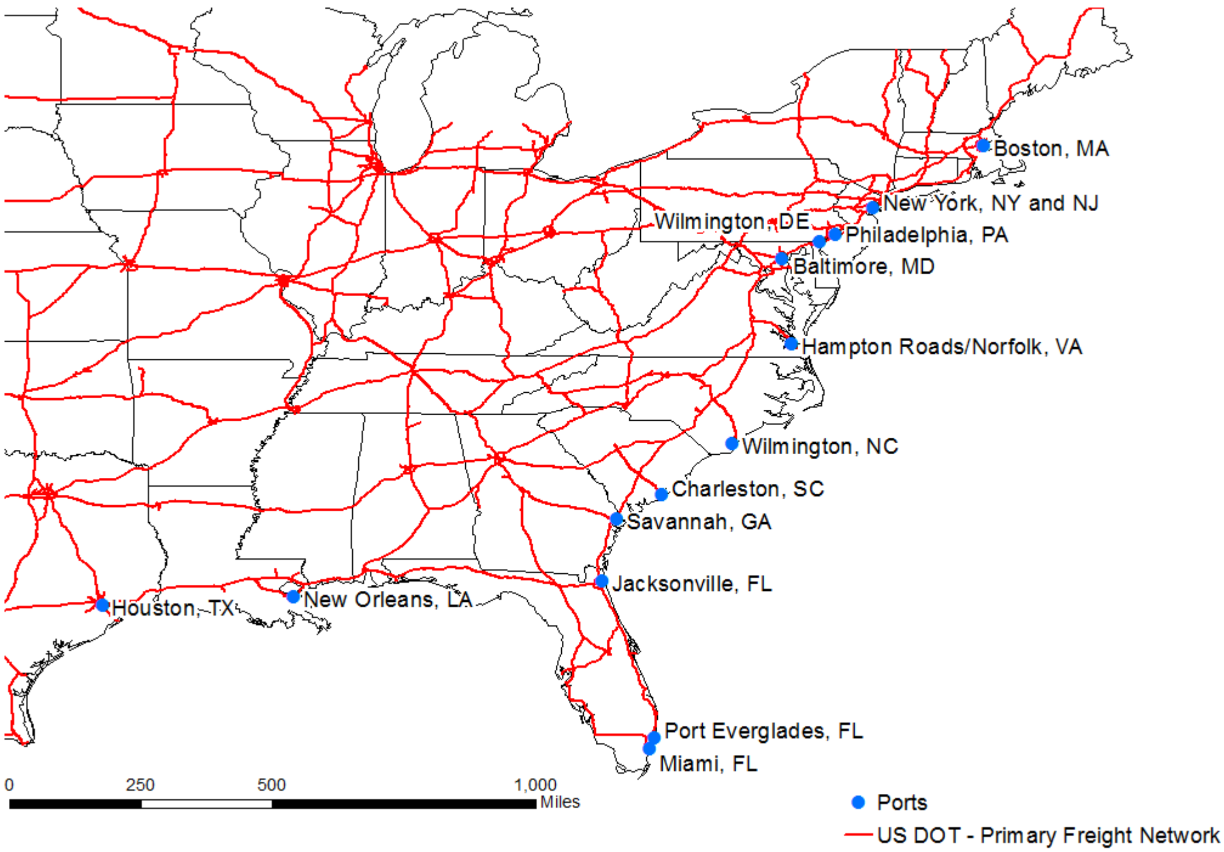


Figure 14: Major Port Locations

New York/New Jersey

The Port of New York and New Jersey was ranked third busiest container port in the United States in 2011 by the American Association of Port Authorities (AAPA), with a container volume of 5,503,485 TEUs (a change of 4.0% from container volume in 2010) and is also the largest port on the East Coast. In 2011, the largest import commodities were furniture and women's and infant apparel, and the largest export commodities were paper, carbon, crepe and automobiles. The largest trading partner overall is China (28.4% of total New York / New Jersey trade), while the fastest-growing import trading partner is Peru (33.7% growth over 2010), and the fastest-growing export trading partner is China (21.7% growth over 2010). Infrastructure projects to expand the port's facilities include roadway, rail and intermodal facility improvements, such as the expansion of the Express Rail system. Additionally, the Port of New York and New Jersey plans to deepen its harbor channels to 50 feet in order to accommodate larger ships and expected demand for international trade with the expansion of the Panama Canal (Port Authority of New York and New Jersey, 2013).

Savannah

The Port of Savannah was ranked fourth busiest American container port in 2011, with a container volume of 2,944,678 TEUs (a change of 4.2% from container volume in 2010). In 2011, the fastest growing export commodity was wood pulp (14% of total exports); the fastest growing import commodity was automotive parts (57% five year growth); and the largest import commodity group was furniture (13% of total imports). The Port of Savannah is a major destination for imports from Northeast and Southeast Asia and exports, and it is a major exporter to Northeast Asia and Europe. The fastest growing markets for imports into Savannah are in Central America (483% five-year growth), and the fastest growing markets for exports from Savannah are located in Northeast Asia (17% or 62,137 TEUs).

The Port of Savannah is near the intersections of I-16 and I-95, as well as two Class I railroads. Both I-95 and I-16 are federally designated freight corridors as part of the Primary Freight Network (draft). There are numerous distribution centers in Chatham County in which the port is located serving port-related functions. Figure 15 below shows the surrounding freight transportation infrastructure.

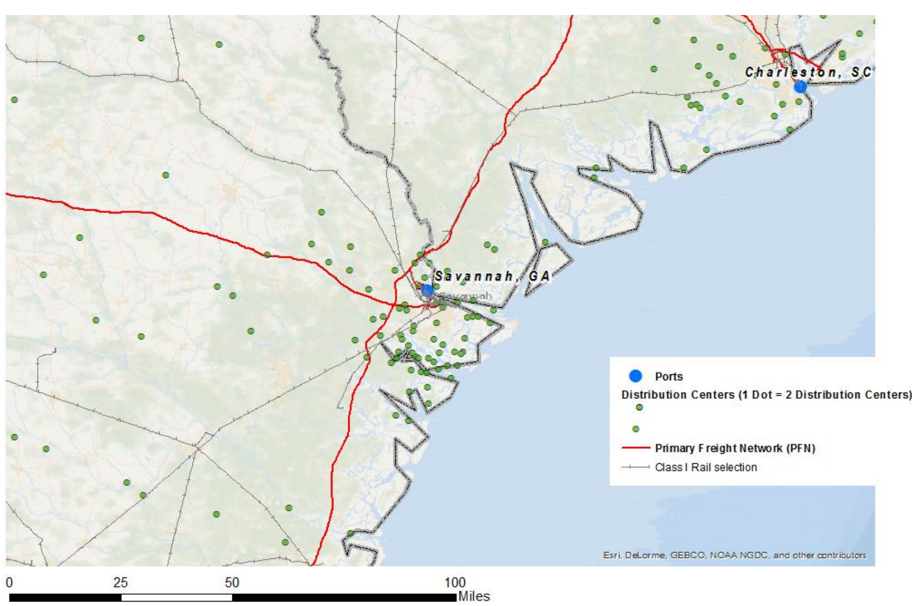


Figure 15: Savannah Transportation Infrastructure

The Port of Savannah plans to expand capacity by deepening the Savannah harbor. The planned deepening of the Savannah harbor was included in a list of seven "nationally and regionally significant" projects to be expedited by executive order (The White House, 2012). The Port of Savannah should see work on the major capacity expansion project begin in the summer of 2014. The Port of Savannah can, and does, currently receive the larger post-Panamax ships, but constrained by tidal cycles. The project will dredge and deepen the Savannah harbor to better accommodate the larger 'post-Panamax' vessels that will soon be able to traverse the Panama Canal. The project was originally proposed in the 1999 Water Resources Reform and Development Act (WRRDA) with a spending cap of $230,174,000 (*Water Resources Development Act of 1999*). After several years of delays and increasing cost estimates the project cost now exceeds that cap. A new Water Resources Reform and Development Act (WRRDA) was receive House of Representatives approval in May 2014 that will increase the total spending authorization to $652 million if it becomes law ("On the Conference Report to Accompany H.R. 3080, Water Resources Development Act of 2013: Roll Vote No. 163," 2014, *Water Resources Reform & Development Act of 2013*). The act would allow the Army Corp of Engineers to begin work on the expansion with an expected completion date of 2016. In addition to the federal authorization, the state of Georgia has set aside $255 million dollars for the project that will qualify for federal matching funds. The Georgia Ports Authority intends to deepen the harbor to 47 feet below mean low water.

Hampton Roads / Norfolk

The Port of Hampton Roads/Norfolk was ranked the seventh busiest U.S. container port in 2011, with a container volume of 1,918,029 TEUs (a change of 1.2% from container volume in 2010). Hampton Roads is one of the deepest natural harbors on the East Coast at 50 feet and has among the largest cranes in the world. In 2011, the largest import commodities were mineral fuel and oil and machinery, and the largest export commodities were mineral fuel and oil, and wood pulp. The largest import trading partners by tonnage are China and Colombia, and the largest export trading partners by tonnage are Brazil and the Netherlands. The top trading partners by commodity value are China and Germany. Projects to expand the Port of Hampton Roads/Norfolk include a project to expand Craney Island eastward to accommodate a fourth terminal, as well as equipment and infrastructure upgrades, including landside road and rail infrastructure (Virginia Port Authority, 2013). The Port of Hampton Roads / Norfolk is connected with inland destinations by I-64—which is a federally designated freight corridor in the Primary Freight Network (draft)—and several state roads, as well as two Class I rail lines. The surrounding cities and counties in southeastern Virginia are home to many supporting warehouses and distribution centers, depicted in Figure 16 below. The Port of Hampton Roads / Norfolk is currently 50 feet deep, and there are early discussions to deepen the harbor to 55 feet.

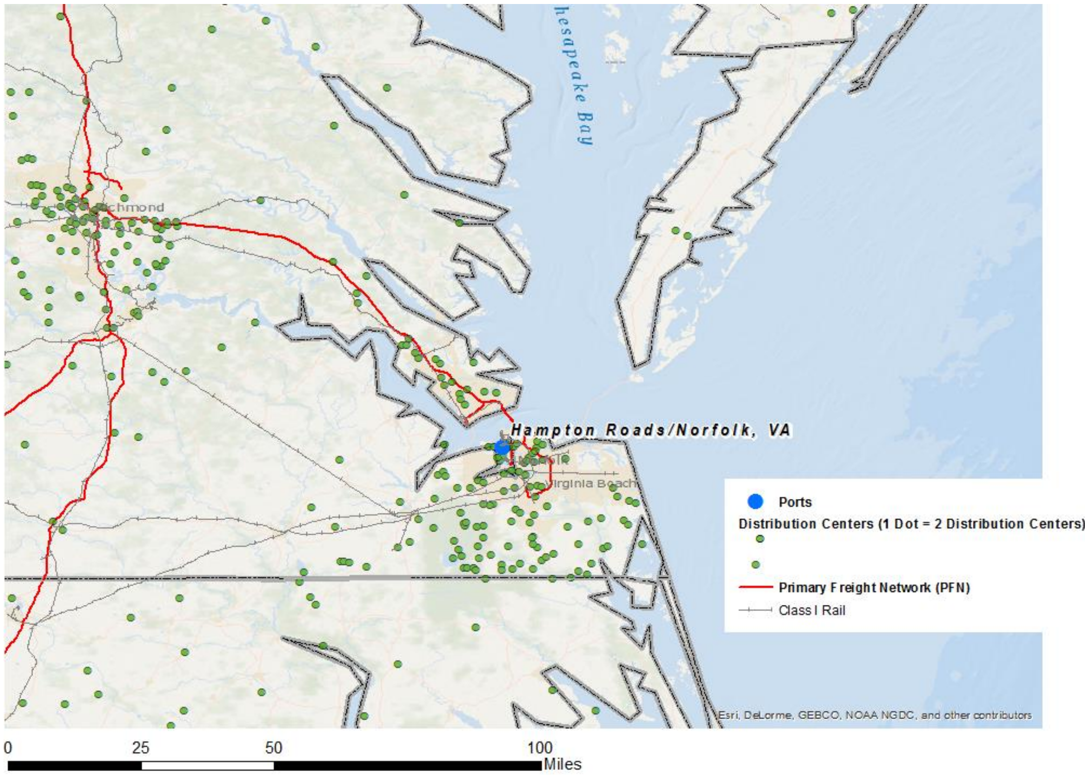


Figure 16: Norfolk Transportation Infrastructure

Houston

The Port of Houston was ranked eighth busiest U.S. container port, with a container volume of 1,866,450 TEUs (a change of 2.7% from 2010). The Port of Houston ranks first in foreign tonnage and U.S. exports, and second in total U.S. tonnage. In 2011, the top bulk commodities were industrial chemicals and fuel coke. The largest import trading partners in U.S. dollars were Europe and North America, while the largest export trading partners in dollars were Latin America and Europe. Projects to expand the Port of Houston include a project to complete the construction of a new container terminal (Bayport) as well as infrastructure investments. The port also has plans to deepen its harbor channels to 45 feet to accommodate the larger container ships that will be able to pass through the expanded Panama Canal (Port of Houston Authority, 2013).

Charleston

The Port of Charleston was ranked tenth busiest in the U.S. in 2011 by the AAPA, with a container volume of 1,381,352 TEUs (a change of 1.2% from 2010). The Port of Charleston is ranked as the eighth port district in the U.S. in dollar value of goods. In 2011, the top export commodities were paper and paperboard (19% of total exports), and wood pulp; while the top import commodities were furniture and auto parts. The top trade lanes in 2009 were Northern Europe (36% of total) and Northeast Asia (22% of total). The Port of Charleston plans to deepen its harbor channels to approximately 47 feet to accommodate larger vessels. The planned deepening of the Charleston harbor was included in a list of seven “nationally and regionally significant" projects to be expedited by executive order (South Carolina Ports Authority, n.d.; The White House, 2012).

Miami

The Port of Miami was ranked twelfth busiest container port in the U.S. in 2011 by the AAPA, with a container volume of 906,607 TEUs (a change of 7.0% from 2010). In 2011, the top import commodities were beverages, apparel, and fruits and nuts, while the top export commodities were wood pulp and base metals. The top import regions were Asia/Pacific and Central America, while the top export regions were Asia/Pacific, the Caribbean and Central America. The Port of Miami is deepening its harbor channels to 50 feet to accommodate larger vessels expected with the Panama Canal expansion. Dredging began in late 2013 and is expected to be completed in 2015 (Miami-Dade County, 2013). Other planned capital improvement projects include roadway and intermodal facility expansions, re-introduced rail service, and the acquisition of larger cranes to service the larger vessels. The planned deepening of the Miami harbor was included in a list of seven "nationally and regionally significant" projects to be expedited by executive order (Miami-Dade County, 2012; The White House, 2012).

Jacksonville

The Port of Jacksonville was ranked 13th busiest container port in the U.S. in 2011 by the AAPA, with a container volume of 899,258 TEUs (a change of 8.8% from 2010). In 2011, the top import commodities by tonnage were coal, fuel coke, gasoline and petroleum, while the top export commodities were automobiles and general cargo. The largest import trade lanes were Puerto Rico and Israel, while the largest export trade lanes were with Colombia and the Virgin Islands. The Port of Jacksonville plans to deepen its harbor channels to approximately 47 feet. The Port of Jacksonville also plans to reconfigure the St. Johns River in order to improve navigation near the harbor. The planned deepening of the Jacksonville harbor was included in a list of seven "nationally and regionally significant" projects to be expedited by executive order (Jacksonville Port Authority, 2013; The White House, 2012).

Port Everglades

Port Everglades was ranked 14th busiest in the U.S. in 2011 by the AAPA, with a container volume of 880,999 TEUs (a change of 11.1% from 2010). In 2011, the top import commodities were fruits and bananas, while the top export commodities were paper and grocery products. The top trade lanes were the Caribbean and Central America, while the top trading partners (both import and export) were Honduras and Guatemala. Port Everglades plans to deepen its harbor channels to 48 feet to accommodate larger vessels expected with the Panama Canal expansion (Broward County Port Everglades Department, n.d.).

Baltimore

The Port of Baltimore was ranked 15th busiest in the U.S. in 2011 by the AAPA, with a container volume of 631,804 TEUs (a change of 8.8% from 2010). In 2011, the top import commodities were coal, oil and scrap metal, while the top export commodities were iron ore, salt and sugar.

The top import trade partners were Chile, Brazil and China, while the top export trading partners were China and Japan. The Port of Baltimore already has a 50 feet harbor channel, and has acquired post-Panamax shipping cranes (Maryland Department of Transportation, n.d.).

New Orleans

The Port of New Orleans was ranked 16th busiest in the U.S. in 2011 by the AAPA, with a container volume of 477,363 TEUs (a change of 11.7% from container volume in 2010), and is the only port in the U.S. served by six Class I railroads. The primary break-bulk cargo commodities served by the Port of New Orleans are steel, nonferrous materials, rubber and forest products. The Port of New Orleans has plans to deepen its harbor channels to 50 feet to accommodate larger vessels expected with the Panama Canal expansion (Port of New Orleans, n.d.). The Port of New Orleans has several roadways that are federally designated freight corridors as part of the Primary Freight Network (draft), and it is home to six Class I railroads, depictured in Figure 17.

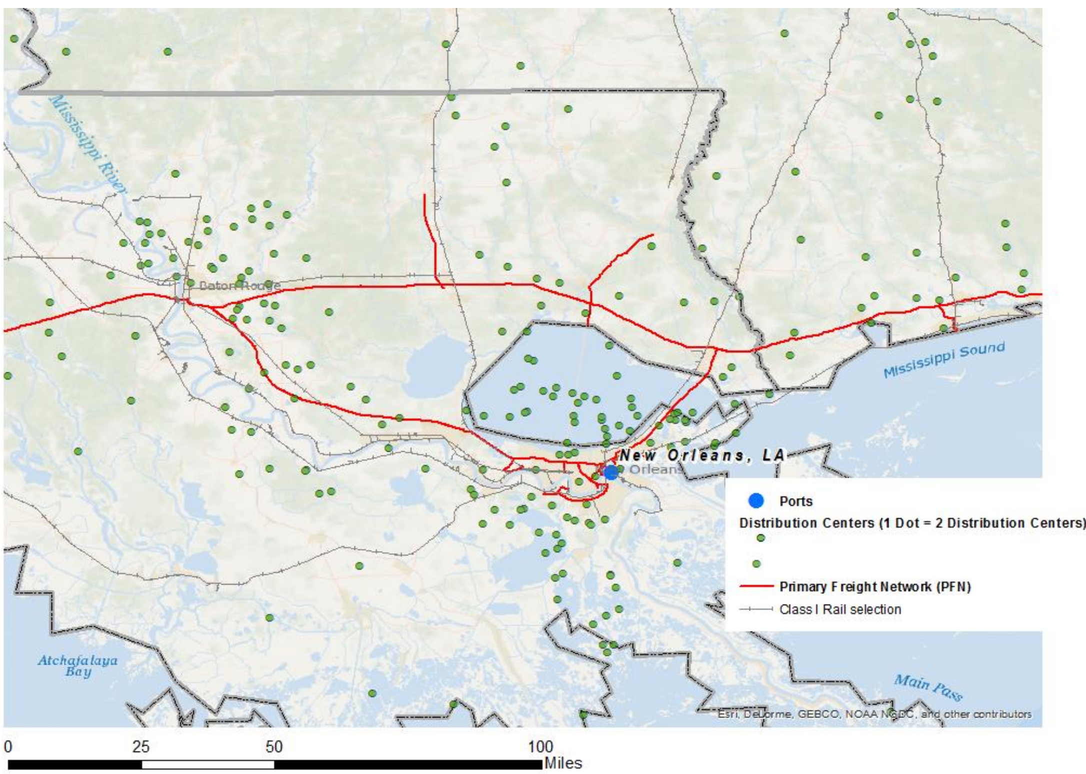


Figure 17: New Orleans Transportation Infrastructure

Philadelphia

The Port of Philadelphia was ranked 18th busiest in the U.S. in 2011 by the AAPA, with a container volume of 291,091 TEUs (a change of 6.7% from container volume in 2010). In 2007, the top import commodities were crude petroleum, refined petroleum products, meat, fruit, wine, beverages, and paper products, while the top export commodities were iron and steel scrap and waste, paper, and meat. The top import trading partners were Nigeria, Cameroon and Turkey, while the top export trading partners were Australia, Cameroon and Turkey (Bureau of Transportation Statistics, 2009). The Port of Philadelphia plans to deepen its harbor channels to 45 feet (as part of the Delaware River harbor deepening project), expand its container facilities and capacity, and improve its infrastructure and security (as a designated Strategic Military Port) (Philadelphia Regional Port Authority, 2013).

Wilmington, NC

The Port of Wilmington in North Carolina was ranked 19th busiest in the U.S. in 2011 by the AAPA, with a container volume of 287,469 TEUs (a change of 8.4% from container volume in 2010). In 2012, the largest import commodities by tonnage were chemicals and grains, while the top export commodities were forest products, wood pulp and woodchips. The top import trading partners were China, Great Britain and Trinidad & Tobago, while the top export trading partners were China, Turkey and South Korea. The largest overall trading partners were China, Great Britain and Belgium. The Port of Wilmington is currently equipped with a 44-foot deep harbor channel, post-Panamax cranes and surface transportation infrastructure improvements (rail and highway) (North Carolina State Ports Authority, 2012).

Wilmington, DE

The Port of Wilmington in Delaware was ranked 20th busiest container port in the U.S. in 2011 by the AAPA, with a container volume of 272,996 TEUs (a change of 3.8% from container volume in 2010). The Port of Wilmington is a leading importer of fresh fruit and juice concentrate. The Port of Wilmington’s harbor channels are 38 feet deep. While the Delaware River deepening will deepen access channels as far as Philadelphia, it will not deepen the Port of Wilmington’s berths (Diamond State Port Corporation, n.d.).

Port Overview

Ports vary widely amongst themselves, especially in terms of their throughput, major commodities, trading partners, and expansion projects. Table 7**Error! Reference source not found.** below provides a detailed list of port characteristics in decreasing order of containerized throughput.

Table 7: Port Details, Ordered by Decreasing Container Volume

Port	Container Volume (TEUs) in 2010	Import Commodities	Export Commodities	International Trade	Plans for Expansion
Los Angeles	7,940,511	furniture and automotive parts	wastepaper and scrap metal	Top trade route: Northeast Asia, Top trading partner: China/Hong Kong	Harbor deepening, terminal expansion, infrastructure improvements
Long Beach	6,061,085	crude oil and electronics	petroleum coke and petroleum bulk	Top trade route: East Asia, Top trading partner: China/Hong Kong	Harbor deepening, infrastructure improvement
New York/New Jersey*	5,503,485	furniture and women's and infant apparel	paper, carbon and crepe and automobiles	Top trading partner: China	Harbor deepening, infrastructure improvement
Savannah*	2,944,678	Top commodity is furniture; fastest-growing is automotive	Fastest-growing export is wood pulp	Fastest-growing import market is in Central America, Fastest-growing export market is in Northeast Asia	Harbor deepening, infrastructure improvement
Oakland	2,342,504	machinery and electronics	dried fruit & nuts and meats	Top import trading partner: China, Top export trading partner: Japan and China	Infrastructure improvements, army base redevelopment, harbor deepening
Seattle	2,033,535	machinery and electrical machinery	grain, seed and fruit and machinery	Top trading partners: China, Japan and South Korea	Plan to increase container volume by 50%, naturally deepwater port
Hampton Roads/Norfolk	1,918,029	mineral fuel and oil and machinery	mineral fuel and oil and wood pulp	Top import trading partner: China and Colombia, Top export trading partners: Brazil and the Netherlands	Terminal expansion, infrastructure improvements, naturally deepwater port

Port	Container Volume (TEUs) in 2010	Import Commodities	Export Commodities	International Trade	Plans for Expansion
Houston	1,866,450	Top bulk commodities: industrial chemicals and coke	N/A	Top import trading partners ($) : Europe and North America, Top export trading partners ($): Latin America and Europe	Terminal expansion, infrastructure improvements, harbor deepening
Tacoma	1,485, 617	vehicles and parts and industrial machinery	grains and cereals	Top trading partners: China/Hong Kong and Japan	Terminal expansion, infrastructure improvements, naturally deepwater port
Charleston*	1,381,352	paper, paperboard and wood pulp	furniture and auto parts	Top trade lanes: North Europe and Northeast Asia	Harbor deepening
Honolulu	938,821	N/A	N/A	N/A	Military reservation redevelopment
Miami*	906,607	beverages, apparel and fruits and nuts	wood pulp and base metals	Top import regions: Asia/Pacific and Central America, top export regions: Asia/Pacific, the Caribbean and Central America	Harbor deepening, infrastructure improvement, crane acquisition
Jacksonville*	899,258	coal and coke, gasoline and petroleum	automobiles and general cargo	Top import trade lanes: Puerto Rico and Israel, Top export trade lanes: Colombia and the Virgin Islands	Harbor deepening, navigation improvements
Port Everglades	880,999	fruits and bananas	paper and grocery products	Top trade lanes: the Caribbean and Central America, Top trading partners: Honduras and Guatemala	
Baltimore	631,804	coal, oil and scrap metal	iron ore, salt and sugar	Top import trading partners: Chile, Brazil and China, Top export trading partners: China and Japan	Naturally deepwater port, has acquired post-Panamax cranes

Port	Container Volume (TEUs) in 2010	Import Commodities	Export Commodities	International Trade	Plans for Expansion
New Orleans	477,363	Iron and steel, forest products and aluminum	Chemicals, animal and vegetable products, forest products	Top import trade routes: Europe and Asia, Top export trade routes: Europe, Asia and South America	Harbor deepening
Anchorage	423,381	Top commodities: vehicles and petroleum	N/A	N/A	Terminal expansion, infrastructure improvements (planned)
Philadelphia	291,091	crude petroleum, refined petroleum products, meat, fruit, wine, beverage, and paper products	iron and steel scrap and waste, paper, and meat	Top import trading partners: Nigeria, Cameroon and Turkey, top export trading partners: Australia, Cameroon and Turkey	Harbor deepening, terminal expansion, infrastructure improvements
Wilmington (NC)	287,469	chemicals, grains and urea	forest products, wood pulp and woodchips	Top import trading partners: China, Great Britain, Trinidad & Tobago, Top export trading partners: China, Turkey & South Korea, Top overal trading partners: China, Great Britain and Belgium	Naturally deepwater port, has acquired post-Panamax cranes
Wilmington (DE)	272,996	Top importer of fresh fruit and juice concentrate	N/A	N/A	Harbor deepening

N/A: Information not applicable or not available
*East coast ports whose harbor channel deepening projects have been fast-tracked by the White House
Source: Center for Quality Growth and Regional Development, compiled from multiple sources including the American Association of Port Authorities (AAPA) and the ports' websites

Port Preparations

Several ports are aggressively pursuing opportunities to deepen and expand their harbors to accommodate larger ships. This includes the Georgia Ports Authority, which is coordinating the Savannah River dredging to 47 feet. The Port of Hampton Roads / Norfolk already has a natural 50 foot channel leading to berths with 50 foot drafts. Table 8 and Figure 18 below summarize other port deepening projects in major eastern U.S. ports. Furthermore, Figure 19 shows port deepening status.

Table 8: Port Deepening Projects

Port	Current Depth (feet), Mean Low Water	Future Depth (feet) , Mean Low Water	Expected Completion
Houston	45	More channels will be 45' depth	TBD
New Orleans	47	50	TBD
Miami	42	50	2015
Port Everglades	48	48	TBD
Jacksonville	40	47	TBD
Savannah	42	47	2016
Charleston	45	47	TBD
Wilmington, NC	44	44	N/A
Norfolk /Hampton Roads	50	55	N/A
Baltimore	50	50	N/A
Wilmington, DE	38	38	N/A
Philadelphia	40	45	2017
New York and New Jersey	45	50	2014

Source: Center for Quality Growth and Regional Development, compiled from multiple sources including the American Association of Port Authorities (AAPA) and the ports' websites

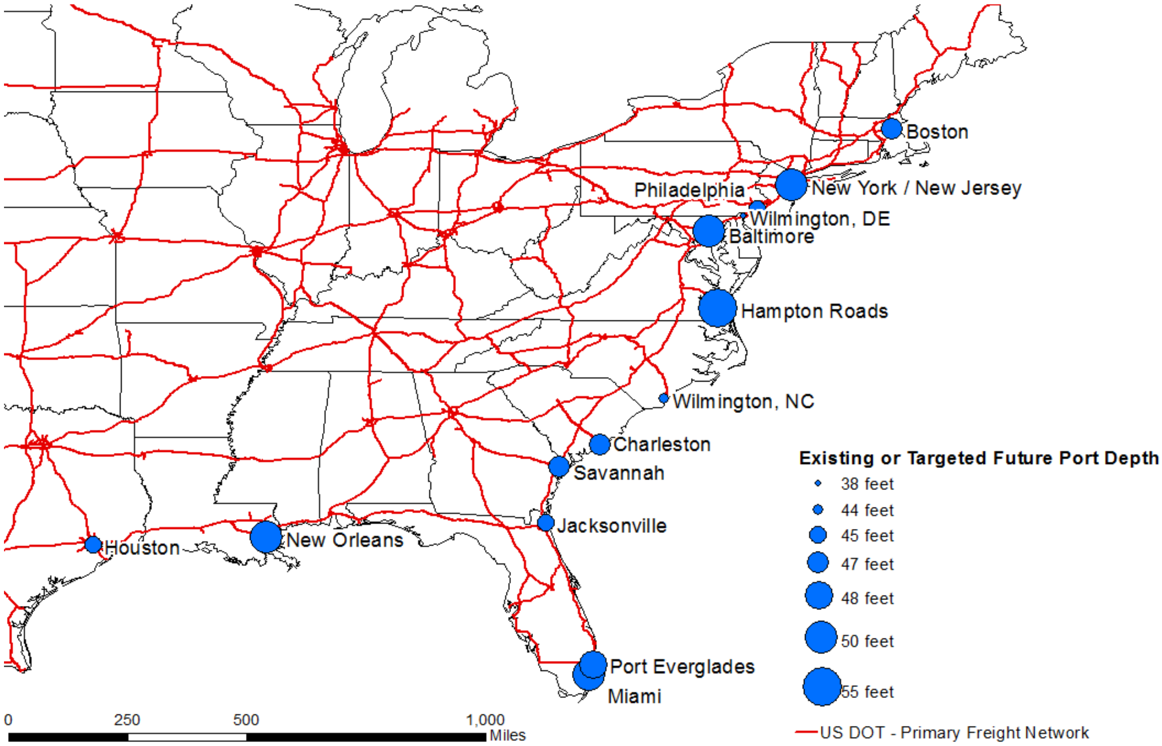


Figure 18: Planned Port Depths

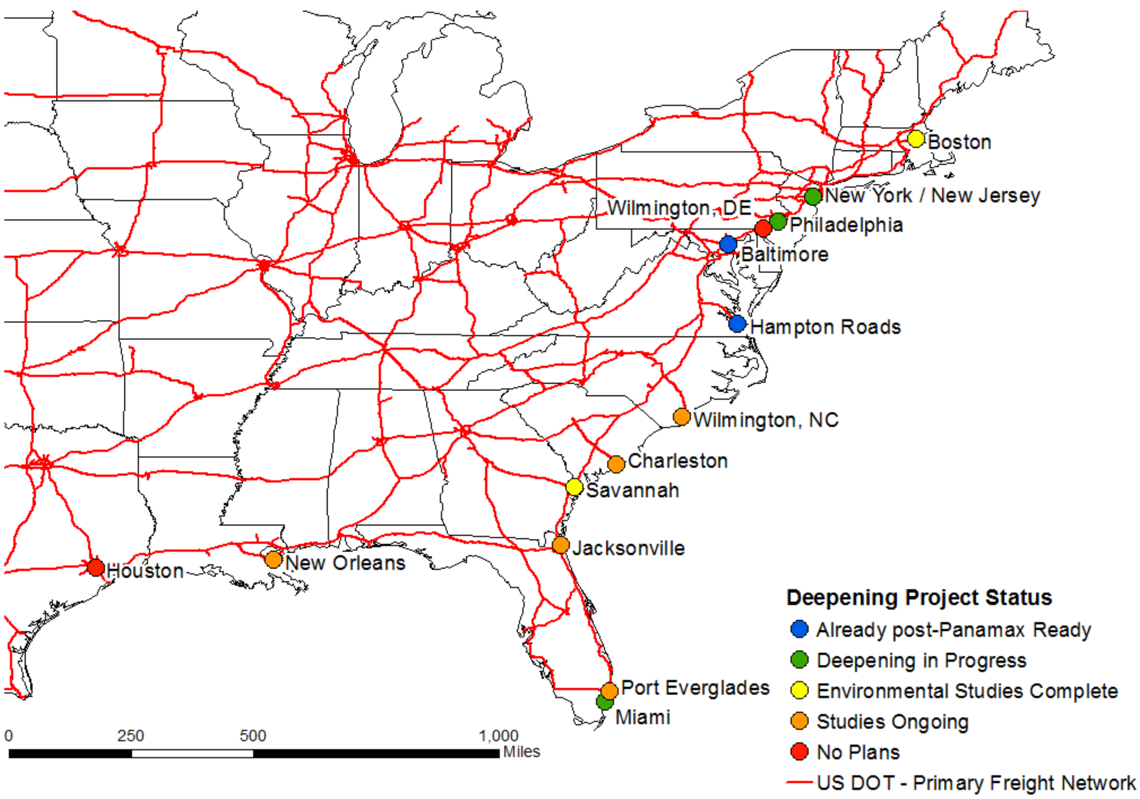


Figure 19: Port Deepening Status

Readiness for post-Panamax vessel drafts of nearly 50 feet is a spectrum that depends not only on harbor depth, but also on tidal effects. Tidal ranges at each port affect actual port depth at any given time. Many times, tides may allow a port to accommodate post-Panamax ships for several hours daily even when its mean low water depth is below 50 feet. Therefore, not all port expansion projects will result in the same capacity even after deepening projects are complete (Kendall, Shaw, & Kendall, 2012).

SECTION IV. FREIGHT MOVEMENT FROM A MEGAREGIONS PERSPECTIVE

Case Study Introduction

To better understand the specific truck movements from the East Coast and Gulf Coast ports, and resulting impacts on roadway transportation, three ports were selected as case studies for additional detailed analysis. The following case study ports were selected: the Port of Hampton Roads / Norfolk, VA; the Port of Savannah, GA; and the Port of New Orleans, LA. These three ports were chosen as case studies because they are gateways to three different megaregions (DC-Virginia, Piedmont Atlantic, and Texas Triangle respectively). Moreover, each port has a unique commodity flow mix and different levels of access to landside infrastructure, which make research results more easily generalizable to other large East Coast and Gulf Coast ports.

The research team conducted a detailed analysis of truck movement emanating from three ports utilizing GPS truck flow data. The findings generated from the analysis will inform the transportation decision making process by identifying roadway infrastructure inadequacies that could hinder freight movement between the ports and inland consumers. Each of the three ports provides a gateway to the following megaregion-scale freight movement routes: the Port of New Orleans connects vessel movement up the Mississippi River and into the Texas Triangle Megaregion's eastern edge. The Port of Norfolk makes up a large part of the Port of Virginia, which is the largest seaport in the DC-Virginia Megaregion. Finally, the Port of Savannah is the largest seaport near the Piedmont Atlantic Megaregion and one of the country's consistently fastest growing container terminals.

Understanding each megaregion's freight and economic characteristics frames analysis on how the Panama Canal expansion may affected truck movement and economic activity in the states and megaregions around each port. To that end, Section IV highlights major freight corridors, distribution centers hubs, industrial clustering, and the primary commodity movement within each megaregion.

Piedmont Atlantic Megaregion

The Piedmont Atlantic Megaregion is composed of several core metropolitan areas, including Birmingham, Atlanta, Charlotte, Durham, and Raleigh. Theses metropolitan areas contain the greatest density of people and highest intensity of travel and economic interaction across the megaregion. The Piedmont Atlantic Megaregion also contains or is near several gateway cities, including the port cities of Charleston, Savannah, Jacksonville, and Mobile. Nashville, Charlotte, and Atlanta are among the megaregion's major rail and airport hubs. These gateway cities provide important domestic and international links that facilitate the flow of goods, people, information, and culture. All of the cities are connected not only to each other, but also to the numerous small cities and large swaths of rural and undeveloped land that surround them (Regional Plan Association, 2014a).

Several interstate highway corridors anchor the megaregion, namely I-85, I-20, I-26, and I-77 among others. The spatial pattern of the megaregion includes major branches and corridors which connect the key nodes. Within the Piedmont Atlantic Megaregion, trucks transport 89% of freight by value as of 2002, and the percentage is expected to increase slightly through 2035 (Ross, Woo, West, Meyer, & Amekudzi, 2011)

Texas Triangle Megaregion

The Texas Triangle Megaregion is primarily in the state of Texas around the cities of Dallas, Fort Worth, Austin, San Antonio, and Houston. It is a growing megaregion that already generates about 7% of American gross domestic product, and it is expected to be home to 35 million people by 2050, a 15 million increase over today (Regional Plan Association, 2014b). Freight movement is also projected to increase substantially. From 2002 to 2035, there will be a projected 313% increase in freight demand. The megaregion's exports to other counties and states outside of the megaregion have a higher average value than those remaining in the megaregion. Sixty percent of the value of regional products leave the megaregion, compared with only 33% of the tonnage (Ross et al., 2011).

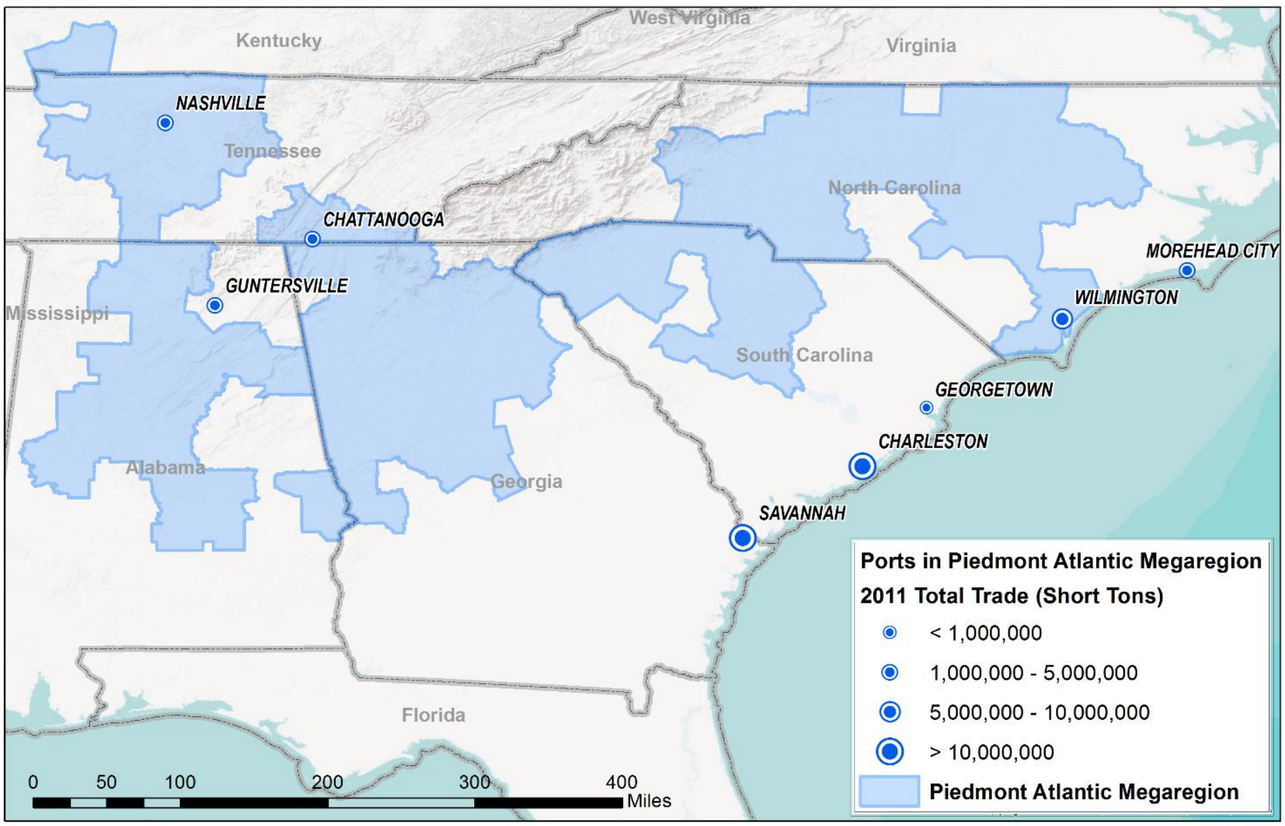
DC-Virginia Megaregion

The DC-Virginia Megaregion represents the southern portion of the northeastern megaregion of the United States and is anchored mainly by the four metropolitan areas of Washington DC, Baltimore, Richmond and Norfolk. The region is oriented around the I-95 and I-64 highways, which form north-south and east-west axes respectively. Both of these corridors are heavily trafficked and expected to continue growing. The I-95 corridor is projected to increase traffic volumes by 208% by 2035, and I-64 is projected to see a 155% volume increase. This growth will require significant investment to accommodate the increased demand (Ross et al., 2011).

Port Facilities

Piedmont Atlantic Megaregion

The following Figure 20 shows the eight major port facilities in the Piedmont Atlantic Megaregion along with their total 2011 trade volume. Table 9 summarizes the ports' characteristics. Five of the eight ports are cargo-oriented, and four of the five have deep-water channels (i.e., deeper than 40 feet), which can accommodate Panamax vessels. The major commodities associated with each port are listed in Table 9. The largest of these ports compete amongst themselves for transoceanic shipments. While Nashville, Chattanooga, and Guntersville service navigable rivers, the coastal ports—especially Savannah and Charleston—compete for import and export traffic. These coastal ports distinguish themselves through price, quality of port facilities, proximity to customers, and quality of transportation infrastructure.



Data Source: US Army Navigation Data Center

Figure 20: Ports in Piedmont Atlantic Megaregion and Their Total Trade Volumes

Table 9: Profile of Ports in Piedmont Atlantic Megaregion

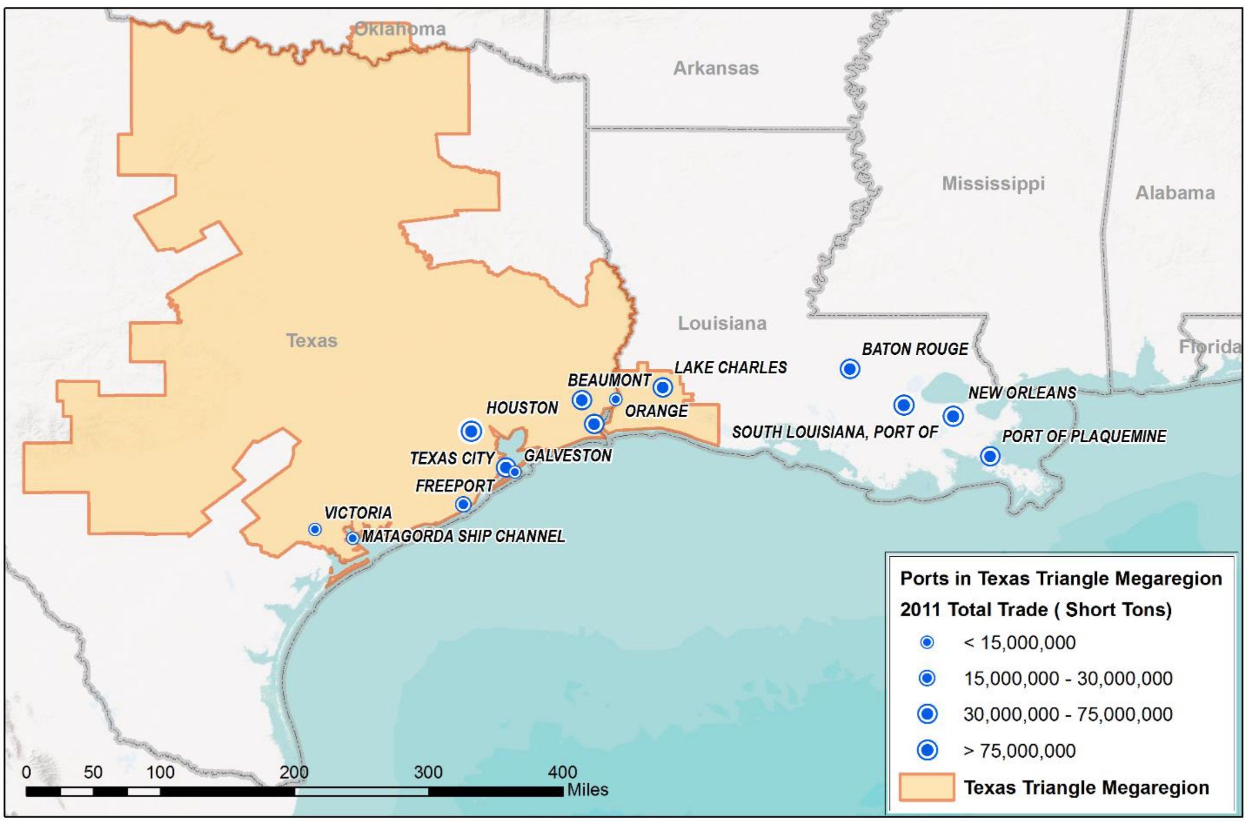
Port Name	Port Type	Total Trade (short tons) In 2011	Trade Share	Max Channel Depth (feet)	Number of Docks	Commodities: Main Imports	Commodities: Main Exports
Savannah, GA	Panamax (post-Panamax* deepening set to begin)	35,459,297	50.1%	42	61	Furniture; retail consumer goods; machinery, appliances & electronics; automotive; hardware & houseware; food; apparel; mineral; toys; chemical;	Wood pulp; food; paper & paperboard, incl waste; clay; automotive; fabrics, incl raw cotton; machinery, appliances & electronics; chemical; resins & rubber; retail consumer goods
Charleston, SC	Panamax (post-Panamax* deepening being studied)	17,916,618	25.3%	45	121	Furniture, auto parts, sheets and towels and blankets, fabrics, auto & trucktire & tubes, general cargo, menswear	Paper and paperboard, wood pulp, auto parts, logs and lumber, fabrics, general cargo
Wilmington, NC	Panamax	6,972,535	9.9%	42	32	Chemicals, grains, urea, ore, mica, schist, machinery/Pts.	Forest products, wood pulp, gen. merchandise/Misc. Food products, forest products
Morehead City, NC	Deepwater	3,569,512	5.0%	45	17	Sulfur products, rubber, scrap metal, ore, mica, schist, metal products	Phosphate, woodchips, metal products, military, gen. merchandise/misc
Chattanooga, TN	Inland	2,404,012	3.4%	9	32	Processed foods, iron and steel products, textiles, apparel, cosmetics, pharmaceuticals, clay products, furniture, machinery, paper, petroleum products	
Nashville, TN	Inland	1,918,167	2.7%	20	39	Dry bulk commodities, including sand and gravel, coke, salt, ferroalloys, and dry bulk fertilizers, steel rods, petroleum products, fuel oil, caustic soda, bulk cement, asphalt, steel products	Dry bulk commodities, including sand and gravel, coke, salt, ferroalloys, and dry bulk fertilizers, scrap metal
Guntersville, AL	Inland	1,539,765	2.2%	12	20	Coal, coke, iron ore, and scrap iron	
Georgetown, SC	Seaport	967,625	1.4%	27	17	Steel, cement, aggregates, and forest products	

*Panamax refers to the limit of ship size of 3,000 to 3,400 TEU, and post-Panamax refers to those of 4,000 to 5,000 TEU
Source: Center for Quality Growth and Regional Development, compiled from multiple sources including US Army Corps of Engineers Navigation Data Center

The Port of Savannah is the largest port in the Piedmont Atlantic Megaregion both in terms of trade volume and trade value. In 2013, the Port of Savannah had an annual total trade volume of about 28-million short tons and serves as the point of entry for approximately half of the total volume of commodities shipped into the megaregion. The foreign trade volume through the Port of Savannah was about 20 million short tons in 2011 and thus was responsible for the fourth greatest volume of foreign trade in the country (Maritime Administration, 2013). The other major port located in the Piedmont Atlantic Megaregion is the Port of Charleston, which processed nearly 18 million short tons in 2011 and is responsible for about a quarter of the total tonnage of foreign trade flow exported to and from the Piedmont Atlantic Megaregion.

Texas Triangle Megaregion

Figure 21 shows the fourteen major port facilities in the Texas Triangle Megaregion with magnitudes showing their total trade of volume in 2011. Table 10 summarizes the characteristics of those ports.



Data Source: US Army Navigation Data Center

Figure 21: Ports in Texas Triangle Megaregion and Their Total Trade Volumes

Table 10: Profile of Ports in Texas Triangle Megaregion

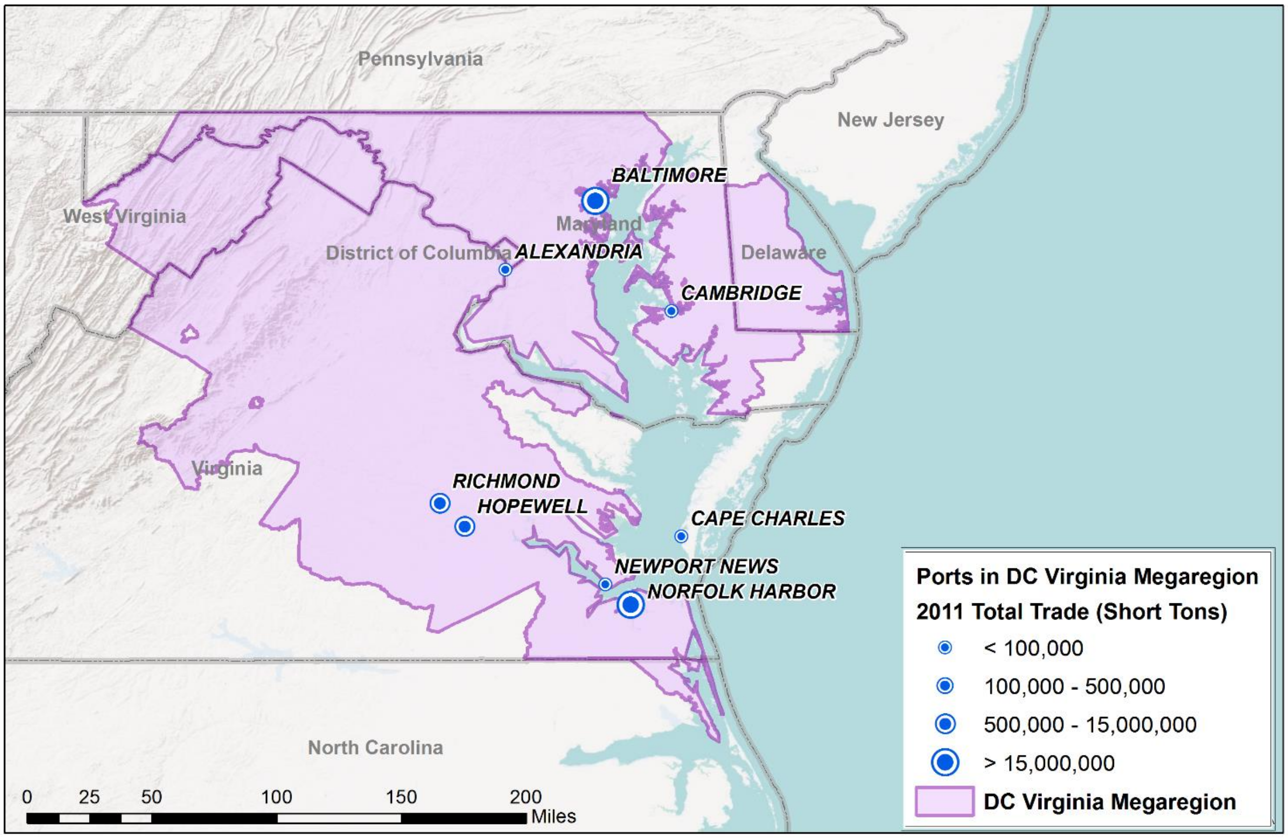
Port Name	Port Type	Total Trade (short tons) In 2011	Trade Share	Max Channel Depth (feet)	Number of Docks	Commodities	
						Main Imports	Main Exports
South Louisiana, LA, Port of	Panamax	246,508,817	26.2%	45	183	Crude oil, chemical/fertilizers, steel products, petrochemicals	Maize, soybeans, wheat, animal feed
Houston, TX	post Panamax*	237,798,639	25.3%	45	388	Petroleum and petroleum products; iron and steel; crude fertilizers and minerals; organic chemicals; wood and articles of wood.	Petroleum and petroleum products; organic chemicals; cereals and cereal products; plastics; animal or vegetable fats and oils
New Orleans, LA	Panamax (post-Panamax* deepening being studied)	77,174,712	8.2%	47	327	Petroleum products, iron, steel, metal ores, non-metallic minerals, coffee, inorganic chemicals, forest products, vegetable fats and oils, natural rubber, fertilizers, organic chemicals	Cereal grain, soybeans, petroleum, animal feeds, organic chemicals, paper and linear board, vegetable fats and oils, iron, steel, metal ores and scraps, inorganic chemicals
Beaumont, TX	Panamax	73,672,069	7.8%	40	98	Forest products, aggregate, military cargo, steel, project cargo	Bulk grain, potash, forest products, military cargo, project cargo
Baton Rouge, LA	Panamax	57,871,900	6.2%	45	138	Molasses, petroleum, steel coils, ores, chemicals	Forestry products, petroleum products, grain, coke, pipe, bagged grains, fertilizer
Texas City, TX	Deepwater	57,757,532	6.1%	45	47	Crude oil	Gasoline, diesel, jet fuel, intermediate chemicals, petroleum coke
Lake Charles, LA	Deepwater	54,246,843	5.8%	40	192	Bagged rice, flour, forest products, aluminum, petroleum products and barites	

Port Name	Port Type	Total Trade (short tons) In 2011	Trade Share	Max Channel Depth (feet)	Number of Docks	Commodities: Main Imports	Commodities: Main Exports
Plaquemines, LA, Port of	Panamax (In progress for post-Panamax*)	54,093,006	5.8%	45	110	Coke, carbon black feed stock, crude, fuel oil, IC 4, gasoline, heating oil, naphtha, natural gas, cobalt, petroleum products, and phosphate	Coal, grain-corn, soybean, wheat
Port Arthur, TX	Panamax	30,274,736	3.2%	40	69	Steel slabs, wood pulp, newsprint, lumber, plywood, project cargo, military	Linerboard, plywood, steel pipe
Freeport, TX	Panamax	23,311,868	2.5%	45	62	Aggregate, chemicals, clothing, foods (fruit), crude, LNG, paper goods, plastics, windmills	Autos, chemicals, clothing, foods, paper goods, resins, rice
Galveston, TX	Panamax	13,743,671	1.5%	45	74	Cotton, heavy cargos of cattle, rice	
Matagorda Port, TX	Deepwater	9,333,126	1.0%	38	137	Wind power equipment, bananas, agricultural equipment, machinery, vehicles, fertilizer products, lumber products, military-related cargos	Bulk grains, containers, machinery, vehicles, linerboard and paper, carbon black, light fuels
Victoria, TX	Inland	3,528,265	0.4%	9	23	Major products transferred are liquid and dry bulk and general and project cargos	
Orange, TX	Inland	696,405	0.1%	25	45	Local industrial facilities with warehousing, packaging bulk cargo, and railroad/truck shopping operations	

*Panamax refers to the limit of ship size of 3,000 to 3,400 TEU, and post-Panamax refers to those of 4,000 to 5,000 TEU
Source: Center for Quality Growth and Regional Development, compiled from multiple sources including US Army Corps of Engineers Navigation Data Center

DC-Virginia Megaregion

Figure 22 shows the fourteen major port facilities in the DC-Virginia Megaregion and their total trade of volume in 2011. Table 11 summarizes relevant port characteristics.



Data Source: US Army Navigation Data Center

Figure 22: Ports in DC-Virginia Megaregion and Their Total Trade Volumes

Table 11: Profile of Ports in DC Virginia Megaregion

Port Name	Port Type	Total Trade (short tons) In 2011	Trade Share	Max Channel Depth (feet)	Number of Docks	Commodities: Main Imports	Commodities: Main Exports
Norfolk Harbor, VA	post-Panamax*	47,352,771	39.7%	50	133	Mineral fuel and oil; machinery; salt, sulfur, earth, and stone; fertilizers; and furniture and bedding	Mineral fuel and oil, cereals, fertilizers, food waste, animal feed, and wood pulp
Baltimore, MD	post-Panamax*)	44,865,703	37.6%	50	141	Automobiles and small trucks, farm and construction machinery, iron ore, petroleum products, gypsum, sugar, cement, bauxite, salt, crude mineral substances, fertilizer and fertilizer materials, ferroalloys, wood pulp, and paper	Coal, corn, soybeans, lignite, coal coke, petroleum, and fuel oils
Newport News, VA	Panamax	25,200,668	21.1%	40	38	All Manufactured Equipment, Machinery and Products	
Hopewell, VA	Inland	1,018,890	0.9%	23	2	Asphalt, petroleum products, and sodium hydroxide by barge.	
Richmond, VA	Inland	902,213	0.8%	25	56	Chemicals, pharmaceuticals, forest products, machinery, consumer goods, frozen seafood, produce, bottled water from Iceland, recreational campers, steel, steel products, stone, tobacco leaf, aluminum, project cargo, vehicles, recreational boats, wire coils, wire rods, pipe, bulk grain, minerals, and livestock.	
Cambridge, MD	Cruise port	--	--	--	27	--	
Alexandria, VA	Deepwater	--	--	45	18	Military equipment on inland waterways	
Cape Charles, VA	Cruise port	--	--	--	11	--	

*Panamax refers to the limit of ship size of 3,000 to 3,400 TEU, and post-Panamax refers to those of 4,000 to 5,000 TEU
Source: Center for Quality Growth and Regional Development, compiled from multiple sources including US Army Corps of Engineers Navigation Data Center

Major Truck Corridors in the Three Megaregions

The Freight Analysis Framework (FAF3) database and flow assignment provide estimates for 2007 and 2040 freight traffic along the FAF3 road network, which is shown in Figure 23. Truck tonnage is assigned to the network segments by using highway links characteristics, such as route number and milepost, functional classification of the highway, and number of lanes. This allows the Federal Highway Administration to estimate truck volumes, volume to capacity ratios, travel speed, and delays across the network (Federal Highway Administration, 2012). The U.S. Department of Transportation has designated a subset of U.S. highways as part of a 27,000 mile-long Primary Freight Network (draft), which designates the most important freight routes to U.S. economic activity based on congressionally defined freight characteristics, multimodal infrastructure access, and a total mileage cap. An additional 14,000 miles are added to compose the Comprehensive Primary Freight Network (draft). The comprehensive Primary Freight Network includes all roads that meet congressionally defined criteria.

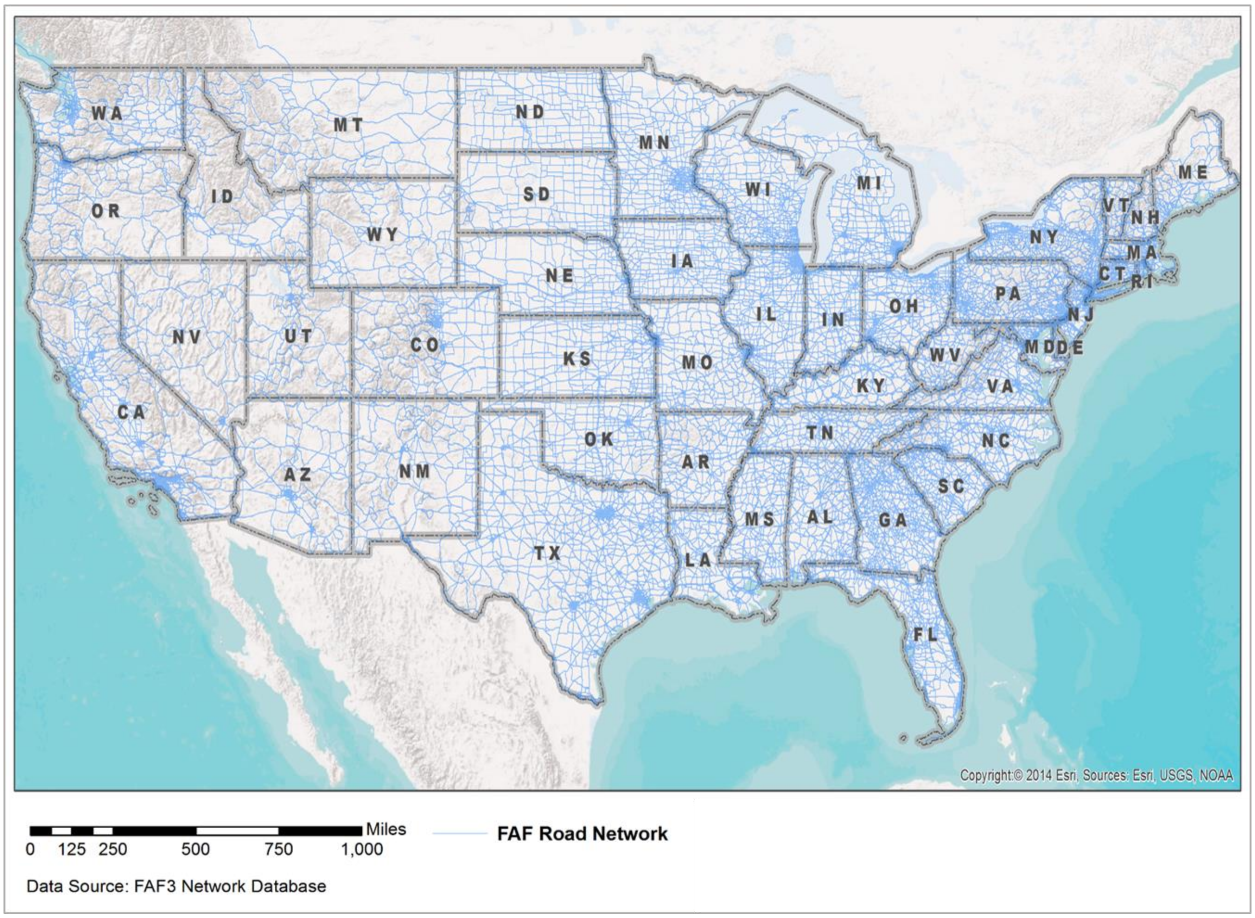


Figure 23: FAF3 Network

Network truck volumes were mapped and the major truck routes for the three study megaregions were identified. Key route characteristics were selected, including truck volume, volume to capacity ratios, average travel speed, and peak hour travel delay to demonstrate the truck travel patterns and the general use of the road network in the three megaregions.

Piedmont Atlantic Megaregion

Major Corridors

Researchers identified the Piedmont Atlantic Megaregion's major truck corridors in Figure 24. Major truck corridors are defined as routes with a daily truck volume greater than 4,000. Table 12 summarizes the top 20 truck corridors by selecting the routes with the highest average daily truck volumes from the major truck corridors. The top 20 corridors are interstate highways, like Interstate 285 (I-285), a circular highway around the City of Atlanta, Interstate 24 (I-24), linking Atlanta and Nashville (via I-75 through Chattanooga), Interstate 75 (I-75), which extends south-north across the country. Table 12 and Figure 106 (see page 214 in Appendix 4) show the forecasted truck volumes along these major corridors in 2040, indicating that there will be a dramatic increase in the truck volumes on most of the routes, and that major truck route volumes could potentially double by 2040.

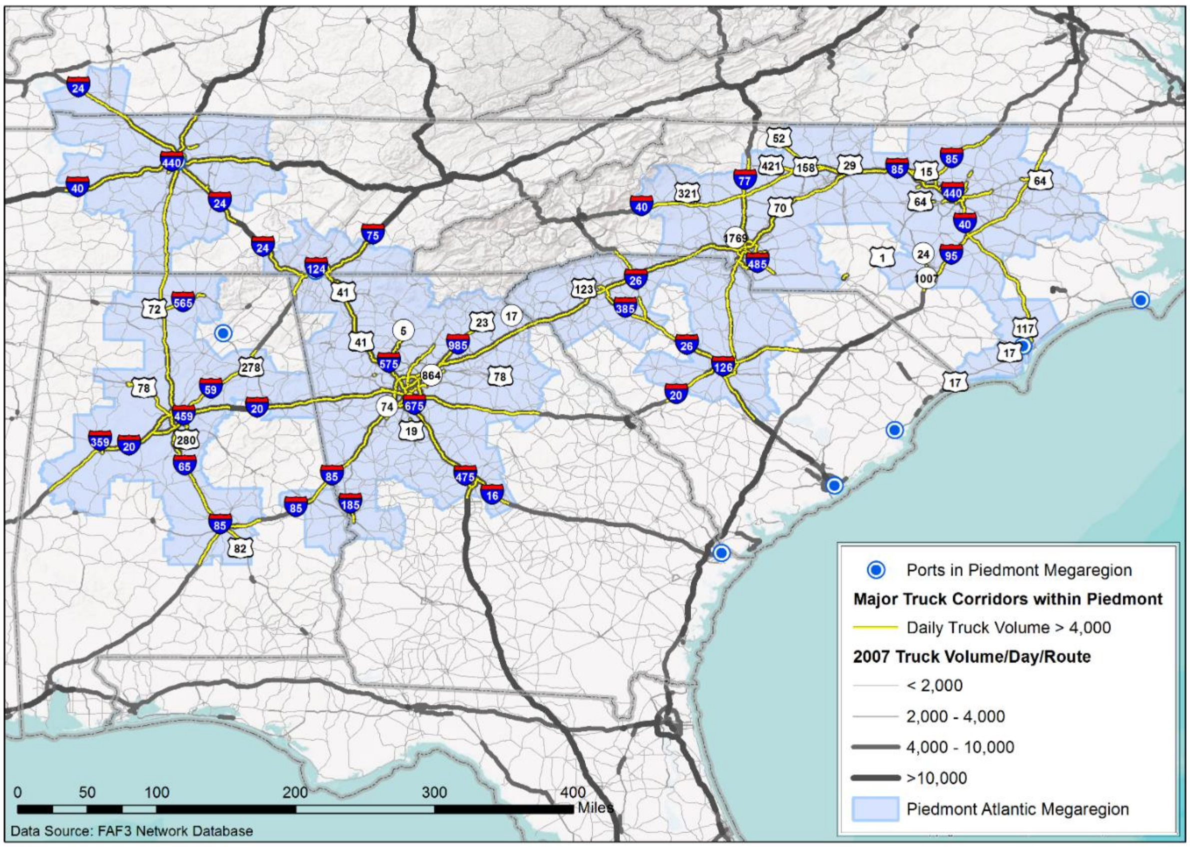


Figure 24: Major Truck Corridors with Volumes Over 4,000 Trucks per Day per Route in Piedmont Atlantic Megaregion

Table 12: Top 20 Truck Corridors in Piedmont Atlantic Megaregion

Rank	1	2	3	4	5	6	7	8	9	10
Route Name	**I285**	**I24 N**	**I75**	**I440 N**	**I540**	**I85**	**I20**	**I277**	**I40**	**I440**
Average Daily Truck Volume 2007	27,643	24,370	20,921	18,579	14,791	14,704	14,122	13,997	13,764	13,395
Average Daily Truck Volume 2040	48,835	51,927	39,055	33,121	30,706	28,724	31,320	27,557	24,715	25,443

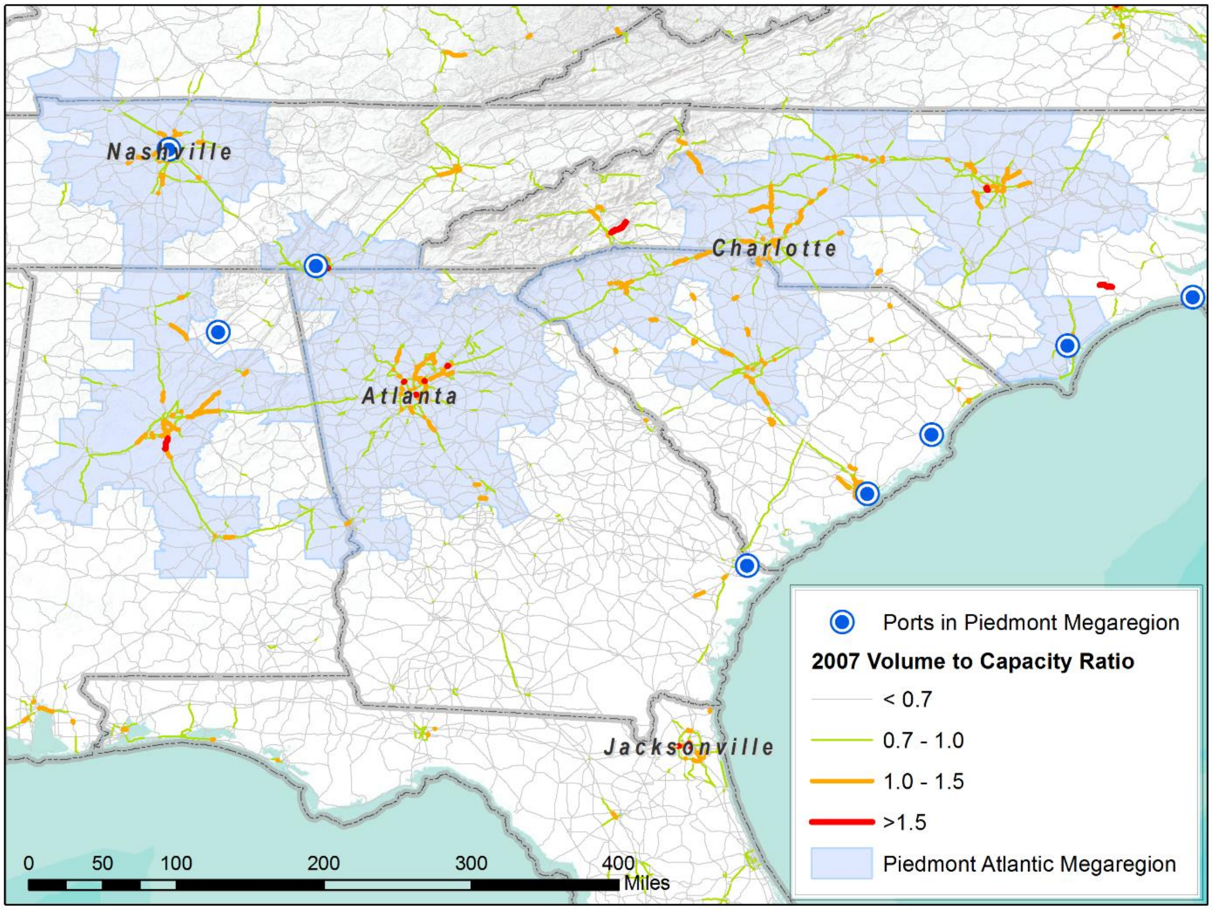
Rank	11	12	13	14	15	16	17	18	19	20
Route Name	**I24**	**I485**	**I77**	**I985**	**I475**	**I65**	**I575**	**I459**	**I16**	**I675**
Average Daily Truck Volume 2007	13,385	12,809	12,377	11,690	11,400	11,146	11,028	10,673	9,801	9,201
Average Daily Truck Volume 2040	26,471	26,499	24,789	21,845	17,255	25,084	20,638	30,159	18,338	15,539

Source: FAF3

The Piedmont Atlantic Megaregion truck corridors align with state-level corridors identified in the Georgia Statewide Freight and Logistics Plan. The Georgia Department of Transportation (2011) examined interstate sections and found I-75 north of Atlanta to be Georgia's most intensive freight corridor, followed by I-75 between Atlanta and Macon. The busiest corridors in Georgia are in and around metro Atlanta, including I-285, I-75, and I-85. Some corridors stand out more at a state scale than a megaregion scale. I-16 between Savannah and Macon is very important for intra-state freight traffic even though it is only the 19th busiest freight corridor in the Piedmont Atlantic Megaregion. The Georgia Department of Transportation found that approximately 80% of the trucks on I-16 were moving freight intrastate (Georgia Department of Transportation, 2013c).

Volume to Capacity Ratio

Figure 25 shows the 2007 volume to capacity ratio (VCR) along Piedmont Atlantic Megaregion routes. Volume to capacity ratios reflect traffic congestion severity. Most of the major truck corridors have a VCR greater than 0.7, indicating that the Piedmont Atlantic Megaregion's freight arterials are congested. Congestion tends to be most severe around major cities, including Atlanta, Nashville, Charlotte, and Raleigh. The major routes linking to the Ports of Savannah, Charleston, and Wilmington are also somewhat congested. Figure 107 (see page 215 in Appendix 4) describes the forecasted VCR on the routes in 2040, showing that most of the major routes will likely to have a VCR greater than 1 by that time if capacity and demand are not addressed. This figure represents a paralyzed transportation system with its arterials severely congested, and it calls for solutions to address congestion before the roads cease to be navigable.



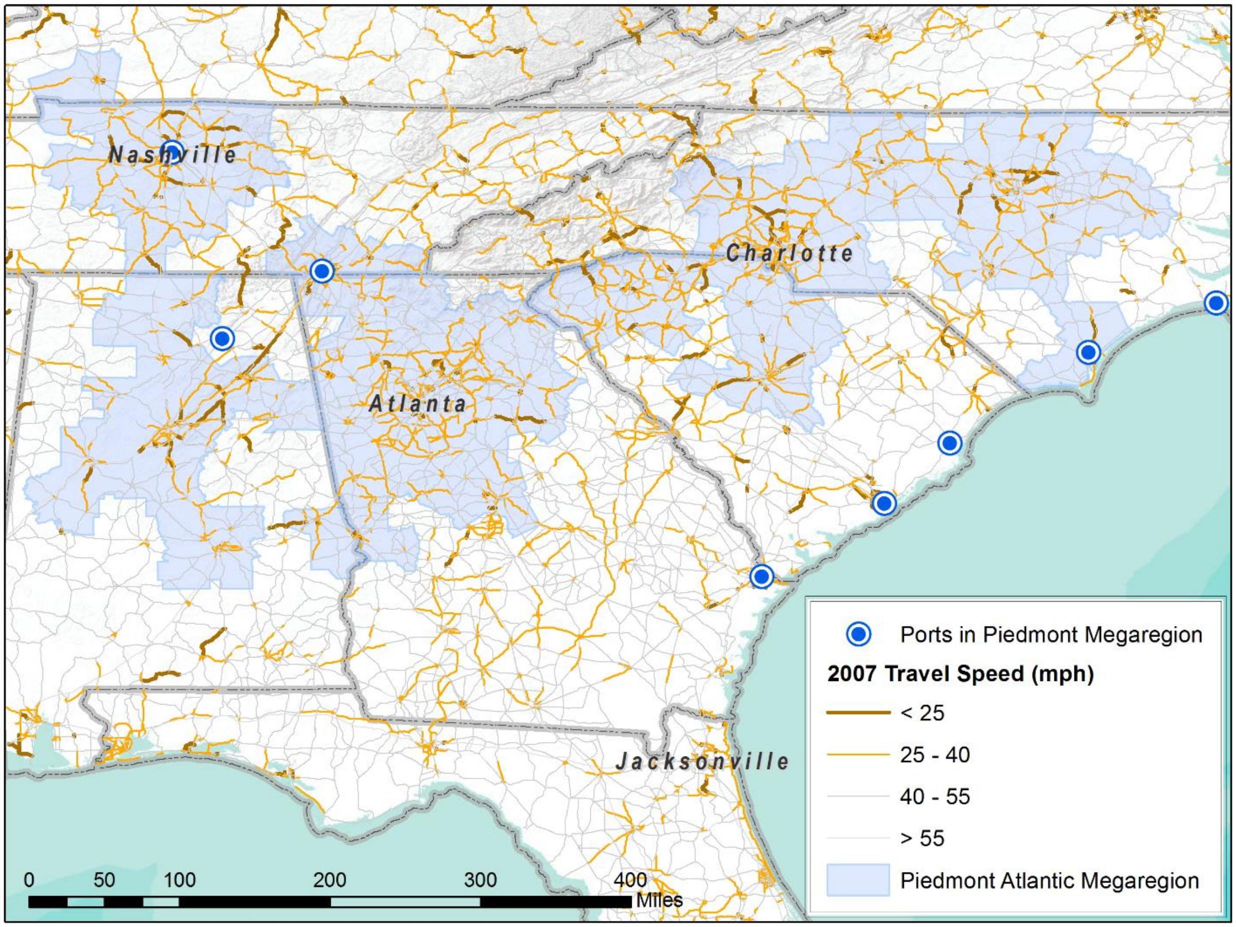
Data Source: FAF3 Network Database

Figure 25: Volume to Capacity Ratio along the Routes in Piedmont Atlantic Megaregion

Megaregion-level congestion findings supports the Georgia Department of Transportation's (2011) bottleneck analysis in the Georgia Statewide Freight and Logistics Plan. The Georgia Department of Transportation found high levels of congestion closest to metro Atlanta. I-285 regularly operates beyond capacity, as do I-75, I-85, and I-20 closest to Atlanta. Significantly, I-16 connecting Savannah and Macon is projected to remain far below capacity through 2050.

Average Travel Speed

Figure 26 shows the 2007 average travel speed on the routes within the Piedmont Atlantic Megaregion. Most parts of the arterials have an average travel speed larger than 55 mph, which is about the free flow travel speed, indicating the current transportation system functions efficiently. The extreme slow travel speed (less than 25 mph) often appears at intersections and is only for small segments of the routes. Figure 108 in the Appendix 5 plots the forecasted average travel speed in 2040 and it depicts a much more deteriorated picture, where most parts of the major corridors across the region have a travel speed of less than 25 mph.

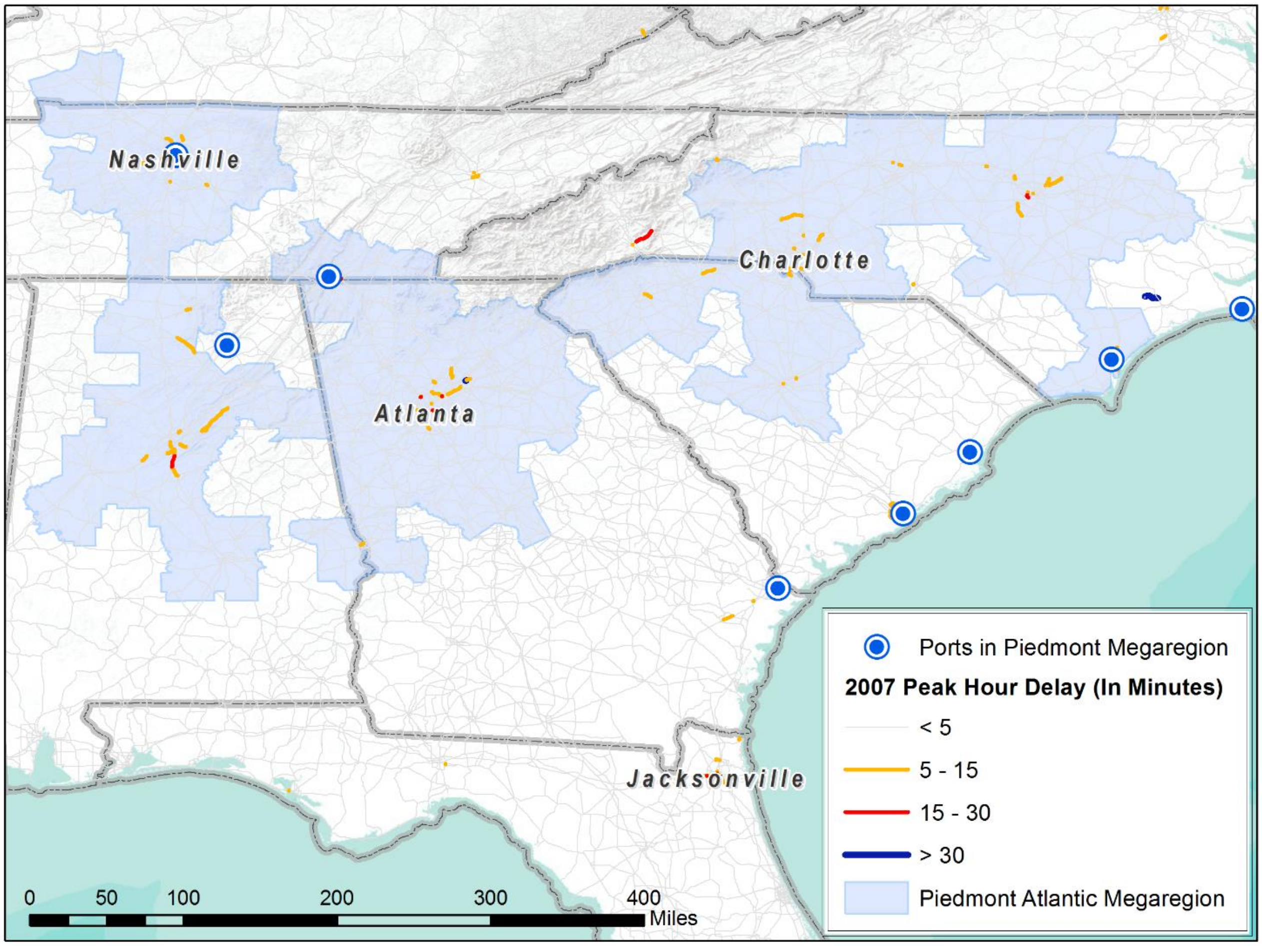


Data Source: FAF3 Network Database

Figure 26: Average Travel Speed along the Routes in Piedmont Atlantic Megaregion

Peak Hour Travel Delay

Figure 27 shows the 2007 peak hour travel delay in minutes for the Piedmont Atlantic Megaregion. Generally, the peak hour delay is less than three minutes on most of the routes except some segments in the major cities. However, the current travel delay will probably expand drastically by 2040 and most segments of the major routes within the megaregion have more than 12 minutes' peak hour delay, as shown in Figure 109 (see page 216 in Appendix 4).



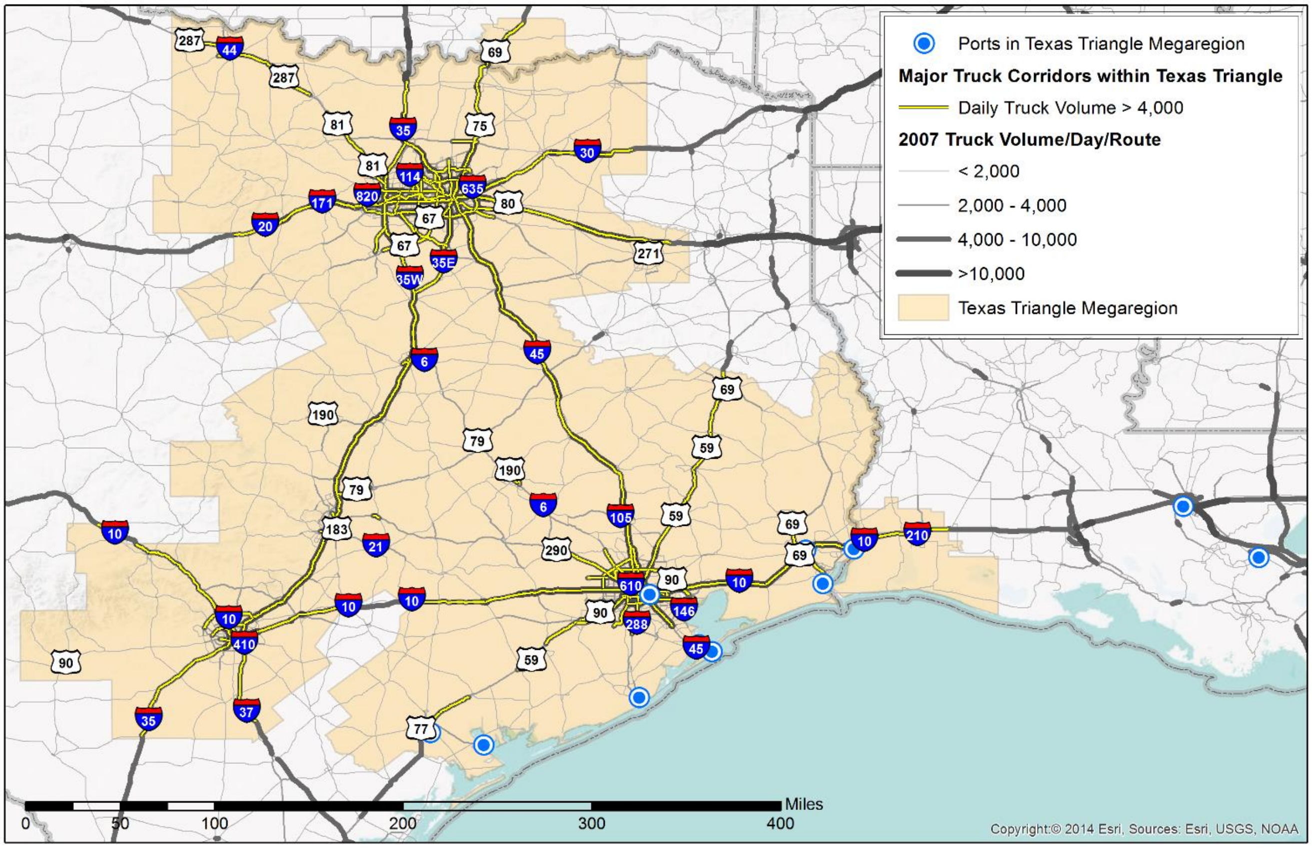
Data Source: FAF3 Network Database

Figure 27: Peak Hour Delay along the Routes in Piedmont Atlantic Megaregion in 2007

Texas Triangle Megaregion

Major Corridors

The Texas Triangle is composed of the metro regions of Dallas, Fort Worth, Austin, San Antonio, Houston, and surrounding counties. Figure 28 shows the major truck corridors inside the megaregion boundary. The major corridors are identified by selecting all the routes with a daily truck volume greater than 4,000 within the Texas Triangle Megaregion, as shown in Figure 28, which summarizes the top 20 truck corridors with the highest daily truck volume among each route. Most of the top 20 truck corridors are interstate highways like Interstate 35, linking San Antonio to Dallas, and there are also some US highways and state highways with heavy daily truck flows, like U.S. Route 75 (US75), linking Dallas to the north, and Texas State Highway 225 (S225), going west-east through Houston. The major truck corridors will possibly be impacted most if there is any change to the truck movement derived from the Panama Canal expansion. Figure 102 (see page 212 in Appendix 4) shows the forecasted 2040 truck volumes per day per route in the Texas Triangle Megaregion.



Data Source: FAF3 Network Database

Figure 28: Major Truck Corridors in Texas Triangle Megaregion

Table 13: Top 20 Truck Corridors in the Texas Triangle

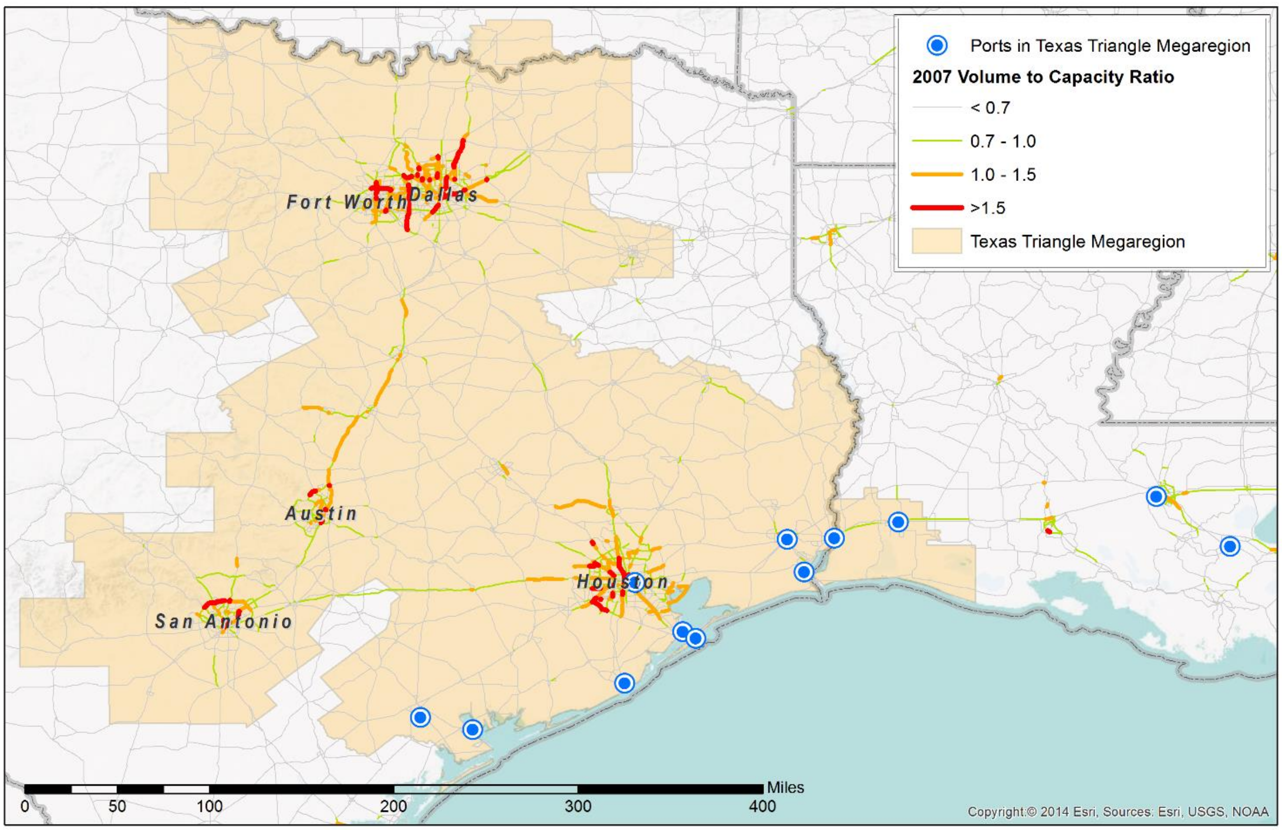
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Route Name	**I35**	**I635**	**I45**	**I35W**	**I35E**	**I30**	**S548 S**	**U75**	**I610**	**I10**
Average Daily Truck Volume 2007	17,435	16,523	16,512	15,317	14,155	13,188	13,107	12,692	12,390	12,245
Average Daily Truck Volume 2040	36,500	32,132	32,140	29,476	28,208	26,602	25,683	24,732	24,062	25,594

Rank	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Route Name	**I20**	**U290**	**S225**	**S183**	**S288**	**U59**	**I37**	**U80**	**S360**	**U90**
Average Daily Truck Volume 2007	11,422	9,842	9,616	9,549	9,438	9,432	9,380	9,172	9,123	8,692
Average Daily Truck Volume 2040	22,181	19,374	18,686	18,327	17,832	18,463	17,706	17,965	17,898	16,831

Source: FAF3

Volume to Capacity Ratio

Figure 29 shows the volume to capacity ratio (VCR) along the road network in the Texas Triangle in 2007, and Figure 103 (see page 212 in Appendix 4) shows the 2040 forecasted VCR. The VCR depicts actual route-specific traffic congestion, taking into account all types of traffic. Generally a VCR below 0.5 implies that there is a free-flow travel speed; a VCR between 0.5 and 0.7 reflects moderate travel condition; a VCR between 0.7 and 1 is a sign of congestion; and a VCR greater than 1 indicates severe congestion. As Figure 29 shows, most of the congestion appears around the four anchor cities of Houston, Dallas, San Antonio, and Austin, where the VCR on the major routes are often above 0.7 and sometimes above 1. Congestion also tends to happen on certain important road intersections, such as the intersection of I-35 and US190 near the City of Belton. The interstate with the most heavy daily truck volume is I-35, and it is also the most congested major route in the area.

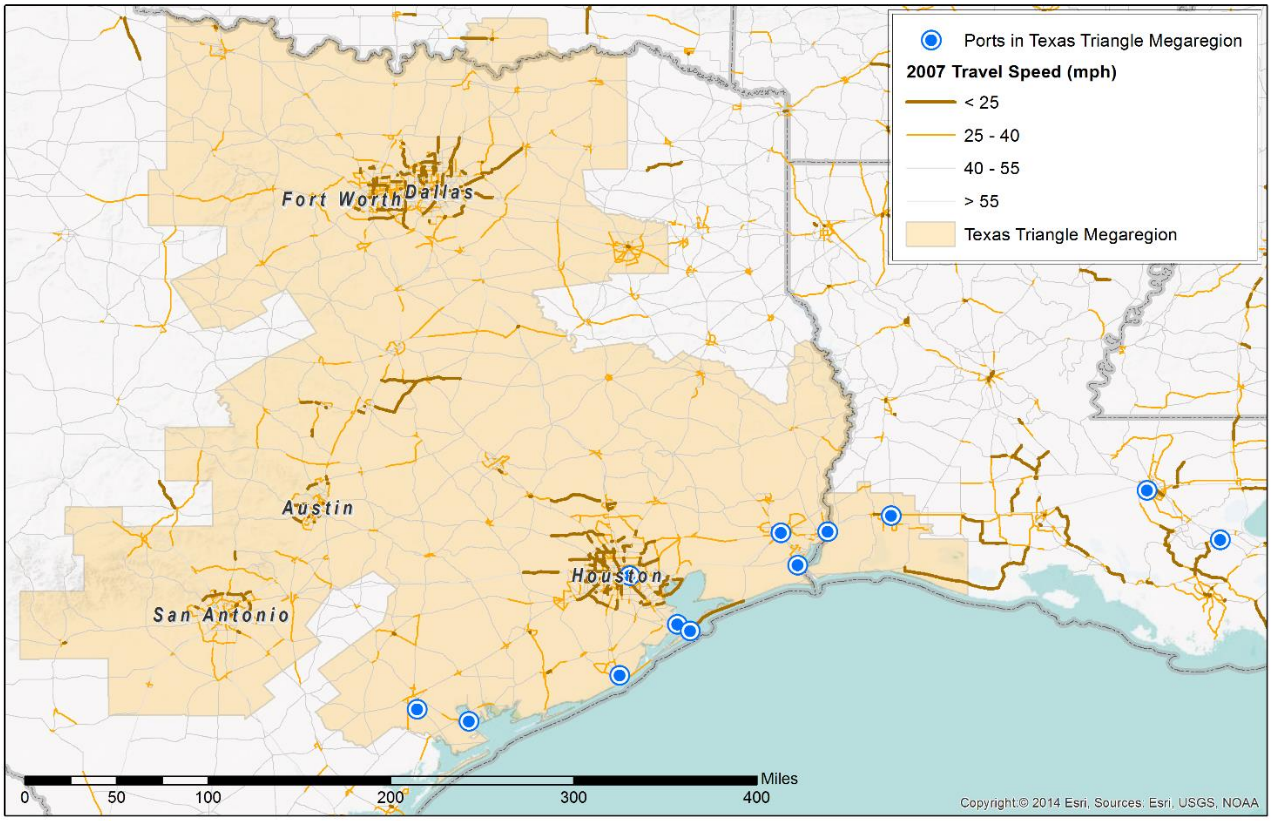


Data Source: FAF3 Network Database

Figure 29: 2007 Volume to Capacity Ratio along Routes in Texas Triangle

Average Travel Speed

Figure 30 maps the actual travel speed along the routes in the Texas Triangle in 2007, and Figure 104 (see page 213 in Appendix 4) maps the forecasted 2040 travel speeds. The maps correspond to the maps of VCR and also reflect traffic congestion. Although it seems that in 2007 the slow travel speeds (less than 25 mph) only appear near the four anchor cities and some big route intersections, such slow speeds will occur on most of the routes in 2040 (see Figure 104 on page 213 in Appendix 4), which will hinder efficient transportation and freight movement.

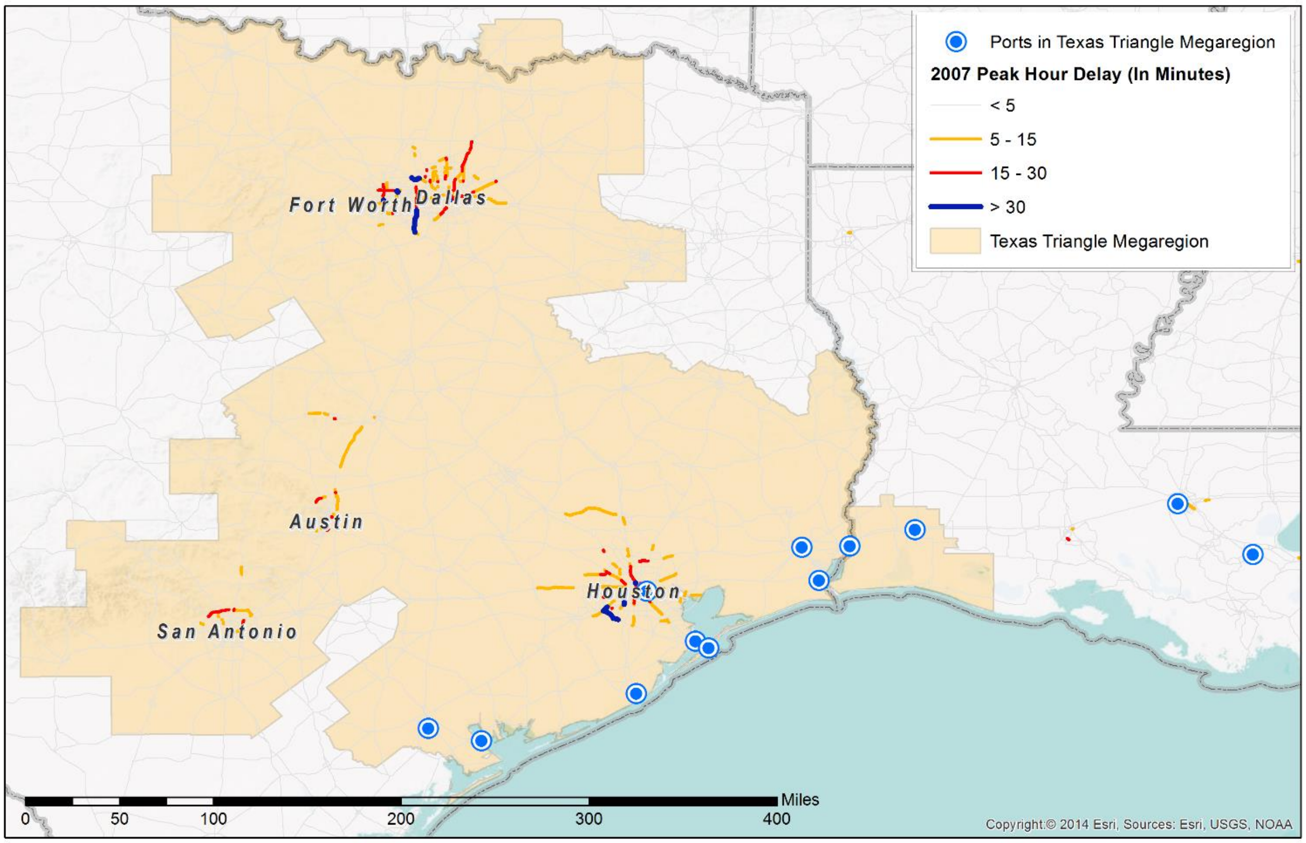


Data Source: FAF3 Network Database

Figure 30: Average Travel Speed along the Routes in the Texas Triangle in 2007

Peak Hour Travel Delay

Figure 31 shows the average peak hour travel delay major Texas Triangle routes in 2007, and Figure 105 (see page 214 in Appendix 4) maps the forecasted average peak hour travel delay in 2040. The average peak hour travel delay reflect the congestion level by showing how much extra travel time people spent on travel due to congestion. Figure 31 shows that in most of the megaregion, the peak hour travel delay is below three minutes, but for some routes within the four anchor cities the travel delay is as high as 12 minutes. The travel delay is calculated on a per vehicle base. Congestion costs can be monetized by summing all vehicles' delay time and multiplying by a dollar value of time. Congestion costs are generally quite large under high volume or severe delays. The forecasted 2040 peak hour delay is much more severe than at present, posing a challenge for future planning of transportation and freight movement.



Data Source: FAF3 Network Database

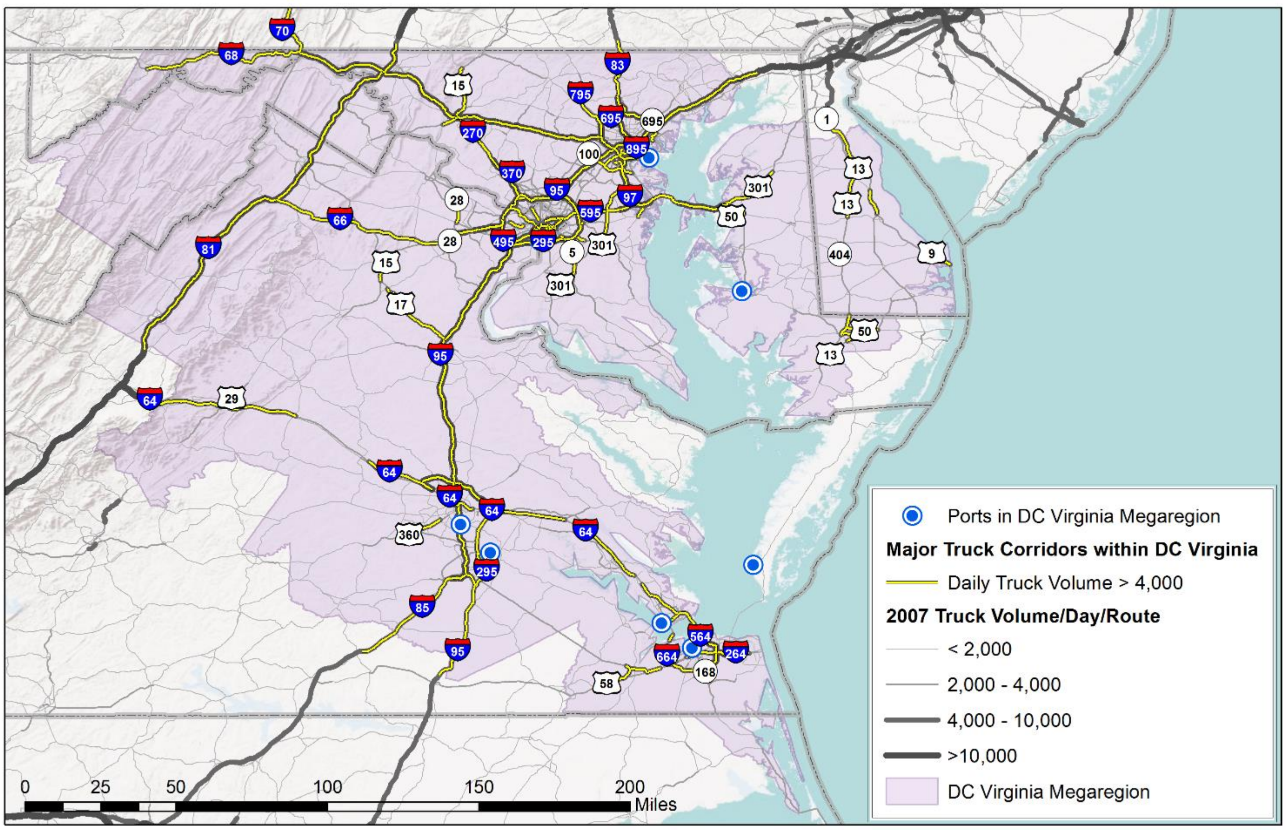
Figure 31: Peak Hour Delay in Minutes along the Routes in the Texas Triangle in 2007

DC-Virginia Megaregion

Major Corridors

The DC-Virginia Megaregion stretches from the Hampton Roads area of Virginia through Richmond, northern Virginia, eastern West Virginia, Washington and Baltimore, as well as eastern Maryland and southern Delaware. Figure 32 shows the major truck corridors with daily truck volumes over 4,000 daily trucks within the DC-Virginia Megaregion, and Figure 110 shows the forecasted truck volumes in this area in 2040.

Table 14 summarizes the top 20 truck corridors by average daily truck volume. Most of the top 20 truck corridors are interstate highways, such as Interstate 95 (I-95), the main interstate highway going along the east coast, Interstate 695 (I-695), the circular highway route around the City of Baltimore, and Interstate 495 (I-495), the circular highway route around Washington DC.



Data Source: FAF3 Network Database

Figure 32: Major Truck Corridors with Daily Truck Volume Larger Than 4,000 in 2007 in DC-Virginia Megaregion

Table 14: Top 20 Truck Corridors in DC-Virginia Megaregion

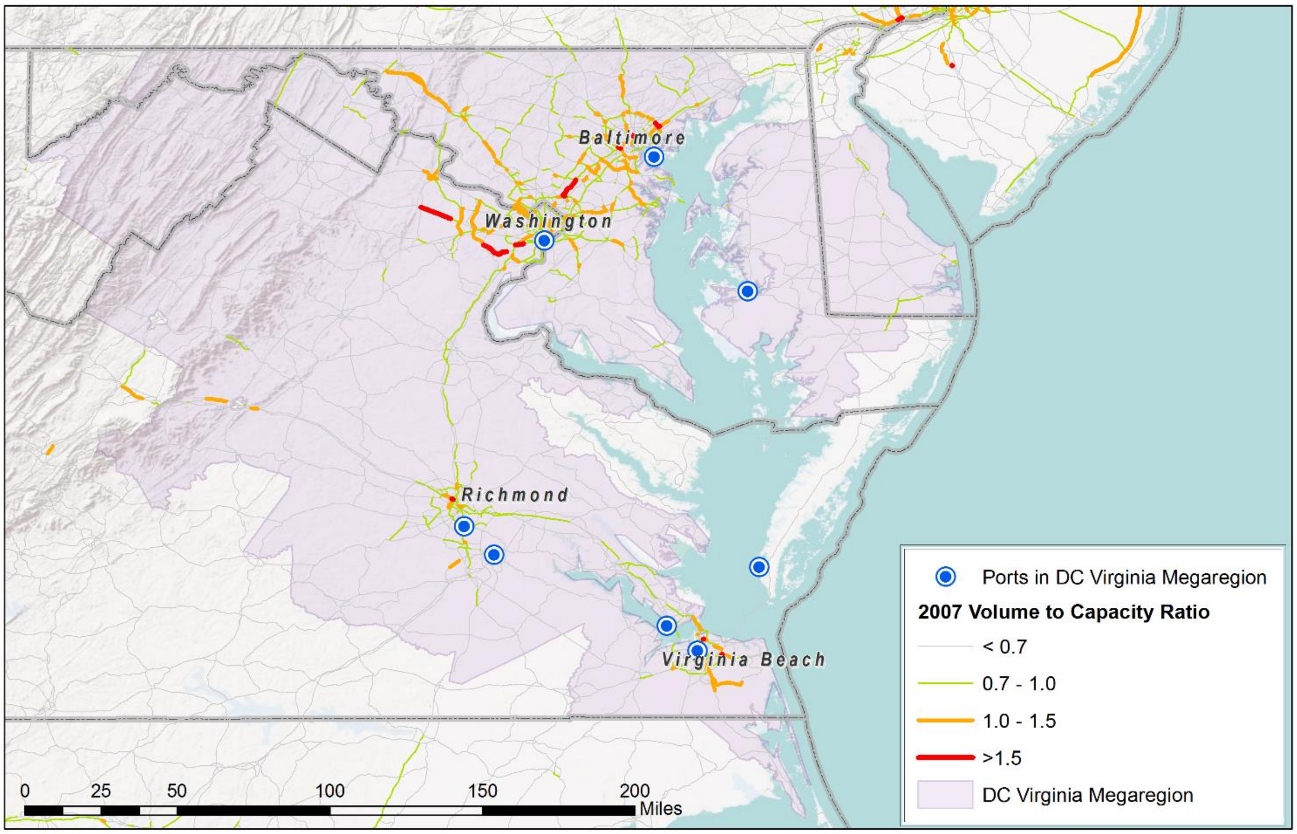
Rank	1	2	3	4	5	6	7	8	9	10
Route Name	I95	I695	I495	I81	I395	I270	I83	I70	I97	I595
Average Daily Truck Volume 2007	17,616	15,459	15,229	14,220	13,393	12,282	11,733	11,640	10,658	10,535
Average Daily Truck Volume 2040	31,995	25,151	26,240	31,126	22,742	20,391	19,479	19,761	17,077	17,580

Rank	11	12	13	14	15	16	17	18	19	20
Route Name	I295	S695	U50	U301	U15	I66	U40	U1	I64	I85
Average Daily Truck Volume 2007	10,379	9,258	9,092	8,407	8,151	8,128	7,709	7,548	7,548	7,505
Average Daily Truck Volume 2040	17,176	15,349	13,342	13,681	13,815	13,913	13,026	10,422	12,903	12,873

Source: FAF3

Volume to Capacity Ratio

Figure 33 maps the Volume to Capacity Ratio (VCR) for the DC-Virginia Megaregion and Figure 111 (see page 217 in Appendix 4) maps the forecasted VCR in year 2040. For 2007, most routes have a VCR less than 0.5, which indicates free flow. However, congestion in and around Washington DC and Baltimore is very severe, and there is also some congestion around Richmond and Norfolk. A VCR of 0.7 is a sign of the beginning of congestion, and a VCR over 1 indicates serious congestion. Figure 33 demonstrates the megaregion's serious congestion. The forecasted 2040 congestion implies that if there is no change to the existing condition, most arterials and the nearby major cities will be severely congested by 2040.

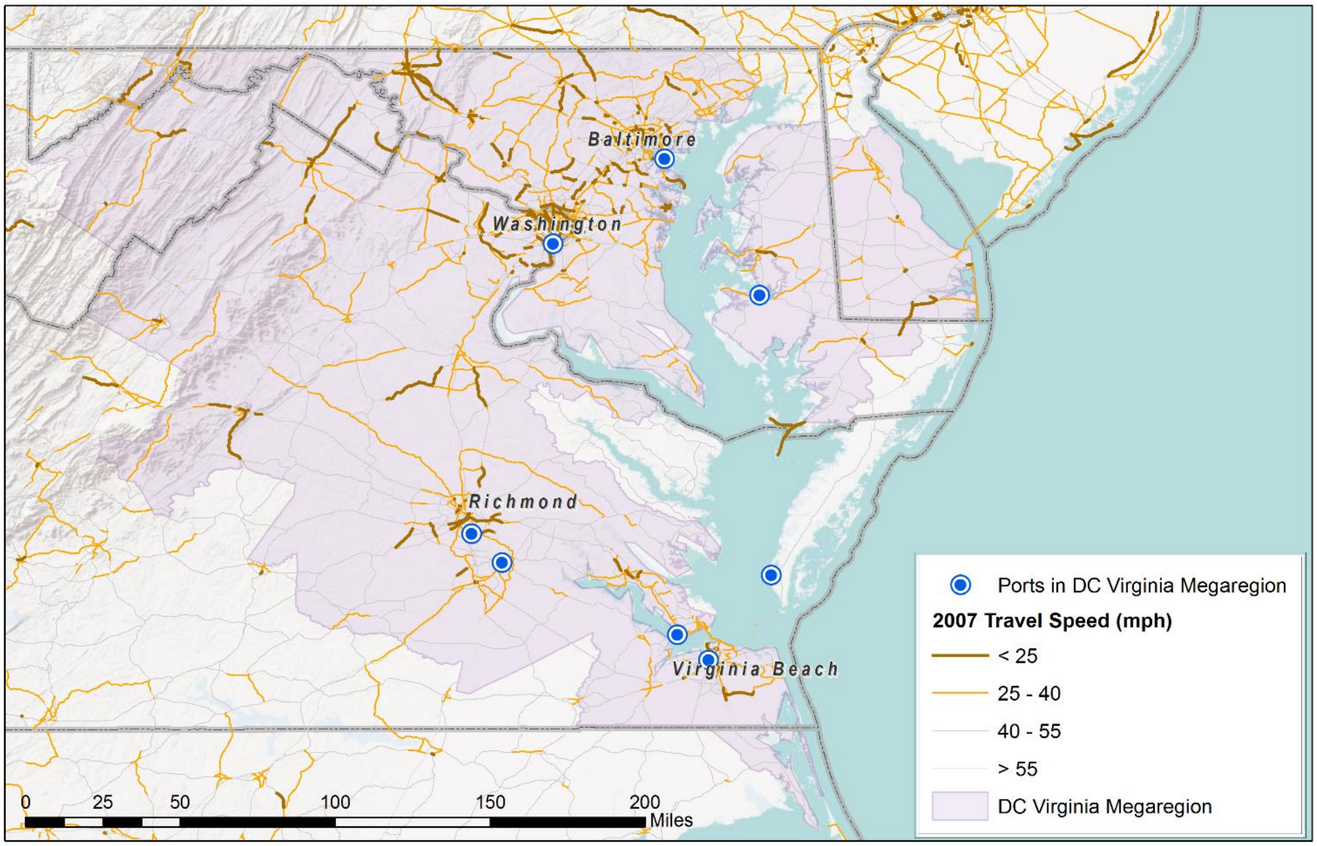


Data Source: FAF3 Network Database

Figure 33: Volume to Capacity Ratio along the Routes in DC-Virginia Megaregion

Average Travel Speed

Figure 34 shows the average travel speed in year 2007 for the DC-Virginia Megaregion and Figure 112 (see page 217 in Appendix 4) shows the forecasted condition in 2040. Currently, travel is very slow only on small road segments around Washington DC and at some intersections. However, projections show the megaregion transportation system near paralysis by 2040 without transformative action. Moreover, currently travel speeds on the routes linking to the Port of Norfolk are mostly between 25 and 40 mph, which is a sign of existing congestion. The 2040 forecasted map shows that nearly all the routes around the port will have a travel speed below 25 miles per hour.

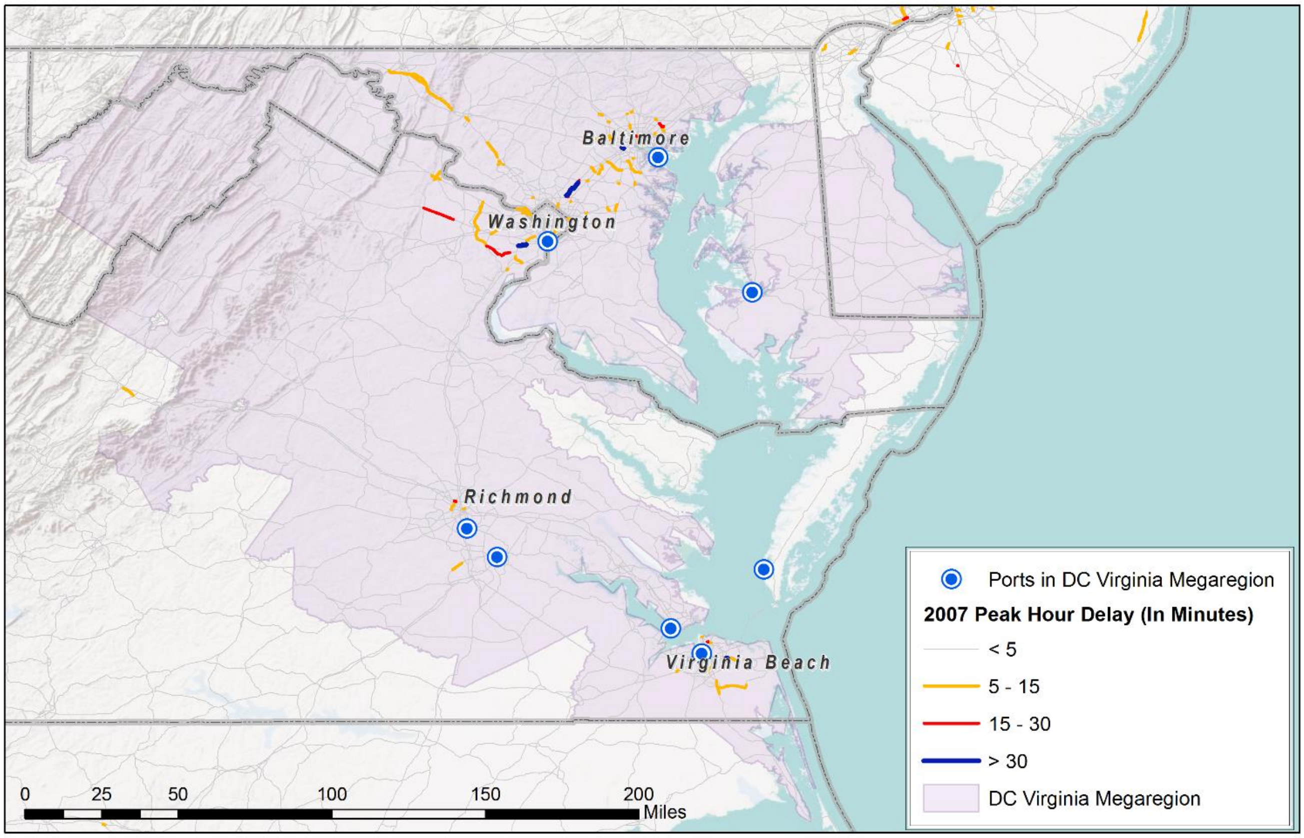


Data Source: FAF3 Network Database

Figure 34: Average Travel Speed in DC-Virginia

Peak Hour Travel Delay

Figure 35 shows the peak hour travel delay in minutes for the DC-Virginia Megaregion, and Figure 113 (see page 218 in Appendix 4) shows the forecasted condition in 2040. As previously stated, peak hour travel delay is based on the extra time spent on travel per vehicle. Even when the present map only shows isolated delays, the total delay may be very significant due to high traffic volume. The 2040 map shows that the whole megaregion faces the challenge of great travel delay in 2040, when most routes would experience over 12 minutes of peak hour travel delay.



Data Source: FAF3 Network Database

Figure 35: Peak Hour Delay in Minutes in DC-Virginia

Industry Clustering

Determining industrial specializations in a region can uncover the underlying economic drivers of freight movement. Industries that are clustered in a region typically indicate export economies which bring in money from outside of the region. The assumption is that highly clustered industries produce more of a good or service than what is demanded locally. One method to pinpoint industrial clustering is to compare location quotients across industries. A location quotient measures an industry's share of regional employment compared to its share of national employment.

County-level employment in the DC-Virginia, Piedmont Atlantic, and Texas Triangle Megaregions was analyzed to determine locations in each that had significant industrial clustering and to determine the strongest industries in the megaregion compared with employment in the rest of the country. According to the Bureau of Labor Statistics (2005), "location quotients are ratios that compare the concentration of a resource or activity, such as employment, in a defined area to that of a larger area or base." When the base is the entire United States, a location quotient greater than 1 indicates that a county has a higher ratio of employment in a given industry than the nation as a whole, whereas a location quotient below 1 indicates a lower employment ratio than the nation as a whole. Location quotient measures account for population size to ensure that clustering reflects industrial strengths beyond those inherent to any location with a large population. They treat counties of any population identically.

A location quotient database was developed from the Bureau of Labor Statistics location quotient calculator located at http://data.bls.gov/location_quotient/ControllerServlet for year 2012 with "U.S. Total" as the base area. It used sector industry groups defined by two-digit North American Industry Classification System (NAICS) codes. See Appendix 1 for the codes with brief definitions from the U.S. Census Bureau.

A database of county-level location quotients by two-digit industry sector was developed for the DC-Virginia, Piedmont Atlantic, and Texas Triangle Megaregions. Each county location quotient was aggregated into a megaregion location quotient by weighting each county by its population. It is important to weigh the location quotients by population to gain a more accurate understanding of the megaregion because counties vary significantly in geographic, economic, and demographic size even within one state. For example, The Bureau of Labor Statistics treats independent municipalities as counties, thus producing data for a series of small areas that would otherwise have the same influence on megaregion statistics as much larger and more populous areas if the location quotients were not weighted by population. An aggregate location quotient for each megaregion and each industry sector was developed and imported into ArcGIS for spatial analysis.

Piedmont Atlantic Megaregion

The Piedmont Atlantic Megaregion is a diverse megaregion that stretches along the I-85, I-20, and related corridors from eastern North Carolina to central Tennessee and Alabama. Certain industries are unusually present in the megaregion compared with other locations and other megaregions.

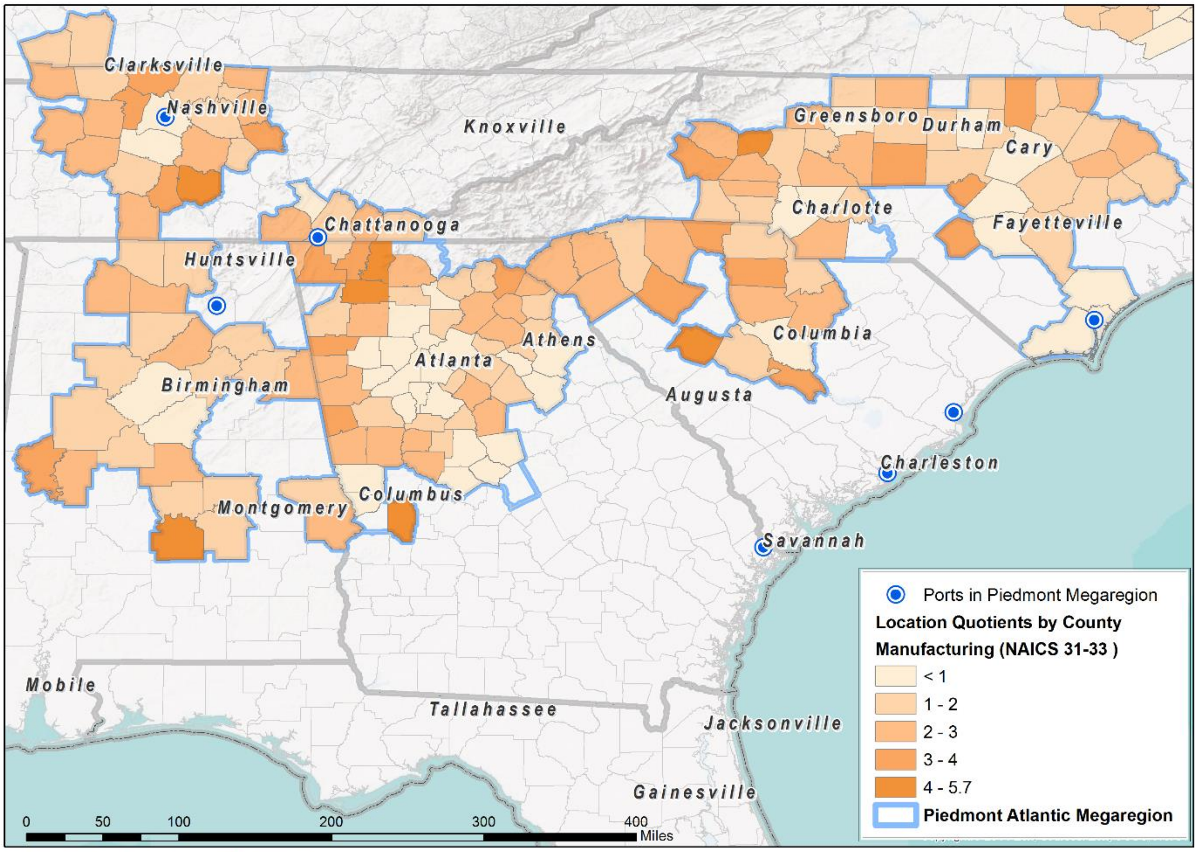
Table 15 ranks the industries in the Piedmont Atlantic Megaregion by location quotient from most to least productive. Location quotients above 1 indicate a relative industrial concentration and location quotients below 1 indicate a less representation of the industry than in the nation as a whole.

Table 15: Piedmont Atlantic Industries, Ordered by Location Quotient

Base Industry: Total, all industries	Location Quotient
NAICS 31-33 Manufacturing	1.62
NAICS 11 Agriculture, forestry, fishing and hunting	1.29
NAICS 48-49 Transportation and warehousing	1.18
NAICS 22 Utilities	1.13
NAICS 44-45 Retail trade	1.12
NAICS 23 Construction	1.05
NAICS 72 Accommodation and food services	1.04
NAICS 42 Wholesale trade	0.99
NAICS 56 Administrative and waste services	0.97
NAICS 62 Health care and social assistance	0.94
NAICS 55 Management of companies and enterprises	0.86
NAICS 51 Information	0.80
NAICS 54 Professional and technical services	0.79
NAICS 61 Educational services	0.78
NAICS 71 Arts, entertainment, and recreation	0.77
NAICS 52 Finance and insurance	0.75
NAICS 53 Real estate and rental and leasing	0.73
NAICS 81 Other services, except public administration	0.73
NAICS 21 Mining, quarrying, and oil and gas extraction	0.47

The industries most clustered in the Piedmont Atlantic Megaregion depend heavily on transporting physical goods, transforming raw and semi-processed materials, and natural resources. Resource intensive industries include the three industries with the highest megaregion location quotient: NAICS 31-33 (manufacturing), NAICS 11 (agriculture, forestry, fishing and hunting), and NAICS 48-49 (transportation and warehousing). However, other resource intensive industries are not common in Piedmont Atlantic, notably NAICS 21 (mining, quarrying, and oil and gas extraction). NAICS 21 has the megaregion's lowest location quotient.

NAICS 31-33 (manufacturing) has the megaregion's highest location quotient, which attests to a long-term trend of manufacturing growth. Manufacturing is prominent throughout the megaregion. However, unlike past manufacturing trends concentrated in cities, manufacturing in the Piedmont Atlantic Megaregion is disproportionately suburban and rural. While the counties containing Atlanta, Birmingham, Nashville, Charlotte, Raleigh, Durham, and Columbia all have low location quotients for manufacturing, the surrounding suburbs and interconnecting rural areas are much higher. This does not necessarily mean that manufacturing is necessarily less present in cities in an absolute sense, but rather than it is much less prevalent in large cities per capita than in rural areas. Figure 36 shows the Piedmont Atlantic location quotients for manufacturing.



Data Source: American Census Bureau 2012

Figure 36: Location Quotients for NAICS 31-33 / Manufacturing

While NAICS 11 (agriculture, forestry, fishing and hunting) appears to have a high location quotient in Piedmont Atlantic, it is really much lower than it appears because many county values were “not calculable” or “not disclosable,” because they were so low. To be sure, there are rural areas with a high NAICS 11 location quotient in Piedmont Atlantic, but the megaregion as a whole does not have as high a NAICS 11 location quotient as it appears. Figure 94 in Appendix 1 shows the areas with a high NAICS 11 location quotient.

NAICS 48-49 (transportation and warehousing) is the next highest location quotient in the Piedmont Atlantic Megaregion, which reinforced work by Dablanc and Ross (2012) describing the megaregion’s logistics hub. Many of the areas with high NAICS 48-49 location quotients are along major roadway corridors, though to be sure not all counties along major highways have highly concentrated logistics employment. In general, the most concentrated logistics employment is either in or around urban centers, or along the highways connecting them (Figure 95 in Appendix 1).

The Piedmont Atlantic Megaregion has a high location quotient for NAICS 22 (utilities), though in reality it may not be as high as it appears because of a large number of counties with “not calculable” or “not disclosable” quotients. Figure 96 in Appendix 1 shows the counties with the largest concentration of utility employment per capita.

Finally, Piedmont Atlantic has a large proportion of retail employment, which is NAICS 44-45. Retail is often highest per capita in the counties around the central city, whether the city is Nashville, Atlanta, Charlotte, or Durham. Retail is also spread very widely around the megaregion, which likely reflects the fact that retail serves local residents, which inhibits excessive retail clustering on a regional or megaregion scale. Figure 97 in Appendix 1 shows relative retail concentrations.

Texas Triangle Megaregion

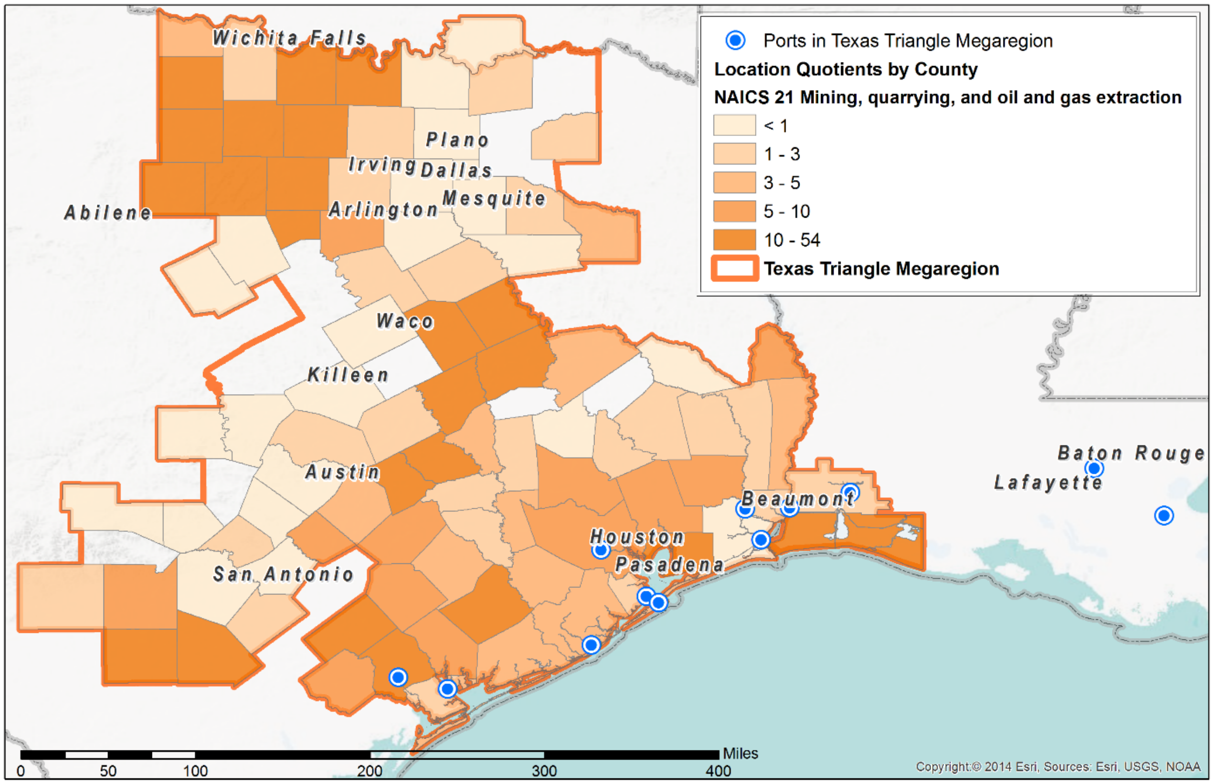
Texas Triangle’s location quotients reflect the concentration of different industries per capita compared with the rest of the country. Texas Triangle’s industrial concentrations differ significantly from those in DC-Virginia or Piedmont-Atlantic. Table 16 shows all location quotients in the Texas Triangle Megaregion in decreasing order. The lowest location quotients are NAICS 61 (educational services), NAICS 55 (management of companies and enterprises), and NAICS 11 (agriculture, forestry, fishing and hunting).

Table 16: Texas Triangle Location Quotients, Decreasing Order

Base Industry: Total, all industries	Location Quotient
NAICS 21 Mining, quarrying, and oil and gas extraction	3.34
NAICS 23 Construction	1.39
NAICS 53 Real estate and rental and leasing	1.18
NAICS 56 Administrative and waste services	1.09
NAICS 42 Wholesale trade	1.09
NAICS 22 Utilities	1.09
NAICS 52 Finance and insurance	1.06
NAICS 72 Accommodation and food services	1.06
NAICS 48-49 Transportation and warehousing	1.04
NAICS 54 Professional and technical services	1.04
NAICS 44-45 Retail trade	1.01
NAICS 31-33 Manufacturing	0.95
NAICS 51 Information	0.91
NAICS 62 Health care and social assistance	0.88
NAICS 81 Other services, except public administration	0.83
NAICS 71 Arts, entertainment, and recreation	0.75
NAICS 61 Educational services	0.68
NAICS 55 Management of companies and enterprises	0.66
NAICS 11 Agriculture, forestry, fishing and hunting	0.33

NAICS 21 (mining, quarrying, and oil and gas extraction) is by far the highest location quotient, at 3.34, which means that the industries are 3.34 times as concentrated in the Texas Triangle than in the nation as a whole. The high level of concentration speaks to the strength of the Texas Triangle’s energy sector. However, it is not spread evenly in the Texas Triangle. NAICS

21 activity is concentrated northwest of the Dallas-Fort Worth area, in the center (around Leon and Freestone Counties), and along the megaregion's southern edge. Figure 37 shows the activity concentrations.



Data Source: American Census Bureau 2012

Figure 37: NAICS 21 Activity in the Texas Triangle

NAICS 23 (construction), whose location quotient is 1.39, is the second most concentrated industry in Texas Triangle. It is spread more evenly throughout the country, as visible in Figure 98 in Appendix 1.

Finally, NAICS 53 (real estate and rental and leasing) is the third highest location quotient in the Texas Triangle (location quotient of 1.18). NAICS 53 activity is spread in all parts of the megaregion, with some concentrations in or adjacent to the cities of Dallas (Dallas County), Kileen (Bell County), Houston (Harris County) and San Antonio (Bexas County) (see Figure 99 in Appendix 1).

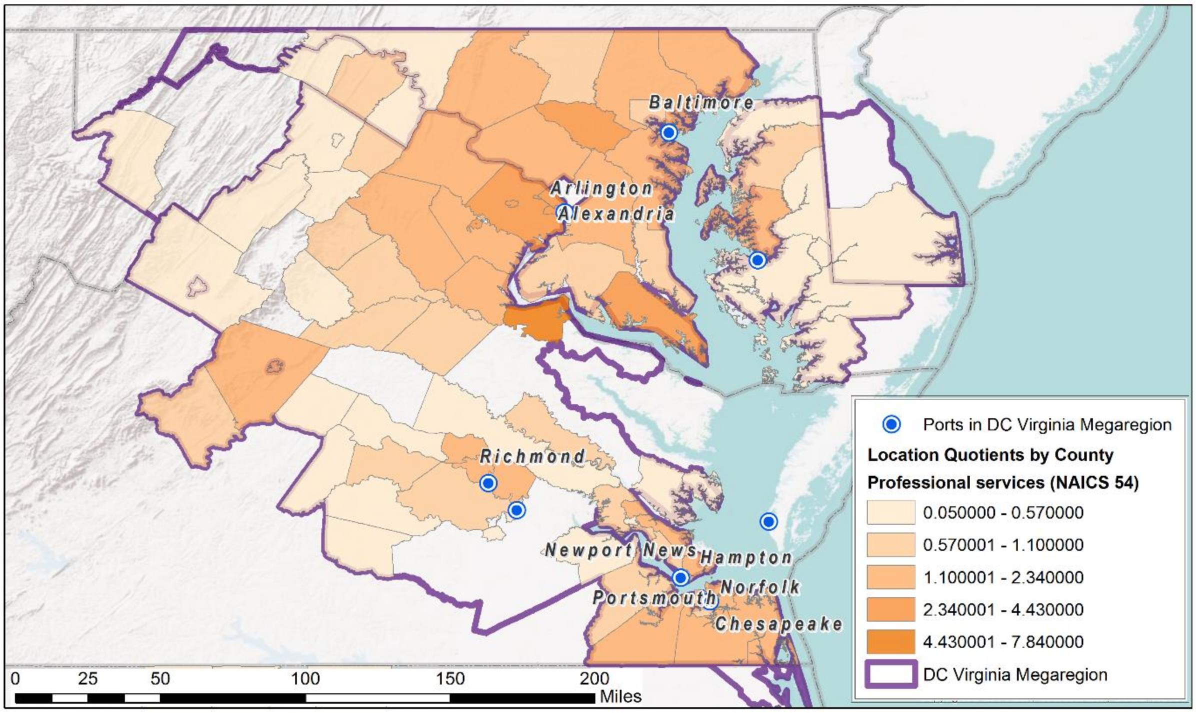
DC-Virginia Megaregion

Two of the three most concentrated industries in DC-Virginia are service and knowledge oriented, whereas the least prominent industries are NAICS 21 (mining, quarrying, and oil and gas extraction) and NAICS 11 (agriculture, forestry, fishing and hunting), which are both natural resource intensive. These rankings by location quotient can be seen in Table 17 below, which list industries in DC-Virginia in ordered by an aggregate location quotient and weighted by county population.

Table 17: DC-Virginia Industries, Ordered by Location Quotient

Base Industry: Total, all industries	Location Quotient
NAICS 54 Professional and technical services	1.40
NAICS 61 Educational services	1.26
NAICS 23 Construction	1.09
NAICS 81 Other services, except public administration	1.04
NAICS 71 Arts, entertainment, and recreation	1.00
NAICS 99 Unclassified	0.95
NAICS 72 Accommodation and food services	0.91
NAICS 53 Real estate and rental and leasing	0.88
NAICS 44-45 Retail trade	0.88
NAICS 62 Health care and social assistance	0.81
NAICS 48-49 Transportation and warehousing	0.75
NAICS 55 Management of companies and enterprises	0.74
NAICS 51 Information	0.72
NAICS 56 Administrative and waste services	0.71
NAICS 52 Finance and insurance	0.68
NAICS 22 Utilities	0.66
NAICS 31-33 Manufacturing	0.58
NAICS 42 Wholesale trade	0.53
NAICS 11 Agriculture, forestry, fishing and hunting	0.26
NAICS 21 Mining, quarrying, and oil and gas extraction	0.16

NAICS 54 (professional and technical services) is the most concentrated industry with a location quotient of 1.40. It is most concentrated in the District of Columbia as well as the surrounding counties. Secondary concentrations are in the areas around Hampton Roads, Richmond, and Charlottesville, VA; and Baltimore County, Montgomery County, and Frederick County, MD. Figure 38 below shows the concentration of NAICS 21.



Data Source: American Census Bureau 2012

Figure 38: Location Quotients for NAICS 54 / Professional Services

NAICS 61 (educational services) is the second strongest industry cluster in DC-Virginia with a location quotient of 1.26. Its location quotient is highest in rural counties including Rockingham County and Madison County, VA; and Jefferson County and Winchester, WV; as well as the District of Columbia and Baltimore, MD. However, there are also more diffuse educational service clusters around the Washington DC metro area, Greater Richmond, Charlottesville, and Hampton Roads, VA. Figure 100 in Appendix 1 shows NAICS 61 concentrations.

Neither of the two largest concentrations in DC-Virginia will require significant amounts of freight movement as they mostly deliver information and services. By contrast, NAICS 23 (construction) is the third most prominent industry, and it would likely generate large amounts of freight movement. Construction is most concentrated in rural and semi-rural counties, including Powhatan, New Kent, Fauquier, Prince William, VA; and George's County, MD, visible in Figure 101 in Appendix 1.

Policy Implications

Each megaregion has its unique major contributors to regional economies. Industry clusters refer to spatial concentrations of interconnected companies, service providers, and firms in related industries, and associated institutions that compete but also cooperate. Clusters reflect a region's competitive advantage for a particular industry. Industry clusters are intended to provide background for the truck movements described in this report by revealing the industries that drive freight movement. Most industries require physical materials for manufacturing, processing, or sale. Many industries also produce commodities for exports. Freight transportation connects each of these steps.

Understanding spatial and economic inter-connectedness will help policymakers to establish goals for necessary transportation infrastructure, other support infrastructure (e.g., telecommunications), and regulatory and administrative supports. Importantly, industrial clustering identifies economic strengths and begins to frame the basis for a strategy aimed at enhancing and expanding economic efficiencies by identifying future opportunities tied to existing capabilities and projected growth.

The location quotient approach used in this section is just a first step. Further analyses to explore a full spectrum of megaregions' industry clustering are needed. Policies should consider various factors such as a shared labor pool, knowledge spillover and information exchange, a combination of capital pool, and the networking relationships the firms have in the regional economy which will drive industry clustering and agglomeration of economy with expected benefits which include cost savings, increased revenues, knowledge spillover, and risk sharing.

Warehouse and Distribution Center Locations

Warehouses and distribution centers are facilities that process freight flows to prepare them for onward movement. They perform functions that support distribution including storage, breaking down shipments, matching supply to demand, packaging shipments, and shipping to stores and customers. Many companies involved in distributing goods operate warehouses or distribution centers to prepare and process those goods. The distinction between a warehouse and a distribution center relates more to function than form. The two may be indistinguishable physically, but distribution centers focus on processing goods and preparing them for shipment whereas warehouses are used for storage. Stored inventories allow customers to meet demand by ensuring that there will be an adequate supply available at the right time. Just-in-time logistics has allowed companies to de-emphasize on-site inventory.

It is important to understand where warehouses and distribution centers are located because they attract, produce, and facilitate freight traffic. Distribution centers shape freight flows between producers, ports, stores, consumers, and other parts of the supply chain. This section analyzes distribution center locations to understand freight dynamics.

The research team analyzed warehouse and distribution center locations for the DC-Virginia, Piedmont Atlantic, and Texas Triangle Megaregions. County-level data was used for the number of warehouse and distribution center establishments in each county provided by the U.S. Census Bureau’s North American Industrial Classification System (NAICS) codes. NAICS code 493 corresponds with warehousing and storage, which the U.S. Census Bureau describes as follows.

> *“Industries in the Warehousing and Storage subsector are primarily engaged in operating warehousing and storage facilities for general merchandise, refrigerated goods, and other warehouse products. These establishments provide facilities to store goods…. They may also provide a range of services, often referred to as logistics services, related to the distribution of goods. Logistics services can include labeling, breaking bulk, inventory control and management, light assembly, order entry and fulfillment, packaging, pick and pack, price marking and ticketing, and transportation arrangement.”* (U.S. Census Bureau, 2012).

The following section describes distribution center and warehouse locations for each megaregion. Because the data does not distinguish distribution centers from warehouses, the word distribution center is used to encompass both functions.

Piedmont Atlantic Megaregion

The Piedmont Atlantic Megaregion’s most concentrated distribution center cluster is in the Atlanta region, which has 329 warehouses and distribution centers in a 25 mile radius from the city center. This is 2.33 times as many as the next densest cluster around Charlotte, NC. Most Atlanta-area distribution centers are fairly clustered in metro Atlanta including the central counties of DeKalb and Fulton. There is a smaller number of distribution centers in counties between 25 and 50 miles from the city center.

Charlotte is also a significant distribution cluster. Charlotte has 141 distribution centers in counties within a 25-mile radius from downtown. However, it is also near the center of a larger cluster that is within 100 miles, concentrated along the I-85, I-40, and I-26 corridors and including places like Greenville, SC and Greensboro, NC.

Figure 39 shows that Nashville has the third largest distribution center concentration. Unlike Charlotte, Nashville has few distribution centers in the broader region. Chattanooga, TN; Birmingham, AL; and Columbia, SC are among the smallest distribution center hubs. While Chattanooga has few distribution centers with 25 miles, its large 100-mile region includes parts of Atlanta, Nashville, and rural Tennessee, each with many distribution centers and which give Chattanooga 588 distribution centers in a 100 mile radius. Chattanooga is an example of a place with relatively little local distribution activity but which is still very well connected to larger distribution networks. Figure 39 below gives a complete list of distribution centers in some of Piedmont Atlantic's key clusters. Table 65**Error! Reference source not found.** and Source: Center for Quality Growth and Regional Development, U.S. Census Bureau, County Business Patterns, 2011

Table 66 in Appendix 3 detail metropolitan region-level distribution centers.

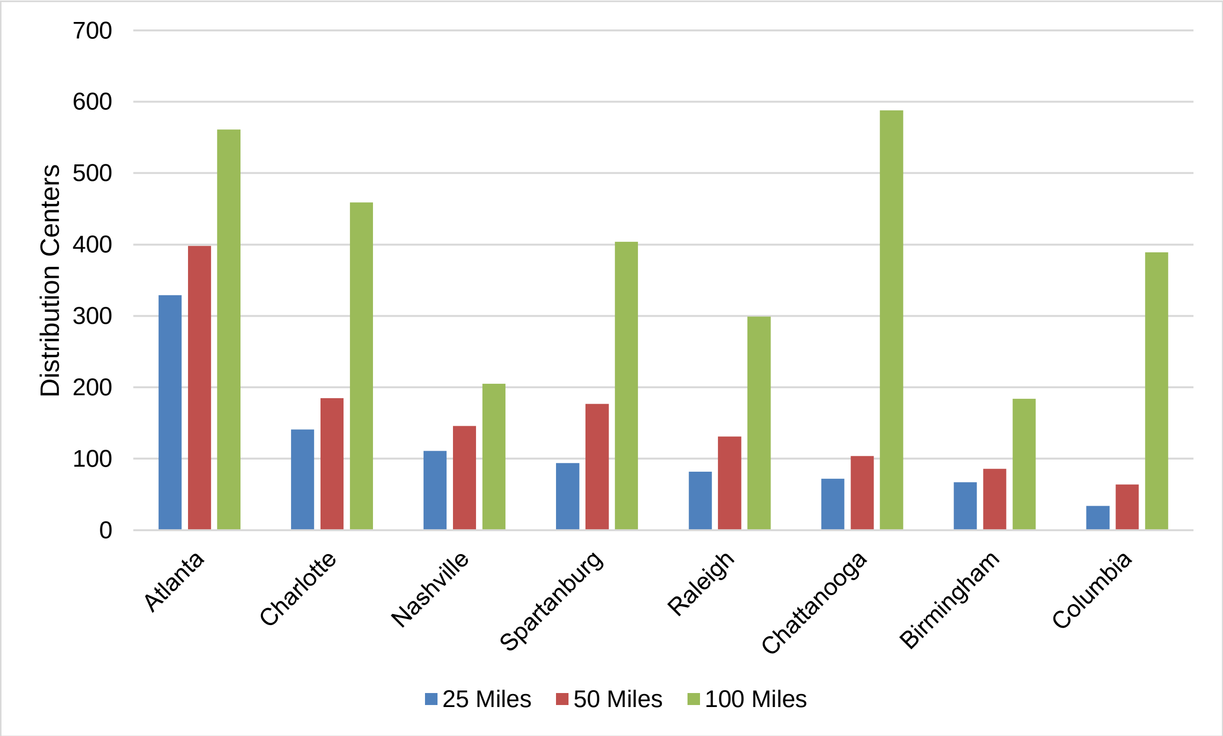
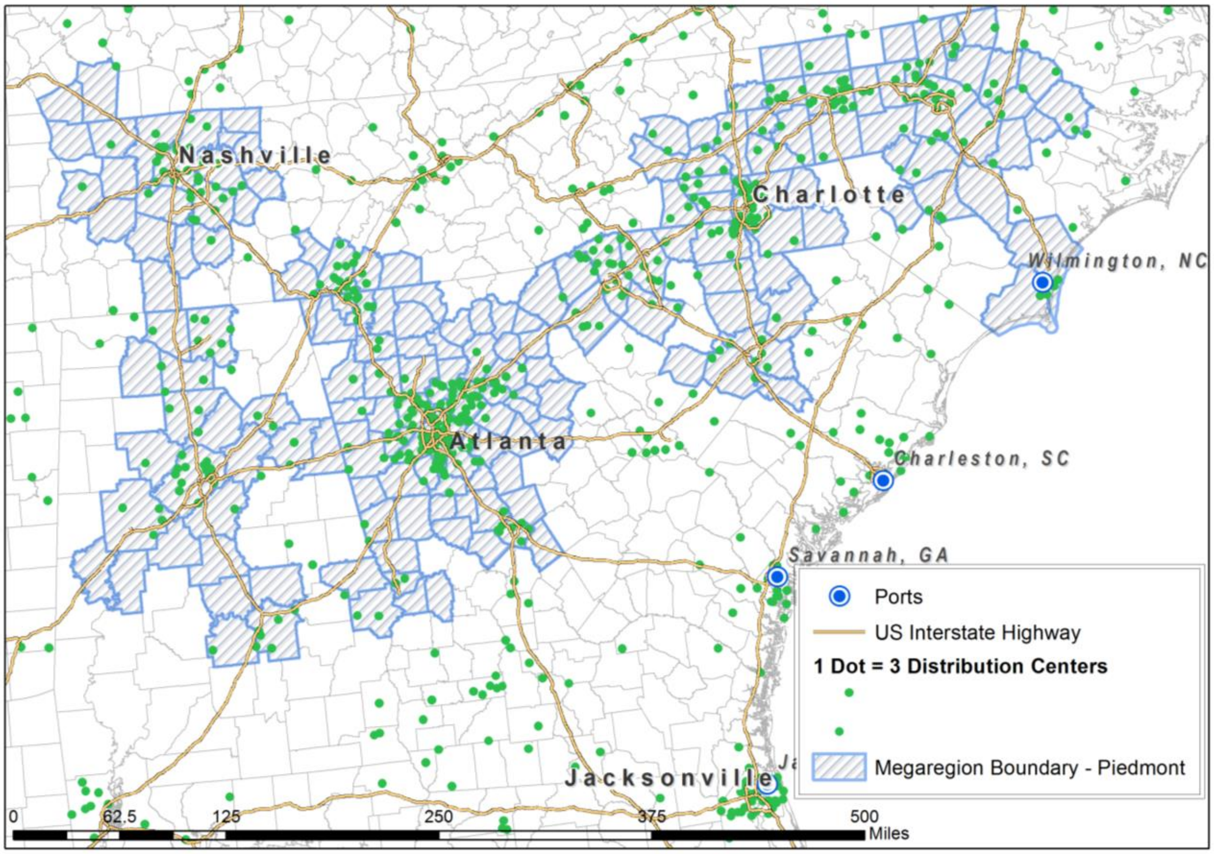


Figure 39: Piedmont Atlantic Megaregion Distribution Centers by Proximity to Cities

Source: Center for Quality Growth and Regional Development, U.S. Census Bureau, County Business Patterns, 2011

Piedmont Atlantic's distribution centers cluster around major cities and transportation infrastructure intersections. The greatest number of warehouses are around cities such as Atlanta, Charlotte, Nashville, and Spartanburg that are at state and interstate highway intersections. Some of these locations also provide nearby commercial airport access. A smaller number of distribution centers cluster around highway corridors or in counties without interstate access. Figure 40 shows Piedmont Atlantic distribution center locations where each dot equals one distribution center.



Data Source: American Census Bureau 2012

Figure 40: Piedmont Atlantic Distribution Centers

Source: Center for Quality Growth and Regional Development, U.S. Census Bureau, County Business Patterns, 2011

Texas Triangle Megaregion

Texas Triangle's distribution centers cluster around major metro regions and highway intersections. With 340 distribution centers within a 25-mile radius of Dallas, the Dallas-Fort Worth area has the largest concentration of distribution centers, more than any other metro area in the Texas Triangle, Piedmont Atlantic or DC-Virginia. Houston is the second largest concentration, with 245 distribution centers if a 25-mile radius. San Antonio and Austin each have fewer than 70 distribution centers in 25 miles, which makes them among the smallest concentrations of any of the megaregions examined.

Compared with Piedmont Atlantic, Texas Triangle's distribution centers are more concentrated around just a couple of metro regions, particularly Dallas and Houston. By comparison, Piedmont Atlantic has a larger number of cities with sizable distribution center concentrations. However, Texas Triangle's distribution centers are more tightly clustered. As Figure 41 shows, the vast majority of the distribution centers around Dallas and Houston are within a 25 mile radius. This compares with places like Spartanburg, SC and Martinsburg, WV where the 50 mile radius had many more distribution centers than the 25 mile radius, and with places like Charlotte, Chattanooga, and Columbia where the 100 mile radius has several times more distribution centers than the 25 mile radius. This is partially due to the fact that the clusters themselves are more widely spaced in the Texas Triangle, such that a 100 mile radius does introduce onto a separate cluster except for San Antonio and Austin. In Piedmont Atlantic and DC-Virginia, distribution center clusters are very often close enough to blend (e.g., Washington DC and Baltimore), or where they are captured in a 100-mile radius.

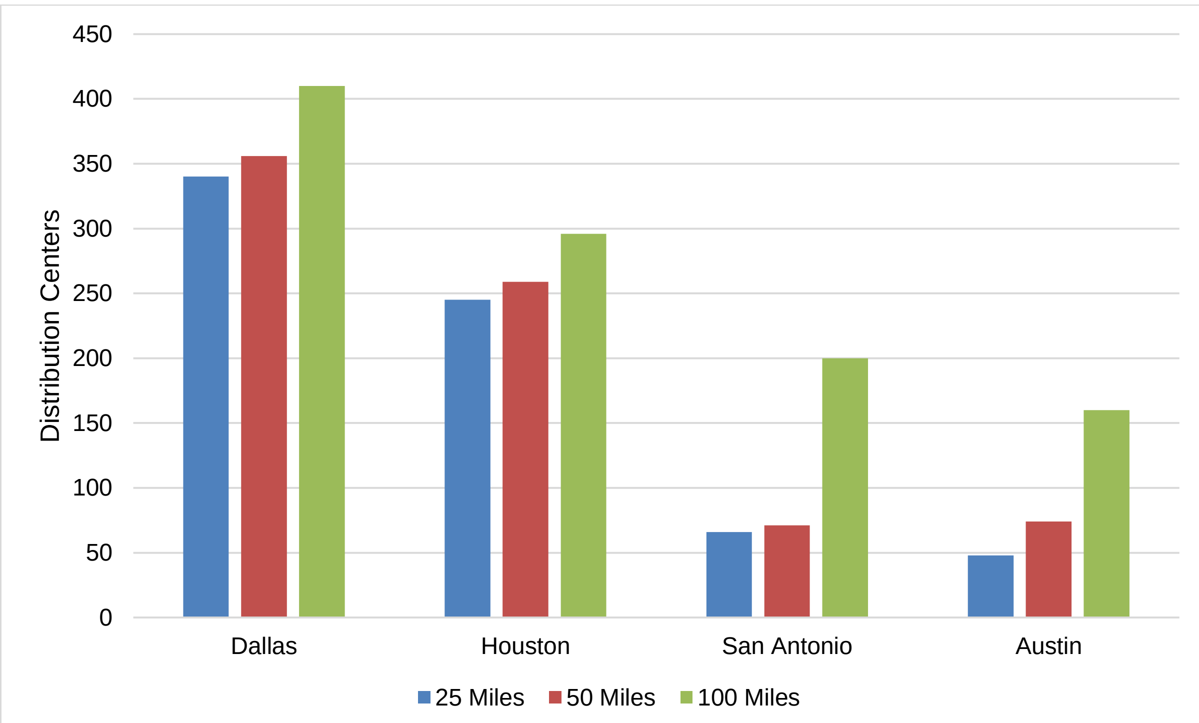


Figure 41: Texas Triangle Distribution Centers by Proximity to Cities

Source: Center for Quality Growth and Regional Development, U.S. Census Bureau, County Business Patterns, 2011

Figure 42 shows the county-level locations of distribution centers in the Texas Triangle. Outside of the clusters in the major cities, the I-35 corridor between San Antonio and Dallas has attracted a large number of distribution centers, as has I-10, in some cases east of Houston. Source: Center for Quality Growth and Regional Development, U.S. Census Bureau, County Business Patterns, 2011

Table 67 and Table 68 in Appendix 3 also detail metropolitan region-level distribution centers.

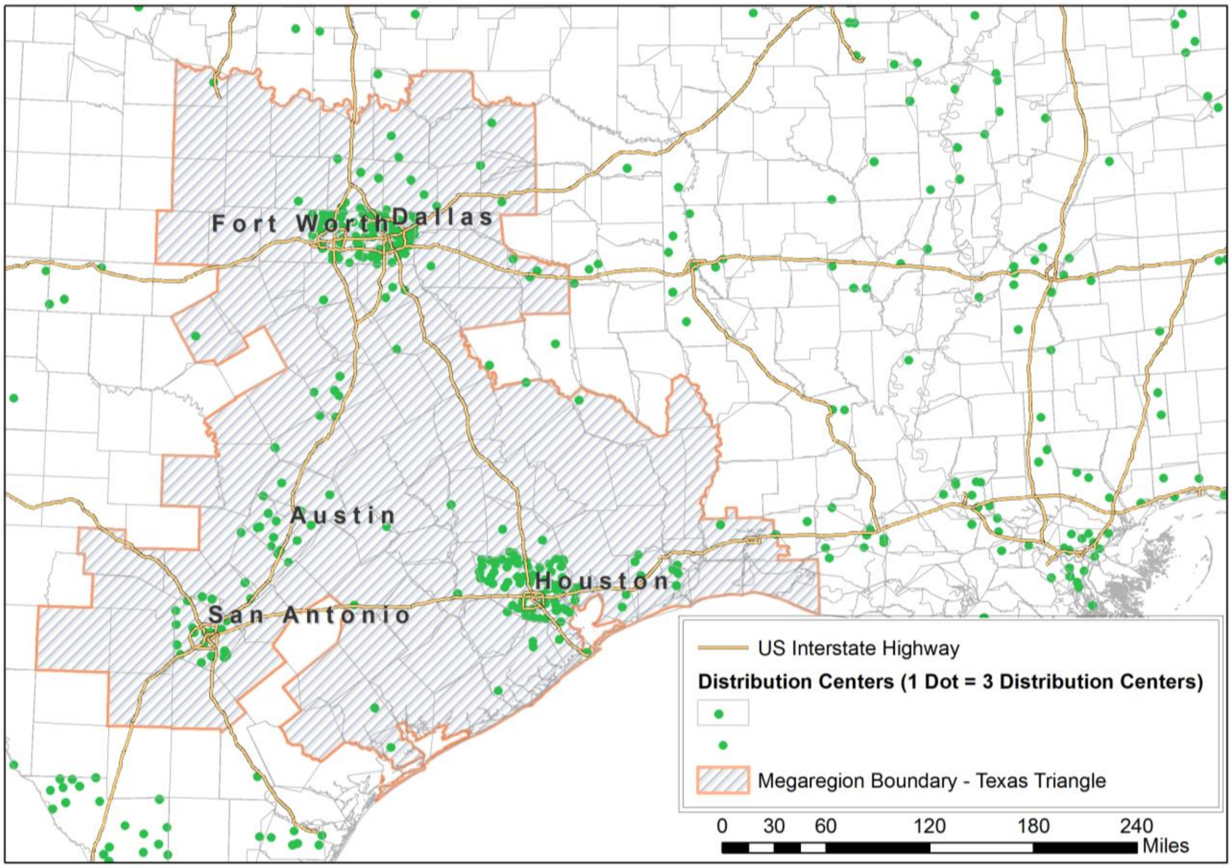


Figure 42: Texas Triangle Distribution Centers

Source: Center for Quality Growth and Regional Development, U.S. Census Bureau, County Business Patterns, 2011

DC-Virginia Megaregion

The DC-Virginia Megaregion is at the southern end of an intensive distribution center cluster in the northeastern United States. As visible in Figure 43 below, Baltimore and Washington DC have the megaregion's highest cluster of distribution centers in a 25-miles radius of the city. Many of the distribution centers in eastern Pennsylvania are within a 100-miles radius of these two cities, which accounts for the much of the jump in the number of distribution centers between a 50-mile radius and a 100-mile radius. For example, Baltimore has 374 distribution centers in a 50-mile radius, but 849 in a 100-mile radius.

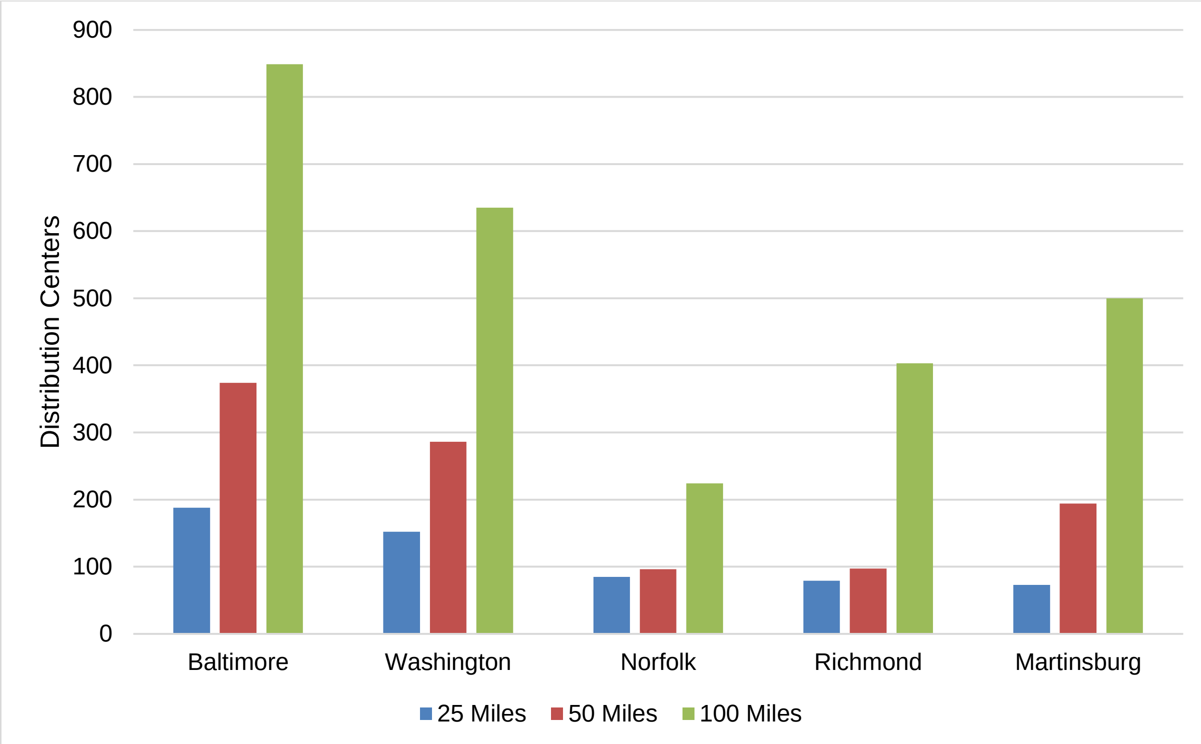


Figure 43: DC-Virginia Distribution Centers by Proximity to Cities

Source: Center for Quality Growth and Regional Development, U.S. Census Bureau, County Business Patterns, 2011

The megaregion's second largest distribution center hub is the Hampton Roads area. There are 85 distribution centers within a 25-mile radius of Norfolk, with a major concentration in nearby Chesapeake, VA. The distribution center density is likely related to the Hampton Roads area's ports in Norfolk, Portsmouth, and Newport News.

Richmond is another concentration of distribution centers, although slightly smaller than the Hampton Roads area. Finally, there are additional distribution centers sparsely arranged in western Maryland, southern Delaware, and eastern West Virginia. Many are located along state and interstate highways, such as I-70 and I-81, both of which pass through Hagerstown, MD, and US-13 in Delaware. Figure 44 shows all distribution centers in the DC-Virginia Megaregion, where each dot represents one distribution center in that county. A dot's location does not necessarily represent its location within the county. Table 69 and Table 70 in Appendix 3 also detail metropolitan region-level distribution centers.

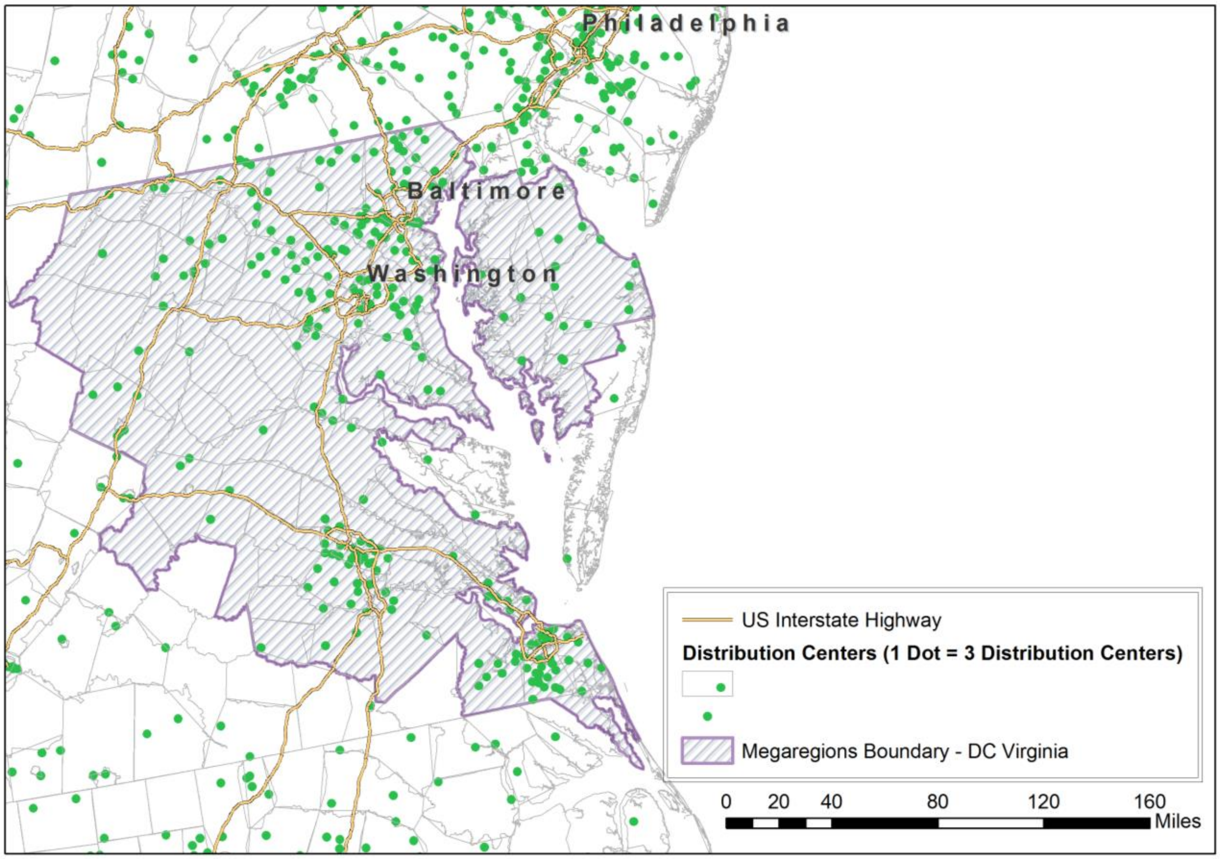


Figure 44: DC-Virginia Distribution Centers

Source: Center for Quality Growth and Regional Development, U.S. Census Bureau, County Business Patterns, 2011

DC-Virginia's spatial arrangement of distribution centers more closely resembles the Piedmont Atlantic than Texas Triangle. Distribution centers are only loosely clustered around cities and highway intersections. In some cases, the clusters blend together, and there is a greater number of distribution centers along rural highway corridors. For example, distribution centers in northern Virginia and central Maryland form a large cluster with no clear boundaries and that blends with the Northeast Megaregion. This contrasts with the much more spatially distinct pattern in the Texas Triangle.

Policy Implications

Understanding where distribution centers are concentrated today and where they are likely to be built in the future can help identify freight corridors and transportation infrastructure in need of investment. Distribution centers operate as company-specific freight hubs. Counties with high numbers of distribution centers are likely to experience significant and sustained inbound and outbound truck traffic. Counties with a trend of increasing distribution centers will likely generate more freight traffic in the future. Planners and policymakers should consider distribution center locations when prioritizing transportation investment to more efficiently allocate funds and strengthen regional economies.

Planners may also want to consider distribution center locations in freight demand models. Freight modeling includes identifying special districts that generate disproportionate amounts of traffic. Using the distribution center clusters to delineate special districts can improve model accuracy.

Future distribution center locations are highly related to zoning and land use regulations. These regulations are handled at the local level while major transportation investments are determined by larger political entities. There is potential for a mutually beneficial partnership between local land use officials, and regional, state, or eventually megaregion transportation planners to ensure that the transportation facilities and zoning regulations are complementary to maximize freight efficiency and transportation spending's return on investment. Location analyses for newly planned facilities should be conducted strategically in conjunction with formulating regional industry clustering policies.

There is also a need for further in-depth analyses. For example, categorizing distribution centers by commodity types can be useful connecting with state/regional multimodal plans to avoid unnecessary congestion, improve safety, and minimize environmental externalities which are expected from massive increases in freight movements.

Commodities Distributions of the Megaregions

Many economic effects of freight movement are related to the commodity types being transported rather than the truck movement itself. Truck movements supply different industries with commodities for their operations. Even when observed truck movement data is available, as it is in this study in the form of GPS-derived data, the commodities inside each truck normally remain opaque to researchers. This section benchmarks commodity imports through American ports into the Piedmont Atlantic, DC-Virginia, and Texas Triangle Megaregions to provide a context for understanding port-related truck movement in Section V and economic impact in Section VII.

FAF3 Data Structure and Processing

The Freight Analysis Framework (FAF3) database and flow assignment was used to estimate imports destined for the Piedmont Atlantic, DC-Virginia, and Texas Triangle Megaregions in 2007 and 2040. The Freight Analysis Framework provides estimates for 2007, 2015, and 2040 freight traffic into and out of geographically defined FAF3 regions. There are 123 domestic regions and 8 foreign regions, which are continental or sub-continental in scale (Federal Highway Administration, 2012). As such, the freight analysis framework estimates domestic freight movements by commodity tonnage and value, as well as imports and exports. FAF3 includes six modes of transportation: truck, rail, water, air, intermodal (except air-truck), and pipeline. FAF3 accounts for 42 commodity types. The commodity names are listed in Table 18. Outside of the table, commodities are referenced by a partial name for ease of reading rather than the complete name or the commodity code.

Table 18: FAF3 Commodities

SCTG Code	Commodity Description
1	Live animals and live fish
2	Cereal grains
3	Other agricultural products
4	Animal feed and products of animal origin, n.e.c.
5	Meat, fish, seafood, and their preparations
6	Milled grain products and preparations, bakery products
7	Other prepared foodstuffs and fats and oils
8	Alcoholic beverages
9	Tobacco products
10	Monumental or building stone
11	Natural sands
12	Gravel and crushed stone
13	Nonmetallic minerals n.e.c.
14	Metallic ores and concentrates
15	Coal
16	Crude petroleum
17	Gasoline and aviation turbine fuel
18	Fuel oils
19	Coal and petroleum products, n.e.c.* (includes Natural gas)
20	Basic chemicals
21	Pharmaceutical products

SCTG Code	Commodity Description
22	Fertilizers
23	Chemical products and preparations, n.e.c.*
24	Plastics and rubber
25	Logs and other wood in the rough
26	Wood products
27	Pulp, newsprint, paper, and paperboard
28	Paper or paperboard articles
29	Printed products
30	Textiles, leather, and articles of textiles or leather
31	Nonmetallic mineral products
32	Base metal in primary or semi-finished forms and in finished basic shapes
33	Articles of base metal
34	Machinery
35	Electronic and other electrical equipment and components and office equipment
36	Motorized and other vehicles (including parts)
37	Transportation equipment, n.e.c.*
38	Precision instruments and apparatus
39	Furniture, mattresses and mattress supports, lamps, lighting fittings, and illuminated signs
40	Miscellaneous manufactured products
41	Waste and scrap
43	Mixed freight
99	Commodity unknown

*n.e.c. = not elsewhere classified

FAF3 zones were aggregated to approximate core megaregion areas. It is necessary to approximate megaregion boundaries since FAF3 regions and megaregion boundaries do not align exactly. This study focuses on the Panama Canal expansion's influence on imports. Therefore, the FAF3 data was carefully processed to pick out the commodities imported through a gateway by water and transported into each of the three megaregions. Imports include both foreign imports into ports in the megaregion being considered and other ports in other megaregions and in non-megaregion areas.

Piedmont Atlantic Megaregion Imported Commodities

While the Piedmont Atlantic Megaregion contains few major ports inside its boundaries, the ports of Charleston and Savannah are two of the largest nearby deep-water ports. This used import gateways in the coastal Piedmont Atlantic states, namely Georgia, South Carolina, and North Carolina.

The Georgia Statewide Freight and Logistics Plan benchmarks state-level commodity movement. The Georgia Department of Transportation found that nonmetallic minerals, movement to and from warehouses and distribution centers (i.e., “secondary traffic”), and clay/concrete/glass/stone are the largest commodity movements in Georgia. These commodity types tend to be moved short distances. For medium- and long-distance truck movements, farm and food-related products, and transportation equipment are Georgia’s largest commodity categories (Georgia Department of Transportation, 2013c).

Figure 45 shows the distribution of commodities by SCTG commodity classifications imported to the Piedmont Atlantic Megaregion in 2007 and the projected distribution and total volume for year 2040. The top imports for both year 2007 and 2040 are fuel oils, nonmetallic minerals, gasoline, pharmaceutical products, and textile products. Comparing the distribution of commodities in 2007 and 2040 reveals that logs and wood, and coal imports into the Piedmont Atlantic Megaregion will likely decrease, while volumes of base metal and precision instruments imports are projected to grow. The total tonnage of commodities imported through the coastal ports will grow by 150%, as projected by the FAF3 data, even without assuming there is impact from the Panama Canal expansion.

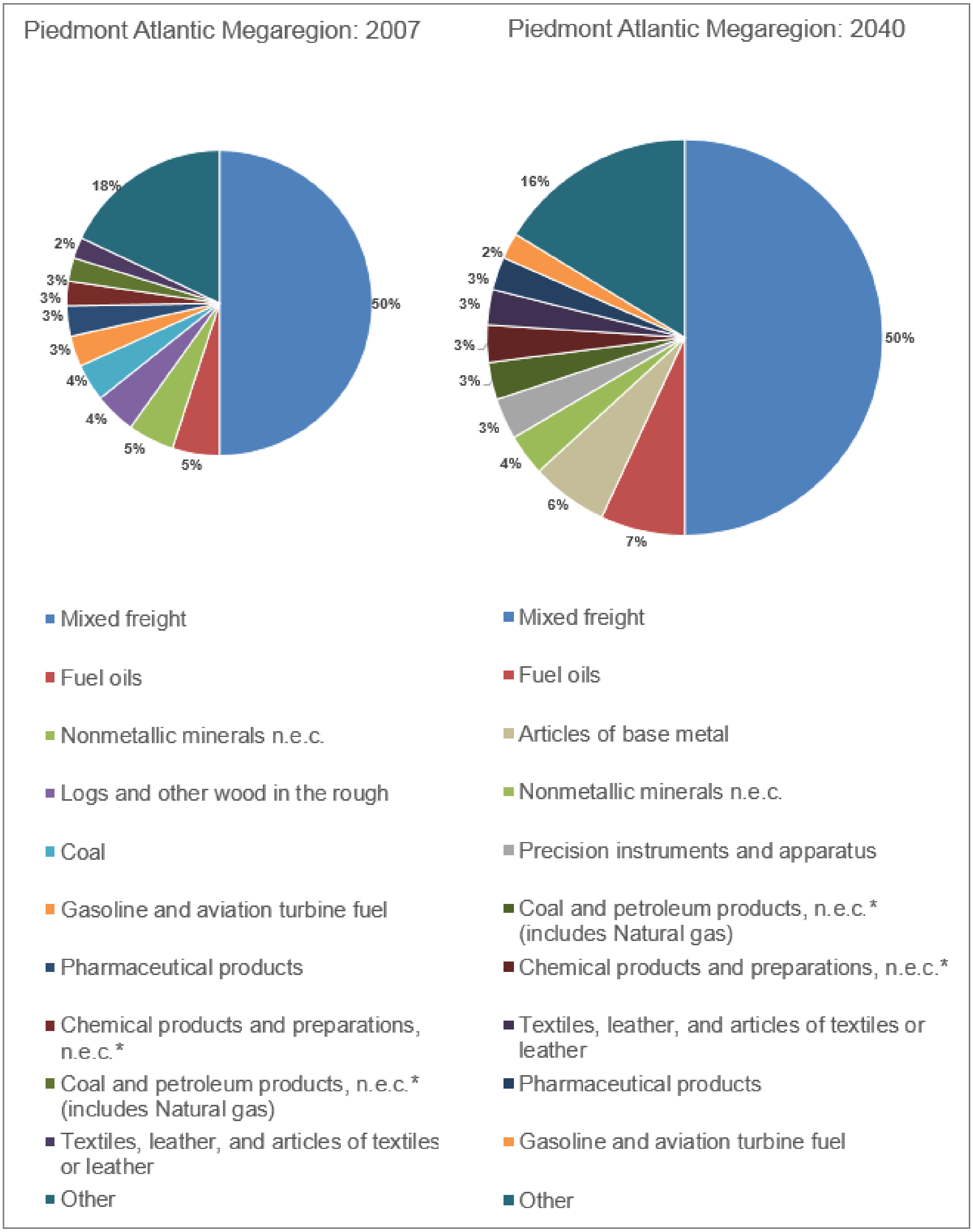


Figure 45. Mix of Commodities Imported to the Piedmont Atlantic Megaregion Through the Coastal Ports, by Tonnage

Figure 46 and Figure 47 below show the breakdown of the commodities imported to the Piedmont Atlantic Megaregion. Megaregion imports (Figure 46) are imported through ports in Georgia, South Carolina, and North Carolina. Piedmont Atlantic Megaregion imports numbered 25 million tons in 2007, and are expected to increase by 167% by 2040. The three largest commodities are coal & petroleum products, base metal, and coal. Coal imports are expected to stagnate, while machinery tonnage may grow 720% by 2040 (Figure 46).

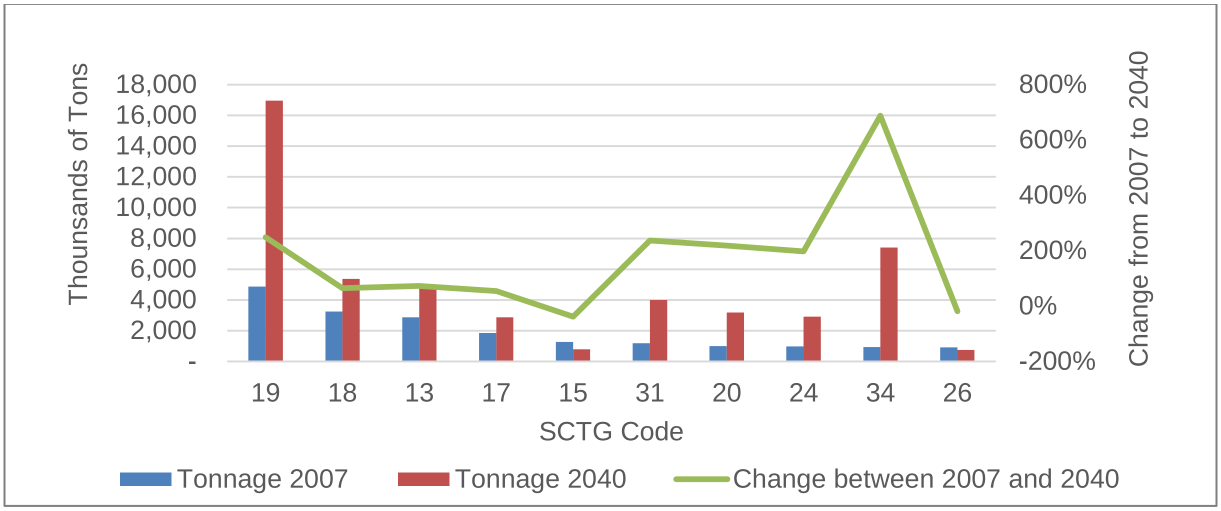


Figure 46: Piedmont Atlantic Megaregion – Megaregion Imports* (Tonnage)

*Mixed freight (43) omitted.

Extra-megaregion imports (Figure 47) enter the United States through a port outside of the Piedmont Atlantic Megaregion and are transported to the megaregion afterwards. 2007 extra-megaregion imports totaled 25 million tons, which is roughly the same as for Piedmont Atlantic Megaregion imports. This means that about half of imports destined through the Piedmont Atlantic Megaregion come through ports on the Georgia coast, and about half come through other gateways by multiple modes. The commodities imported through other gateways is slightly different. Wood products, coal, and fertilizers dominate extra-Piedmont Atlantic Megaregion imports (Figure 47).

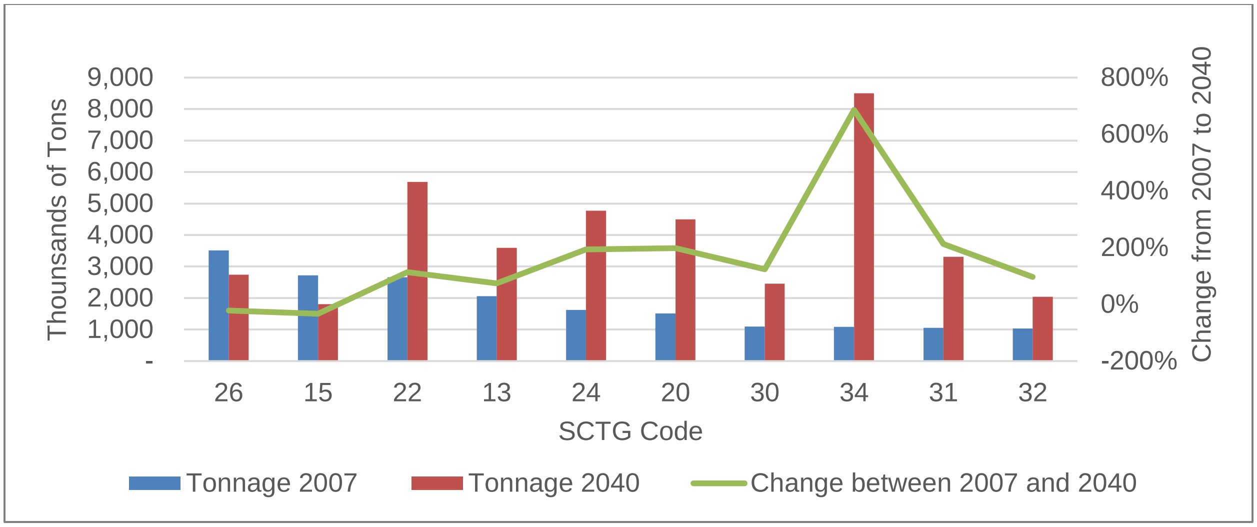


Figure 47: Piedmont Atlantic Megaregion – Extra-Megaregion Imports* (Tonnage)

*Mixed freight (43) omitted.

Texas Triangle Megaregion Imported Commodities

The Texas Triangle consists of the Dallas, Fort Worth, Austin, San Antonio, and Houston metro regions with surrounding counties. This analysis isolated imports by water through any port in Texas, which is FAF3 code 48.

Figure 48 exhibit the distributions of commodities by SCTG classifications imported through the ports into the Texas Triangle Megaregion. The largest import commodity for the Texas megaregion is crude petroleum. Nonetheless, crude petroleum’s relative share of megaregion imports is projected to fall from 61% to 48% between 2007 and 2040. Other major import commodities for both year 2007 and 2040 include coal and petroleum products, fuel oils, basic chemicals, metallic ores, nonmetallic minerals, gasoline, and base metal. The FAF3 data suggests that there will be machinery imports, coal, and petroleum will grow.

The Texas Triangle Megaregion’s import growth between 2007 and 2040 is more moderate than in the Piedmont Atlantic Megaregion. However, Texas Triangle import tonnage is forecasted to grow by 79% between 2007 and 2040.

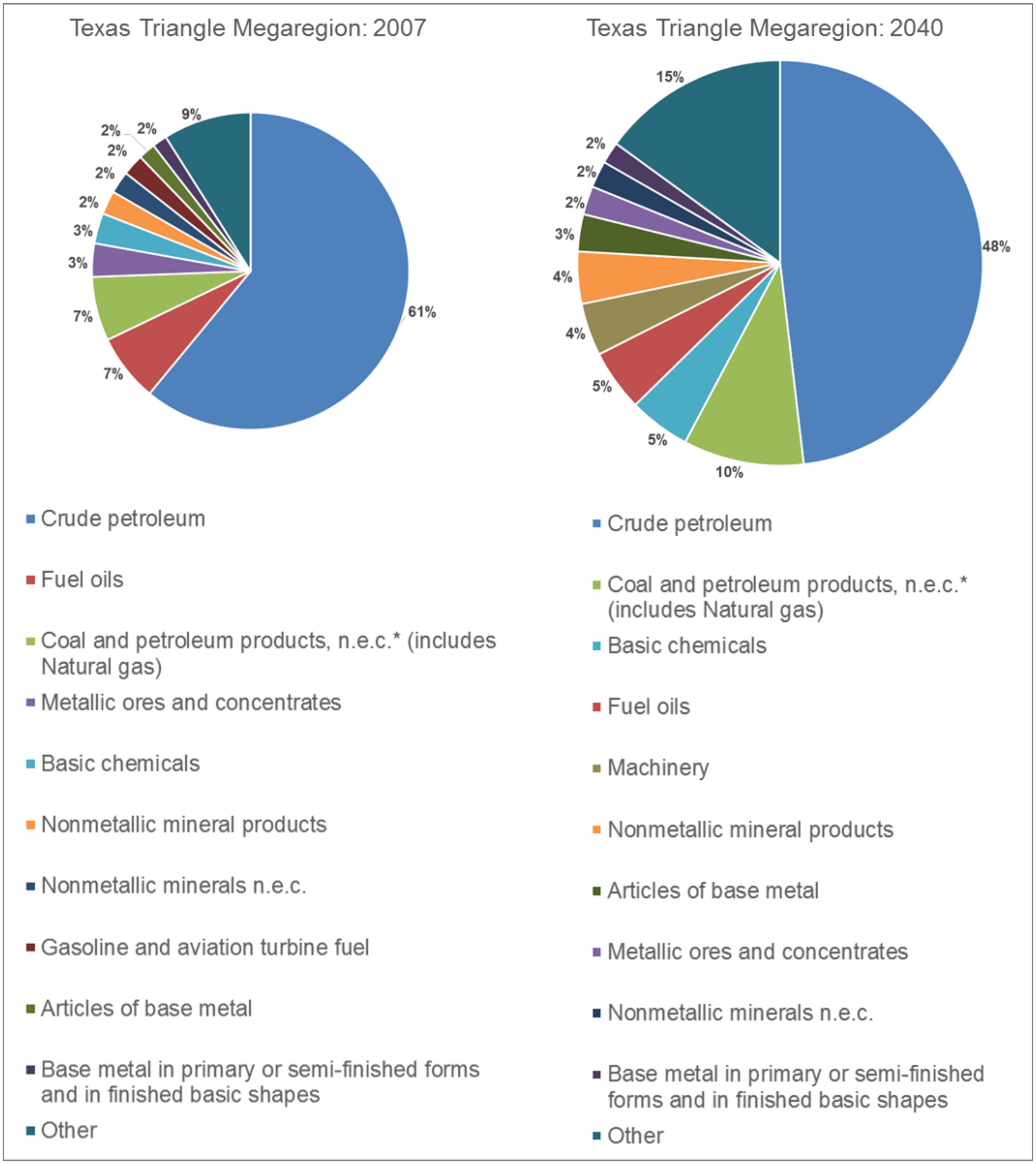


Figure 48. Mix of Commodities Imported to the Texas Triangle Megaregion Through the Coastal Ports, by Tonnage

Figure 49 and Figure 50 show import commodities for ports located inside the megaregion (Texas Triangle Megaregion Imports) and outside the megaregion (extra-megaregion imports). Crude petroleum is by far the largest megaregion import by tonnage. Its 2007 tonnage was 170 million tons, expected to increase only slightly by 2040 to 189 million tons. Import growth of megaregion import commodities is expected to be modest, with some growth rates as low as 20% among the top 10 imports, as shown in Figure 49.

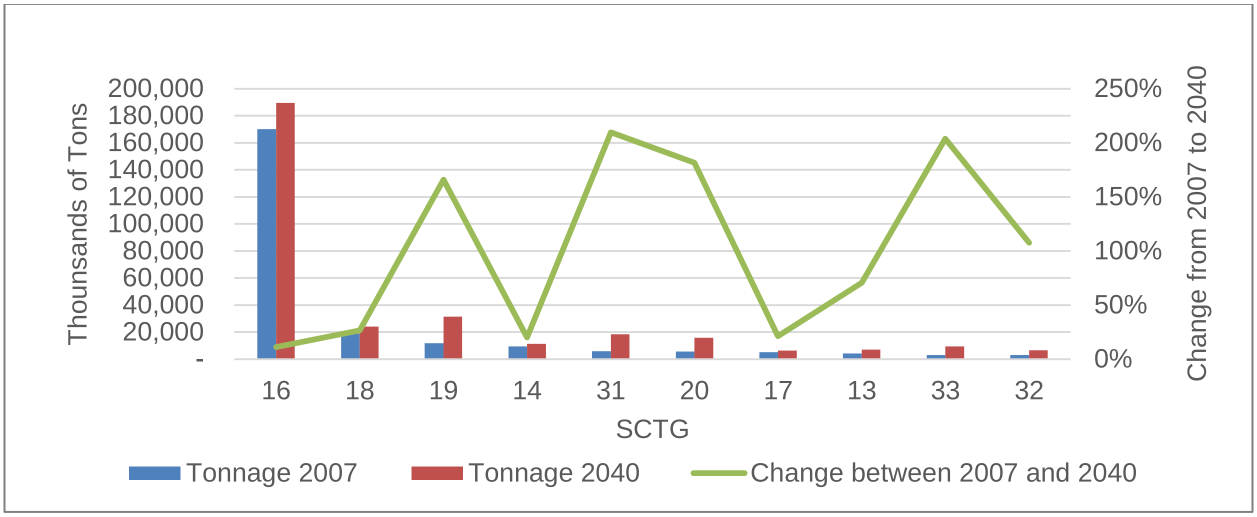


Figure 49: Texas Triangle Megaregion – Megaregion Imports* (Tonnage)

*Mixed freight (43) omitted.

Extra-megaregion import commodities are imported into non-Texas Triangle gateways but travel domestically into the megaregion. The largest of these is coal & petroleum products (SCTG 19), and crude petroleum (SCTG 16). In contrast to megaregion imports, extra-megaregion petroleum imports are expected to grow rapidly (762% between 2007 and 2040), meaning that a larger portion of Texas Triangle's crude petroleum is likely to be imported through gateways outside of the megaregion (Figure 50).

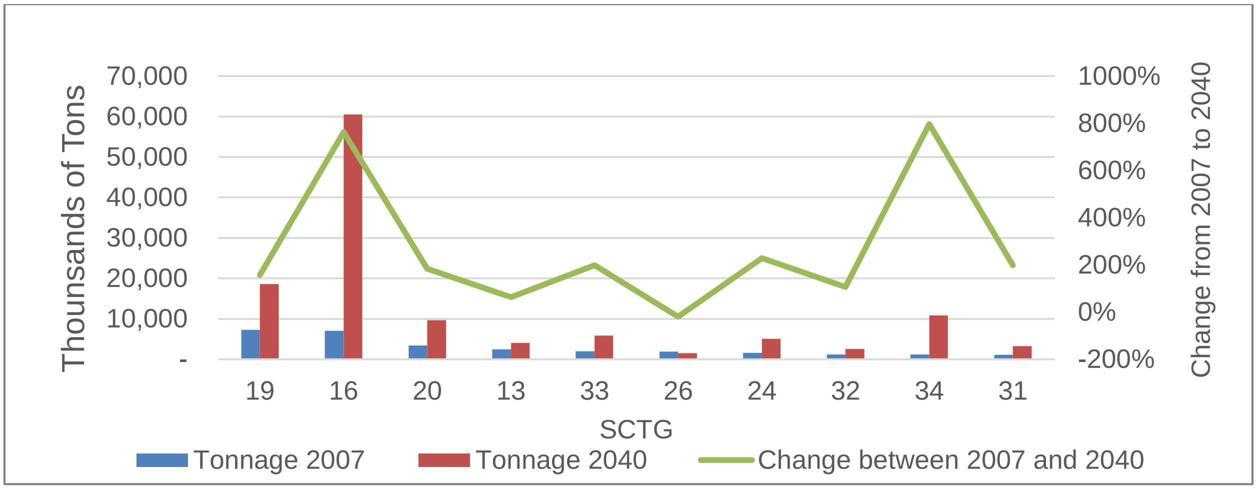


Figure 50: Texas Triangle Megaregion – Extra-Megaregion Imports* (Tonnage)

*Mixed freight (43) omitted.

DC-Virginia Megaregion Imported Commodities

Figure 51 shows that DC-Virginia Megaregion's largest commodities imported through the ports for year 2007 and 2040. The mix of commodities for the DC-Virginia Megaregion follows a similar pattern of the Piedmont Atlantic Megaregion, with the dominant imports as fuel oils, coal, metallic ores, and nonmetallic minerals. There will be an obvious drop in the shares of gasoline, and logs and wood imported to the DC-Virginia Megaregion from 2007 and 2040, which is similar to projected declines the Piedmont Atlantic Megaregion. The share of articles of base metal and fertilizer will grow rapidly from 2007 to 2040. The DC-Virginia Megaregion will witness an approximate 71% increase in total tonnage of commodities imported through the port gateways from 2007 to 2040, which will require substantial growth in the capacity of related infrastructure.

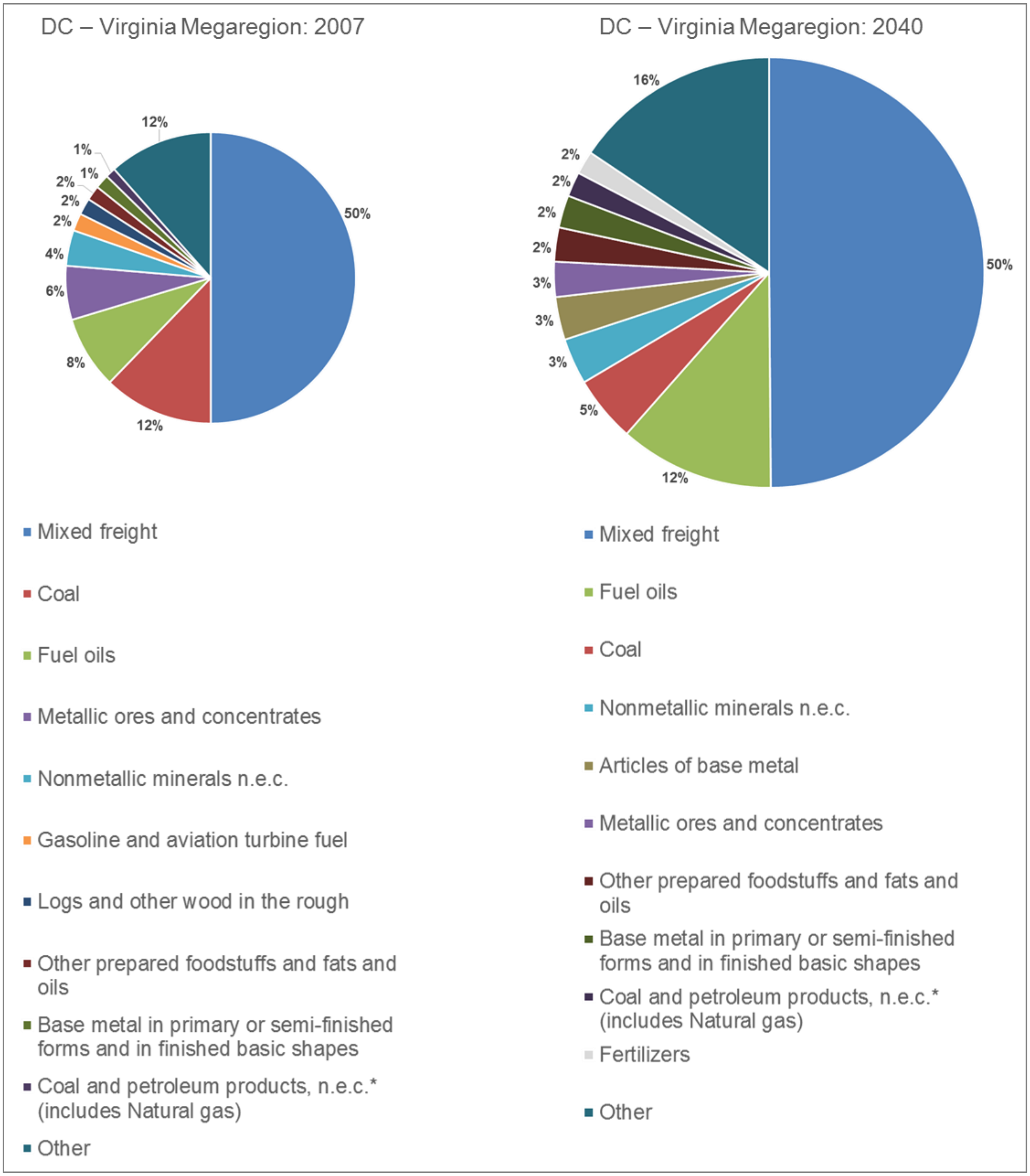


Figure 51. Mix of Commodities Imported to the DC-Virginia Megaregion through the Coastal Ports, by Tonnage

Figure 52 and Figure 53 show the top 10 commodity types imported to the DC-Virginia Megaregion. Figure 52 shows megaregion imports, while Figure 53 shows extra-megaregion imports. DC-Virginia Megaregion imports enter through DC-Virginia ports and remain in the megaregion. Almost all of the top ten megaregion imports are natural resources or energy resources, including coal & petroleum, minerals, fuel oil, gasoline, and wood (Figure 52). Growth rates are expected to be low (less than 150%), and in some cases commodity tonnage will shrink through 2040.

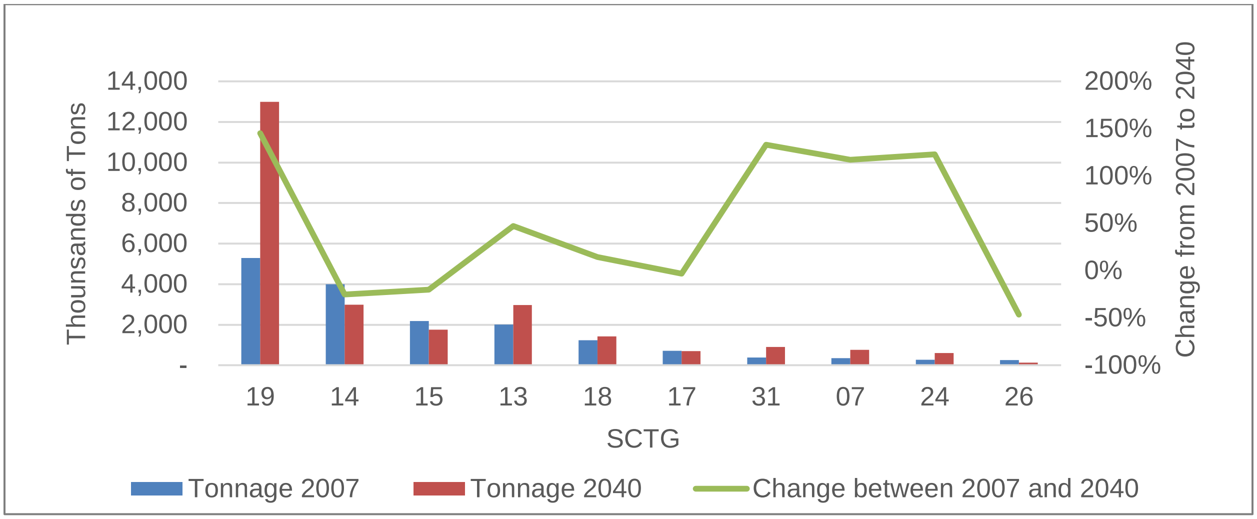


Figure 52: DC-Virginia Megaregion – Megaregion Imports* (Tonnage)

*Mixed freight (43) omitted.

Extra-megaregion import commodities enter the United States through gateways outside of the DC-Virginia Megaregion but are later transported into DC-Virginia. DC-Virginia's extra-megaregion imports also skew towards natural resources and energy. Coal is far and away the largest import, although its absolute tonnage is expected to decline through 2040. By contrast, wood products, articles of base metal, and chemical products are growing at much higher rates (Figure 52).

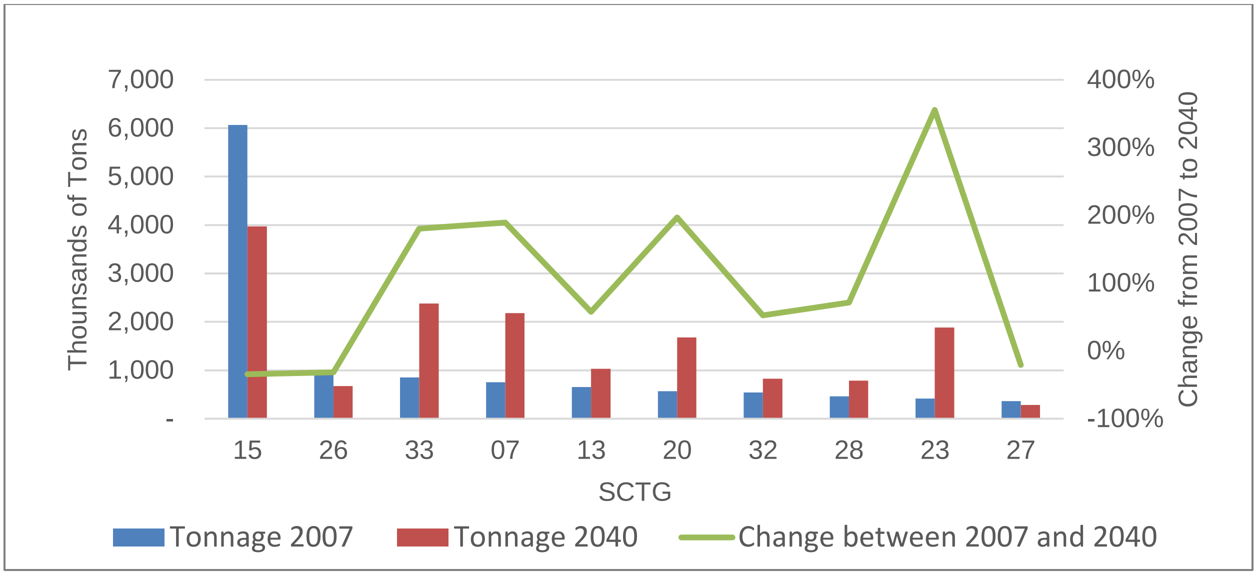


Figure 53: DC-Virginia Megaregion – Extra-Megaregion Imports* (Tonnage)

*Mixed freight (43) omitted.

Policy Implications

This section reviewed commodity imports into the three megaregions closest to the case study ports of Norfolk, New Orleans, and Savannah based on FAF3 data. The analysis is intended to frame freight and economic analysis in following sections. Moreover, understanding spatial structure of industries at megaregion level and associated dynamics of commodity flows can help planners and policymakers develop long-range regional economic development strategies.

Each megaregion has its unique political, economic, environmental circumstances which accommodate its spatial structure of industry settings. Future freight flow will be composed of different commodities in different proportions than freight flows today. In the Piedmont Atlantic Megaregion and DC-Virginia, imports such as logs (25) are projected to fall out of the top 10 while machinery (34) and precisions instruments (38) will replace them. However, mixed fright (43) and bulk commodities such as fuel oil (18), natural gas (19), and petroleum (16) will remain influential in the three megaregions under study. Knowing current spatial and functional relationships among industries should provide planning entities a better vision of megaregions' economic strengths and potential, which will help shape transportation policies.

SECTION V. TRUCK NETWORK ANALYSIS

Analysis of Trucking Route**s** from **Selected Port Facilities**

Introduction

Currently, intercity and interstate freight movement between metropolitan areas occurs primarily along major trucking corridors. Trucks transport over 80% of U.S. freight (based on revenue), which makes investment in infrastructure repair and upgrades essential for economic competitiveness (American Trucking Associations, 2013b), and close to 69% of domestic freight tonnage (U.S. Department of Commerce, 2012). Trucks also move most tonnage to and from 8 of the 14 ports addressed earlier in the report along the East and Gulf Coasts. Only those ports specializing in bulk commodities moved larger tonnages by rail, pipeline, and inland waterways (FAF3, 2011). Truck corridors are important infrastructure whose needs can best be addressed at the megaregion scale through inter-jurisdictional cooperation which allows regions, cities and towns to compete globally as cohesive regions connected by efficient and reliable transportation links.

With the expansion of the Panama Canal due to be completed in 2016, there has been much attention on which ports along the United States' eastern coastline will accommodate the new cargo ships. Many ports, such as Savannah, have focused their energies on securing the proper permitting to deepen their ports to accommodate larger vessels (Copeland, 2011). Recognizing the economic benefits that increased port throughput would generate, state and local governments are working to ensure that their seaport receives a share of the increased demand (Associated Press, 2012). However, by focusing attention exclusively on ports, more macro-level planning activities may not be receiving enough attention. Once cargo arrives at the port facility, not only must the facility have enough capacity to handle additional cargo, but the transportation infrastructure that connects the port to the region must also be able to accommodate an increase in port-related traffic.

This study focuses on port-related freight's state and regional impacts, laying the groundwork for regional planning activities at the megaregion scale that accommodate increased port-related freight. To understand how increased port activity will affect regional transportation networks, it is first important to study how the network is currently behaving. Given that trucking accounts for the majority of freight movement in the United States, trucking will be the subject of the study. The first part of the study will focus on characterizing the behavior of trucking operations once a vehicle departs a port facility.

A data key source this study is the American Transportation Research Institute's (ATRI) database of truck Global Positioning System (GPS) position readings. This database, which is comprised of several hundred thousand large trucks equipped with advanced GPS technology, generates several billion position reads annually. These data have been used nationally by the Federal Highway Administration as part of its Freight Performance Measures (FPM) program, as well as by numerous states and metropolitan regions for freight planning purposes.

Research Scope

The American Transportation Research Institute conducted the following steps on the three selected case study ports.

- For each port facility, identify at least 1,000 unique truck trips that have a nexus with the port during each season of a three year period (resulting in a total of 12 samples)
- Run a trip algorithm to determine the first destination of the truck once leaving the port facility (excluding stops at rest areas, major refueling stations)
- Aggregate destination data at the county level to identify destination distributions
- Aggregate route choice data to determine routing distributions
- Analyze the aggregated destination and route choice data to determine trends over the study period.

Methodology

Truck flows can provide valuable information for planners because they contain information on freight origins and destinations as well as trip routes. Understanding how trucks are currently using the transportation network is an important base for projecting future truck movements.

This study's truck flow data source is ATRI's FPM database of trucks equipped with GPS tracking devices. The ATRI FPM database compiles anonymous trucking operations data from several hundred thousand trucks using GPS technology from onboard trucking systems. The database generates billions of data points annually. Each truck used in FPM analysis has a regular position reading (generally recorded every 1 to 15 minutes) and includes information on vehicle location, unique vehicle identification, time/date, and, in many cases, vehicle spot speed. This information can be aggregated and analyzed in a number of different ways, including determining truck travel patterns/flows.

Truck GPS data has unique advantages: GPS devices provide precise and comprehensive data without burdening the companies whose data is being reported. GPS data has the potential to provide more detailed trip information than roadside truck counts and can produce more reliable truck movement information than travel diaries because it does not depend on driver memory or effort. GPS data has the advantage of being much cheaper to collect than conventional techniques. GPS data also provides a new option for collecting truck data for longer periods of time, over larger geographic areas or from much larger samples. The truck GPS data has become recognized as a promising data source for quantitative study of truck behavior characteristics and travel patterns by providing empirical evidence of where and when actual truck movements take place.

On the other hand, the current GPS data has some limitations as well: Since the primary source of ATRI's GPS data is onboard devices installed on commercial trucks mainly from large trucking companies and independent truckers covering mostly tractor-trailer combinations, the dataset is somewhat over-represented by medium to large fleets, and over-represented in medium to heavy duty trucks at the expense of intra-urban pick-up and delivery (P&D) trucks. The ATRI's national database is based on the maximum loaded weight of the truck using the gross vehicle weight (GVW) rating. The database suggests that 89% of the population is Class 8 and the remaining 11% have GVW putting them in the Class 7 or smaller. Additionally, ATRI estimates the following: (1) 72% Very Large or Large Fleet; 28% Small or Medium Fleet, (2) 83% Truckload; 17% Less-than-truckload, and (3) 83% For-hire; 14% Private; 3% other. It does not provide key truck characteristics such as commodity transported, shipment size, and truck classification. Therefore, the current GPS dataset can be utilized best when combined with other data sources and methods of data collection.

A series of FPM data samples were drawn from the larger FPM database to isolate vehicles that serviced the primary port terminals in Savannah, Norfolk, and New Orleans (i.e. the truck was within the boundaries of the facility). A separate sample was isolated for each of the three ports for the following 12 time periods. The samples looked at only outbound truck trips from the selected ports, not inbound to the ports:

First Quarter 2008	First Quarter 2010	First Quarter 2012
Second Quarter 2008	Second Quarter 2010	Second Quarter 2012
Third Quarter 2008	Third Quarter 2010	Third Quarter 2012
Fourth Quarter 2008	Fourth Quarter 2010	Fourth Quarter 2012

Generating samples from these 12 time periods enables an analysis that accounts for the effects of seasonality and the U.S. recession between December 2007 and June 2009.

Once the trucks were isolated for each sample, an algorithm was developed to determine when vehicle stops occurred to generate destination information. An illustration of the algorithm can be found in Appendix 2. Generally speaking, a truck was determined to have reached a destination when it was stationary for more than 30 minutes. Once this occurred, a destination was recorded and the truck movements were no longer tracked. ATRI added an exception to this rule when the vehicle was stopped at known major truck stops, rest areas, or weigh stations. This exception was added to eliminate intermediate stops (e.g. refueling, mandated rest breaks) to determine true destination information. Given the highly diversified operations of the trucking industry, it is impractical correctly classify 100 percent of the trips (e.g. it is extremely difficult, if not impossible, to determine whether a vehicle that stopped at a small fuel station for 35 minutes is delivering fuel to the station, or is simply stopping to refuel and rest). However, ATRI's experience has shown that the aforementioned filters produce highly accurate truck flows with valuable origin/destination information.

Once the algorithm was applied to the data, general destination information (reported at the county level) as well as route selection on the National Highway System (NHS) was aggregated. The following section presents the truck flow analysis findings.

Analysis

The analysis isolated 119,096 truck trips from the 36 FPM samples (three ports with 12 samples each). Figure 54 presents the resulting truck flows from the entire sample, with Savannah flows in red, Norfolk in blue, and New Orleans in green. Not surprisingly, trucks that served these ports tended to remain in the eastern half of the continent as freight bound for the western half of the U.S. would likely arrive via a Pacific Ocean port. The Hampton Roads / Norfolk port appears to have the smallest geographic service area given the competition from the nearby ports, such as the Port of New York and New Jersey that serves the heavily populated northeastern states.

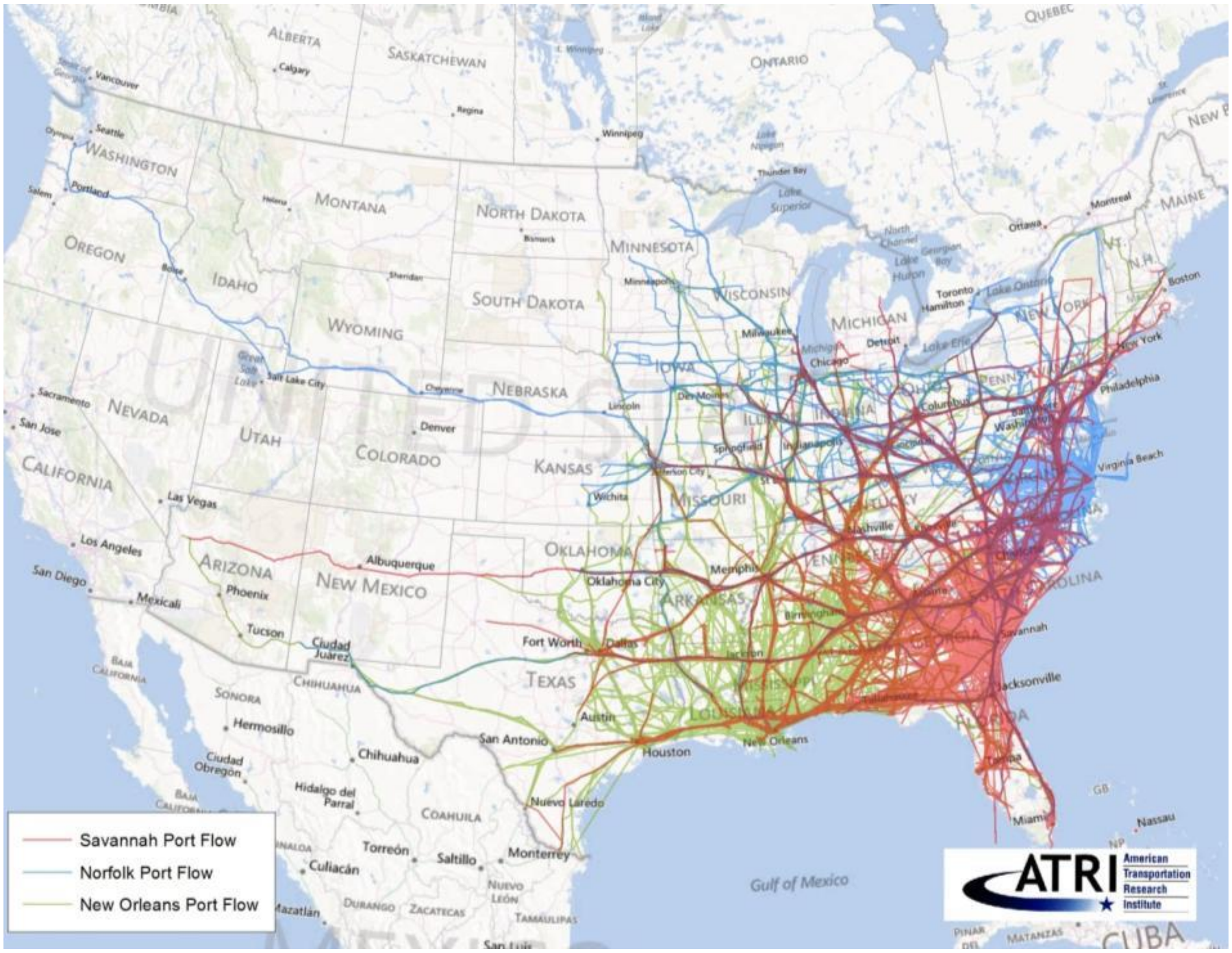


Figure 54: Truck Flows From the Ports of Savannah, Norfolk, and New Orleans

Trip lengths varied among the ports, with the Port of New Orleans generally having the longest trips (mean=168.4 miles, median=117.0 miles), Savannah with the shortest trips (mean=95.1 miles, median = 10.6 miles) and Norfolk in between the two (mean=120.7 miles, median=38.0 miles). Figure 55 presents the trip length distribution for each port. The Port of Savannah trips are skewed towards short-haul trips, compared to the Port of New Orleans trips, which are skewed more towards long-haul trips. The trip length differences are indicative of the operations at each port and of the location of regional distribution facilities.

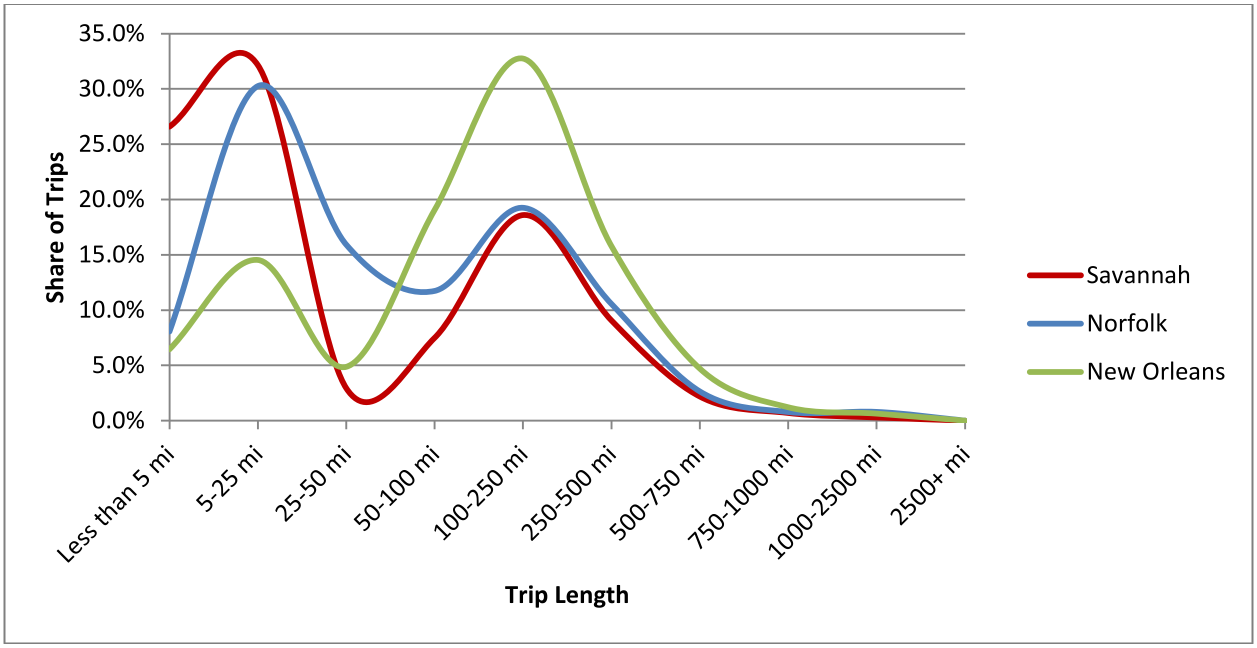


Figure 55: Distribution of Truck Trip Lengths by Port of Origin

Interestingly, there appears to have been a shift during the study period from longer trips to shorter trips. Figure 56 illustrates how the average trip length has changed over the 12 quarters of the study period. There was a sharp drop in average trip lengths in 2008, just as the recession was intensifying. The drop was strongest in New Orleans and Norfolk. However, throughout 2010 and 2012 the average trip lengths remained relatively stable. There are a number of potential explanations for this shift that warrant additional research, including the economic recession and business operations consolidation near ports to reduce transportation costs. Interestingly, Port of Savannah truck trips did not experience a sharp decline in average length.

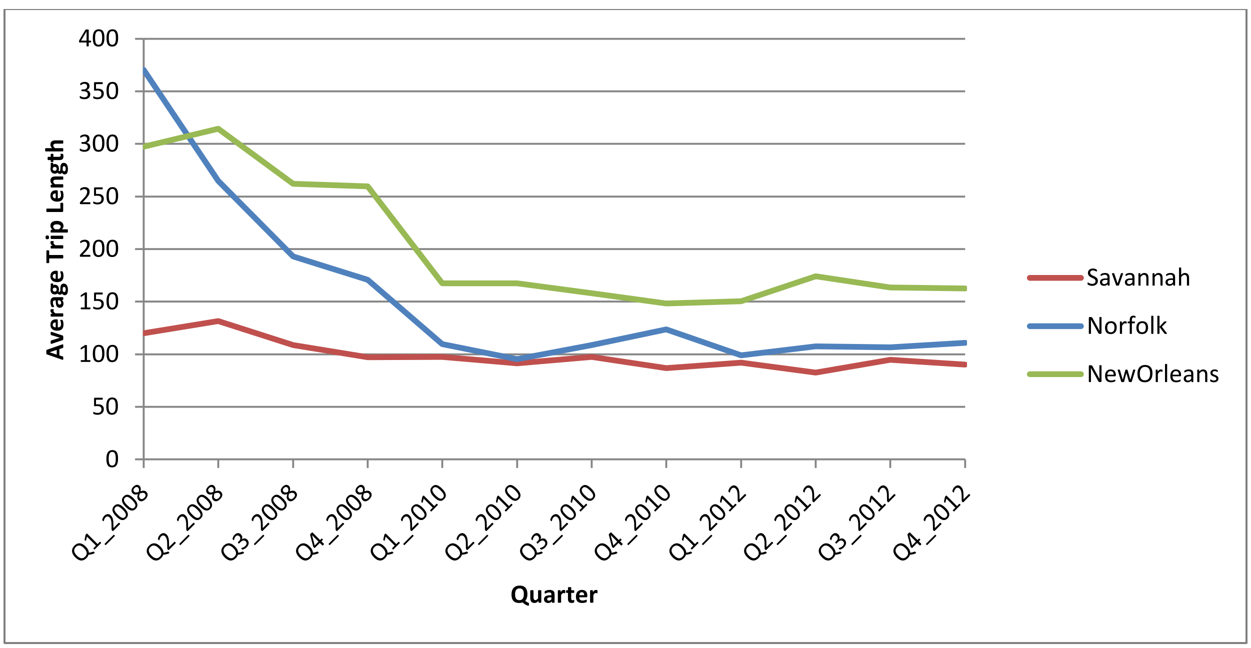


Figure 56: Change in Average Truck Trip Lengths by Quarter and Port of Origin

Port of Savannah

The Port of Savannah, shown in Figure 57, is located north of Savannah's central business district near State Route (SR) 21 in Garden City, GA. The port is strategically located near I-95 and I-16, which allows efficient access to markets to the north, south, and west. The surrounding area is generally undeveloped in nature which is ideal for freight distribution terminals due to the relatively low land values and lack of congestion.

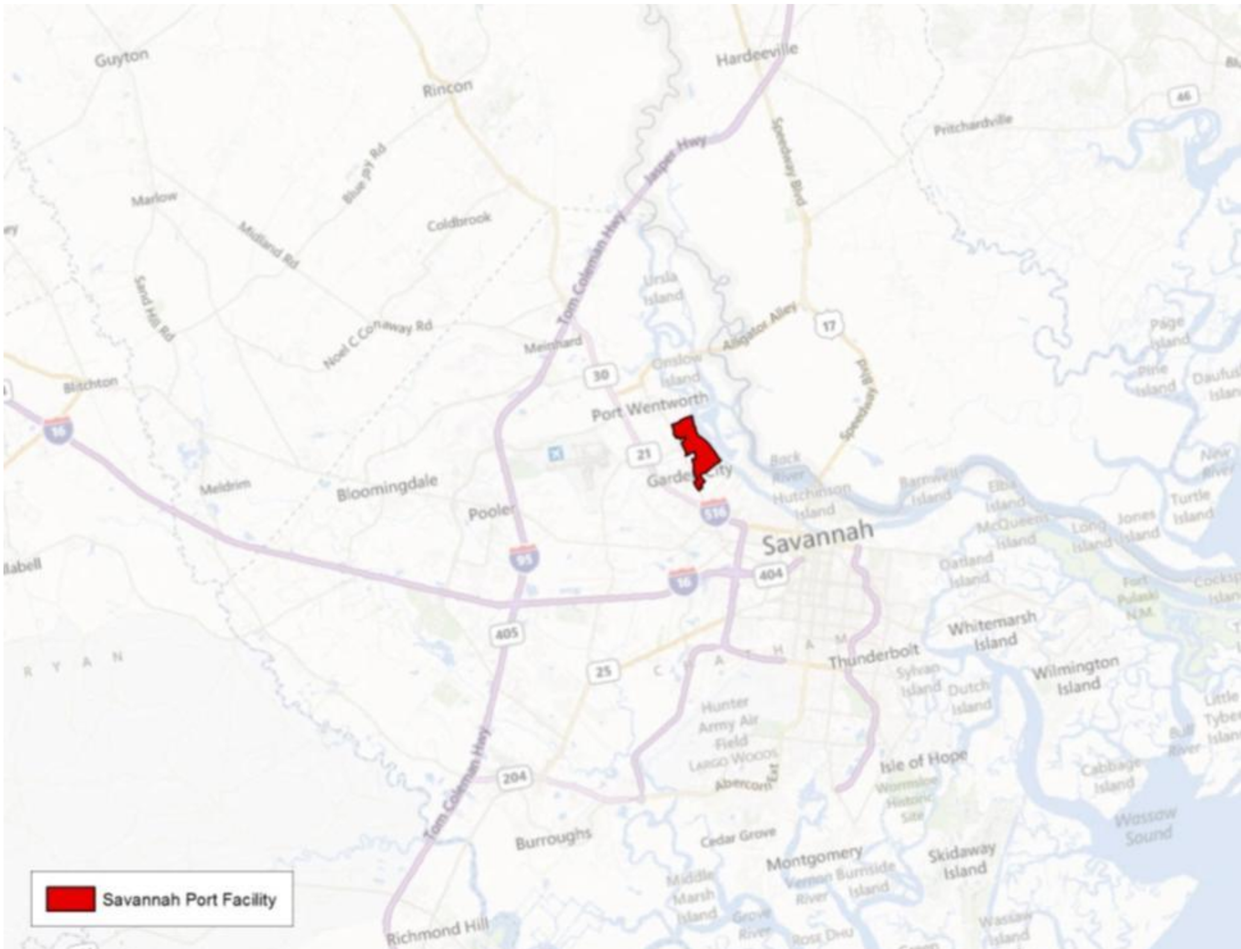


Figure 57: Port of Savannah

Given the suitability for freight distribution facilities nearby, a large share of truck trips from the Port of Savannah are relatively short in length. As illustrated by Figure 58, the majority of truck trips from the port are shorter than 25 miles (58.7% across the three years of analysis). The average trip length during the study period is 95.1 miles, with a median length of only 10.6 miles, which is the shortest trip length of the three ports studied. Interestingly, trip length for Savannah trucks has been trending downward slightly during the study period with average trip lengths of 114.3 miles, 93.0 miles, and 89.7 miles in 2008, 2010, and 2012, respectively. This decrease could be the result of improved rail access or additional distribution facilities near the port as the port continues to grow in importance nationally.

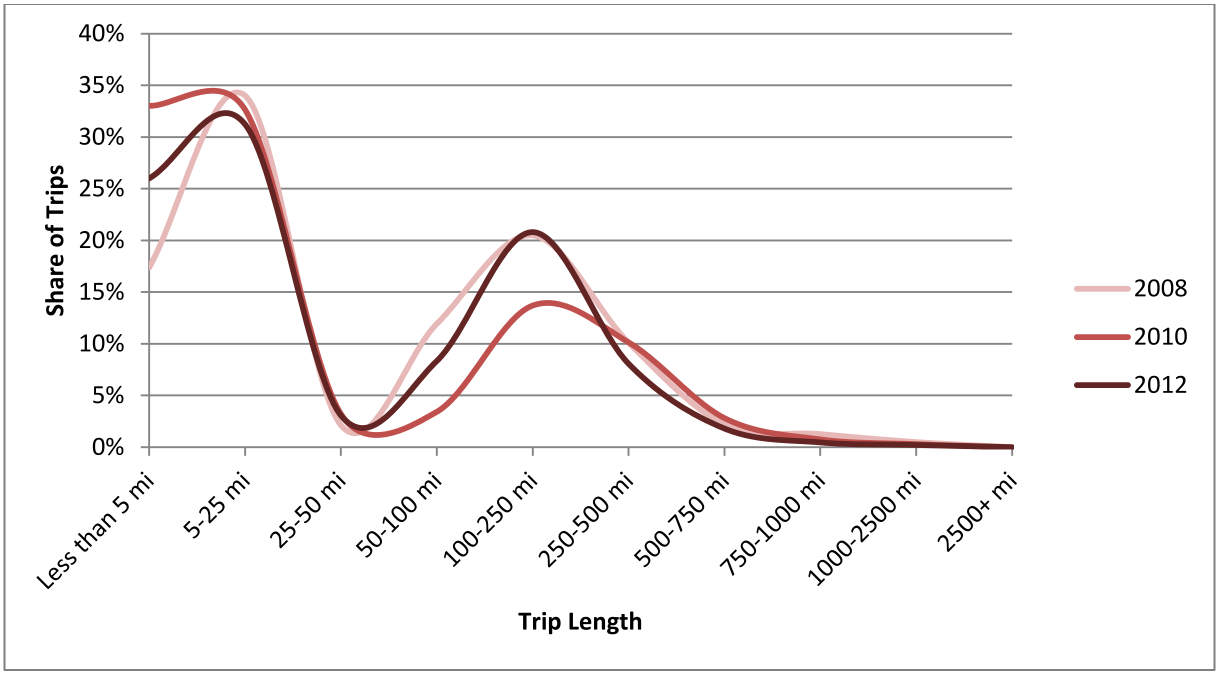


Figure 58: Savannah Trip Length Distribution by Year

With so many trips shorter than 25 miles, it is not surprising that Chatham County, the home of the Port of Savannah, is the top destination for trucks leaving the port. As Table 19 indicates, Chatham County accounts for over two-thirds (67.8%) of the truck trip destinations. Glynn and McIntosh counties are the next most common counties, both of which are in the nearby Brunswick, GA metropolitan area. As shown in the map in Figure 59, many of the other counties listed are in larger metropolitan regions in the southeast, including Atlanta, GA (DeKalb, Fulton, and Spalding counties), Augusta, GA (Richmond County), Charlotte, NC (Mecklenburg County), and Jacksonville, FL (Duval County).

Table 19: Top 20 Port of Savannah-Related Truck Destinations

Rank	County	State	Share of Destinations
1	Chatham	GA	67.8%
2	Glynn	GA	3.7%
3	McIntosh	GA	1.5%
4	Richmond	GA	1.3%
5	Liberty	GA	1.1%
6	Bryan	GA	1.0%
7	DeKalb	GA	1.0%
8	Mecklenburg	NC	0.8%
9	Lexington	SC	0.8%
10	Charleston	SC	0.8%
11	Duval	FL	0.8%
12	Wayne	GA	0.7%
13	Jefferson	GA	0.7%
14	Effingham	GA	0.6%
15	Jasper	SC	0.6%
16	Berkeley	SC	0.6%
17	Fulton	GA	0.6%
18	Golleton	SC	0.6%
19	Washington	GA	0.5%
20	Spalding	GA	0.5%

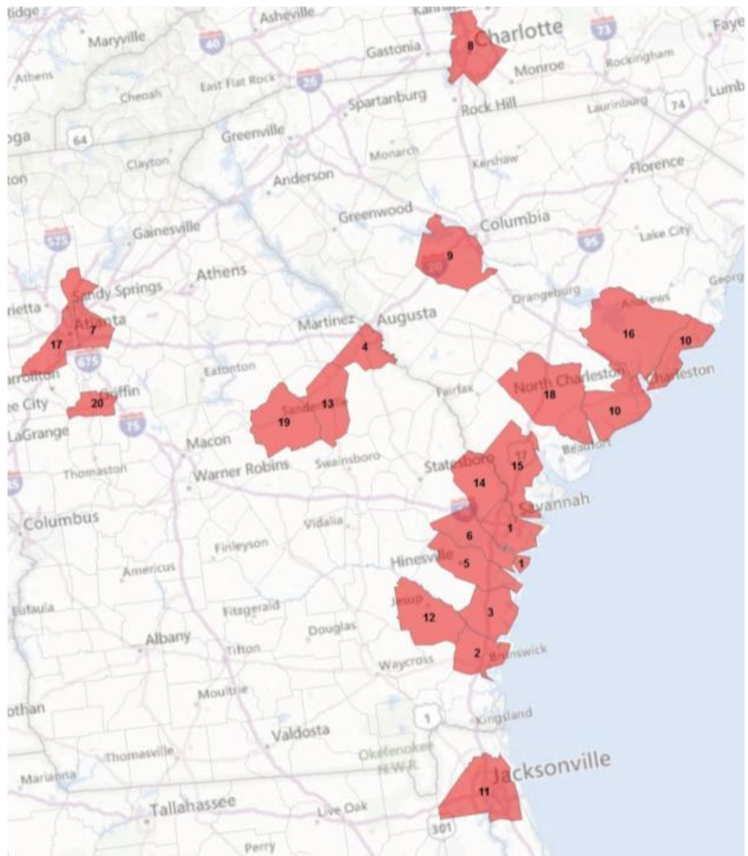


Figure 59: Top 20 Port of Savannah Destinations

As previously stated, Savannah has connectivity to major north/south and east/west corridors which allows the port to serve the entire southeastern United States relatively efficiently. Figure 60 illustrates the primary routes used by trucks once they leave the port as a share of total trips (e.g. a value of 25% indicates one-quarter of all trips analyzed utilized that route). Additionally, Figure 60 also presents the share of trip destinations for each county. The most popular routes for trucks leaving the port (in addition to the main port access roads of SR 25 and SR 307) include I-95, I-16, and SR 21, as indicated in Table 20 From these routes the trucks can connect to other major corridors in the region, such as I-10, I-26, I-20, US 84 and I-77.

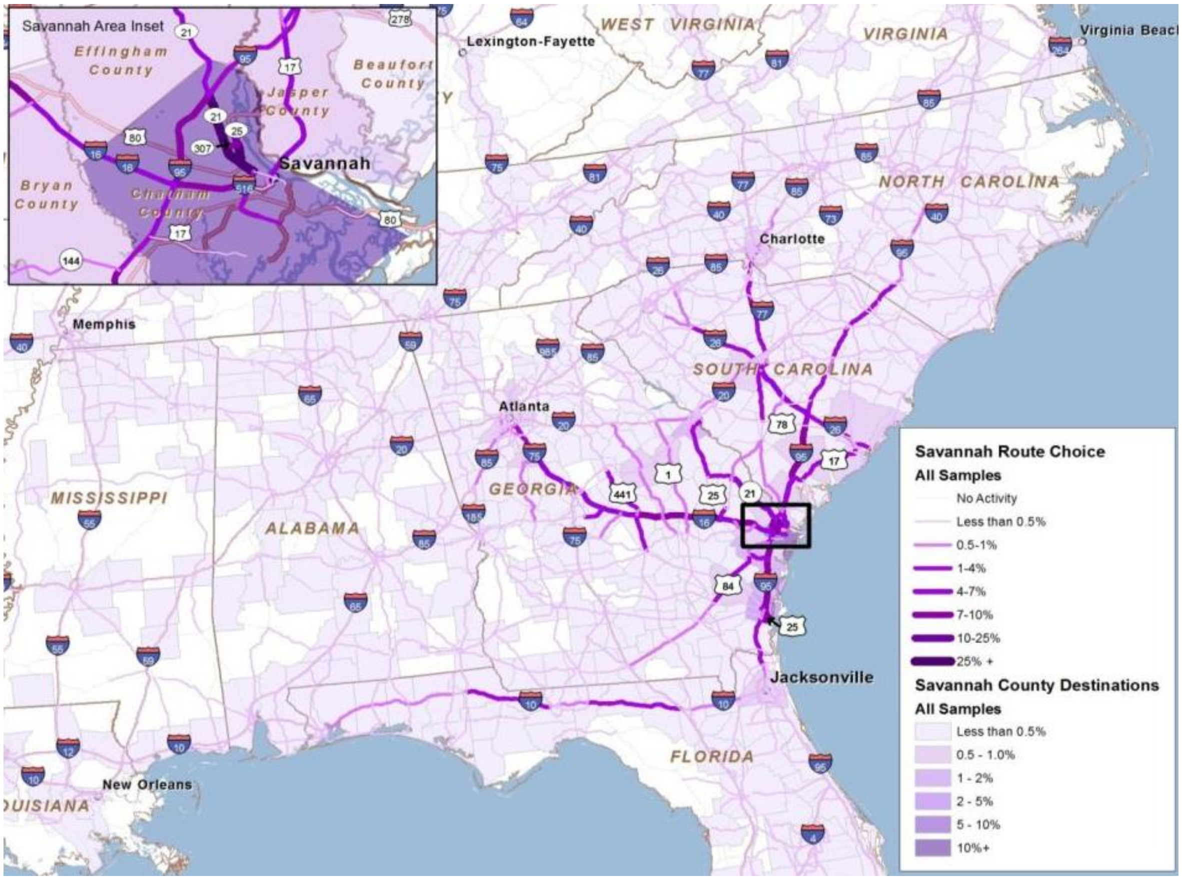


Figure 60: Savannah Route Choice and Destinations

Table 20: Top 10 Most Utilized Segments - Savannah

Rank	Route	Location	Share of Total Trips
1	SR 25	SR 307 south to SR 21 (GA)	73.1%
2	SR 21	SR 307 north to I-95 (GA)	35.3%
3	SR 21	SR 307 south to I-516 (GA)	26.5%
4	SR 25	North of SR 307 (GA)	18.2%
5	I-95	US 84 south to US 25 (GA)	9.9%
6	I-95	SR 144 south to US 84 (GA)	9.7%
7	I-95	SR 21 south to I-16 (GA)	9.5%
8	SR 307	SR 25 to SR 21 (GA)	9.4%
9	I-16	US 25 west to US 1 (GA)	8.3%
10	I-95	US 17 north to US 78 (SC)	8.3%

With trip lengths generally decreasing, there has also been a decrease in the share of trips that utilize certain routes to serve longer-distance destinations. Figure 61 shows the change in route utilization by comparing 2008 and 2012 route selection data. For example, if 20 percent of trucks used a certain segment in 2008 but only 15 percent utilized that segment in 2012, Figure 61 would indicate a decrease in share of 5 percentage points. This analysis indicates a relatively large drop in trips that utilized I-95 northbound and southbound while I-16 and SR 21 experienced a slight increase in utilization. The five segments with the largest utilization growth and the five segments with the greatest decline are presented in Table 21 and Table 22.

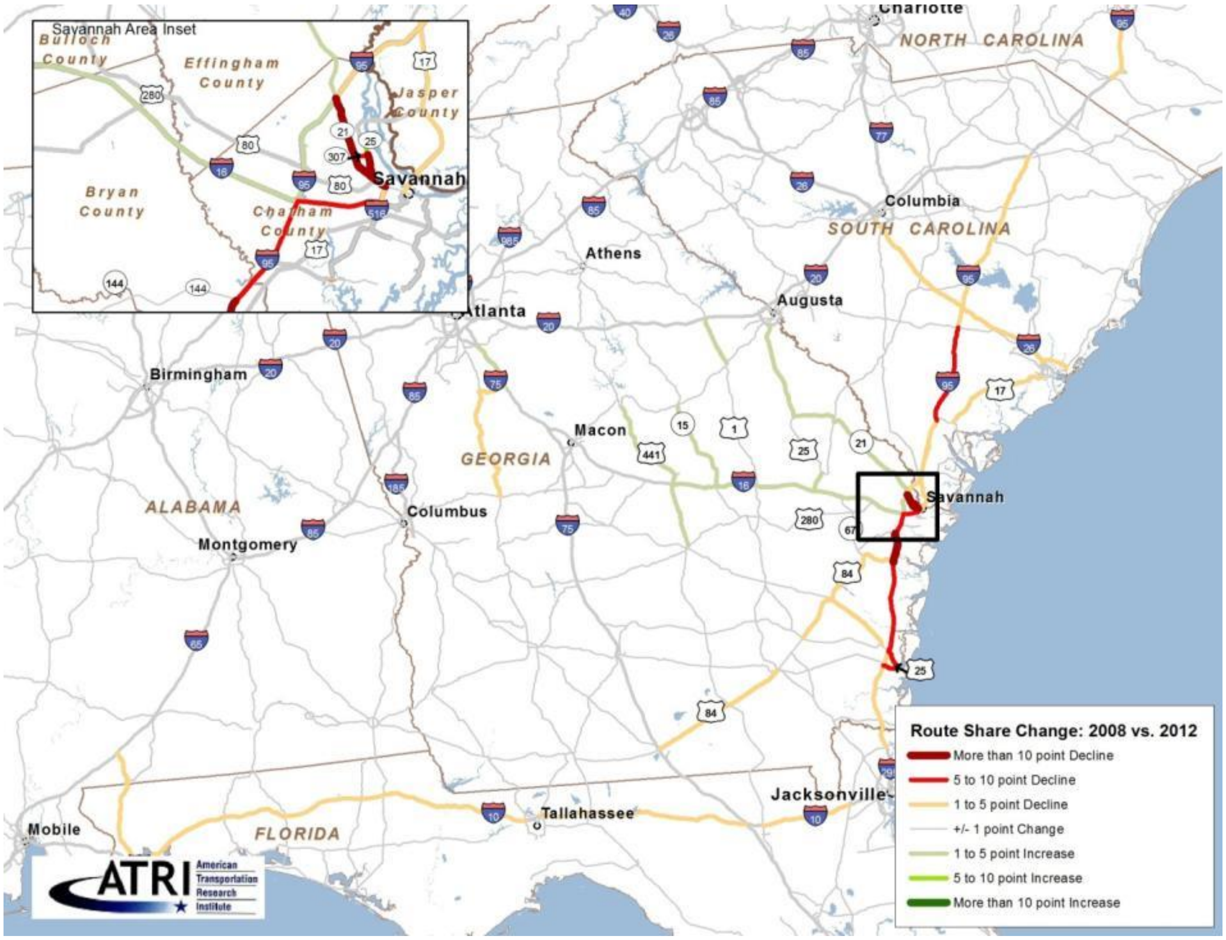


Figure 61: Change in Savannah Route Utilization

Table 21: Largest Increase in Segment Utilization - Savannah

Increasing Utilization – Top 5 Corridors					
Rank	**Route**	**Segment**	**2008 Share**	**2012 Share**	**Change in Share 2008 vs. 2012**
1	SR 25	North of SR 307 (GA)	13.8%[1]	22.5%	8.7%
2	I-16	SR 67 west to US 25 (GA)	4.1%	8.8%	4.7%
3	I-16	US 280 west to SR 67 (GA)	5.7%	10.2%	4.5%
4	I-16	US 25 west to US 1 (GA)	5.9%	9.4%	3.5%

[1] There have been construction detours in this area during those years for major road projects that may have affected the 2008 data.

Increasing Utilization – Top 5 Corridors					
Rank	**Route**	**Segment**	**2008 Share**	**2012 Share**	**Change in Share 2008 vs. 2012**
5	I-95	SR 21 south to I-16 (GA)	5.6%	8.4%	2.8%

Table 22: Largest Decrease in Segment Utilization - Savannah

Decreasing Utilization – Top 5 Segments					
Rank	**Route**	**Segment**	**2008 Share**	**2012 Share**	**Change in Share 2008 vs. 2012**
1	SR 25	SR 307 south to SR 21 (GA)	85.8%	71.2%	-14.6%
2	SR 21	SR 307 south to I-516 (GA)	35.6%	23.8%	-11.8%
3	I-95	SR 144 south to US 84 (GA)	21.3%	9.9%	-11.4%
4	SR 21	SR 307 north to I-95 (GA)	45.3%	34.0%	-11.2%
5	I-95	US 84 south to US 25 (GA)	20.9%	11.0%	-9.9%

Port of Norfolk

As shown in Figure 62, the Norfolk International Terminals analyzed for this study are located north of downtown Norfolk near the Naval Station Norfolk. The site is surrounded by the urban areas of Norfolk, Virginia Beach, Newport News, and Hampton. The port is proximate to I-564 which feeds into the region's main interstate, I-64. Given the Port of Norfolk's urban location, it is possible that many key distribution sites are located further from the port to capitalize on lower land values in less developed areas.

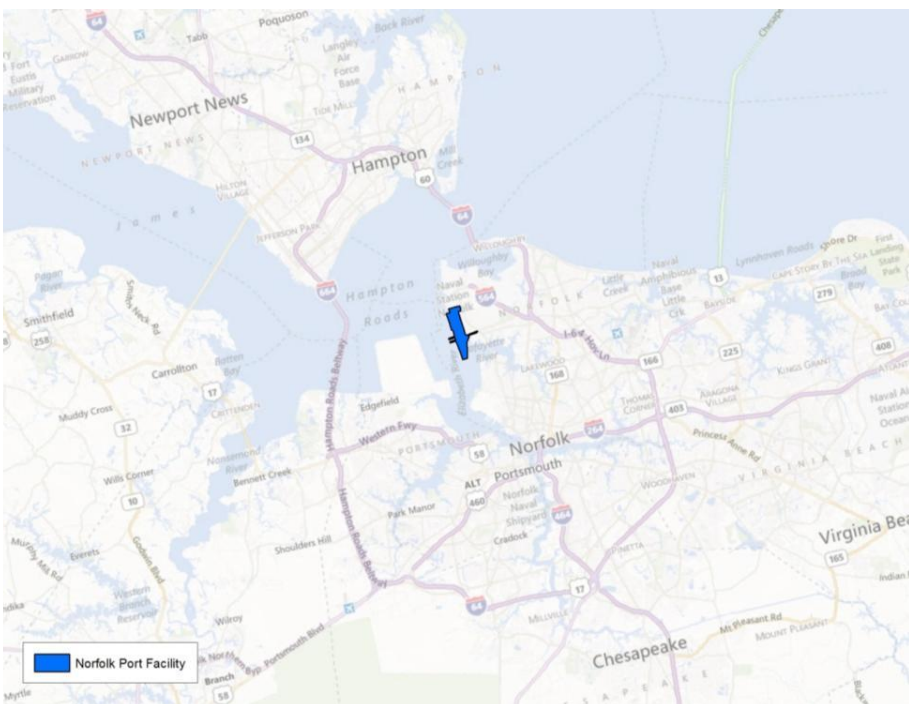


Figure 62: Port of Norfolk

Truck trips from the port are generally longer in length compared to Savannah trips. Over the course of the three years studied, Norfolk trips averaged 120.7 miles in length, with a median length of 38.0 miles. As was found in the Port of Savannah analysis, truck trip lengths from the Port of Norfolk appear to decrease over the course of the study period, as illustrated in Figure 63. In fact, the decrease was rather sharp from 2008 to 2010 (average trip lengths of 208.8 miles and 109.3 miles, respectively) before leveling out in 2012 (average trip length of 105.7 miles).

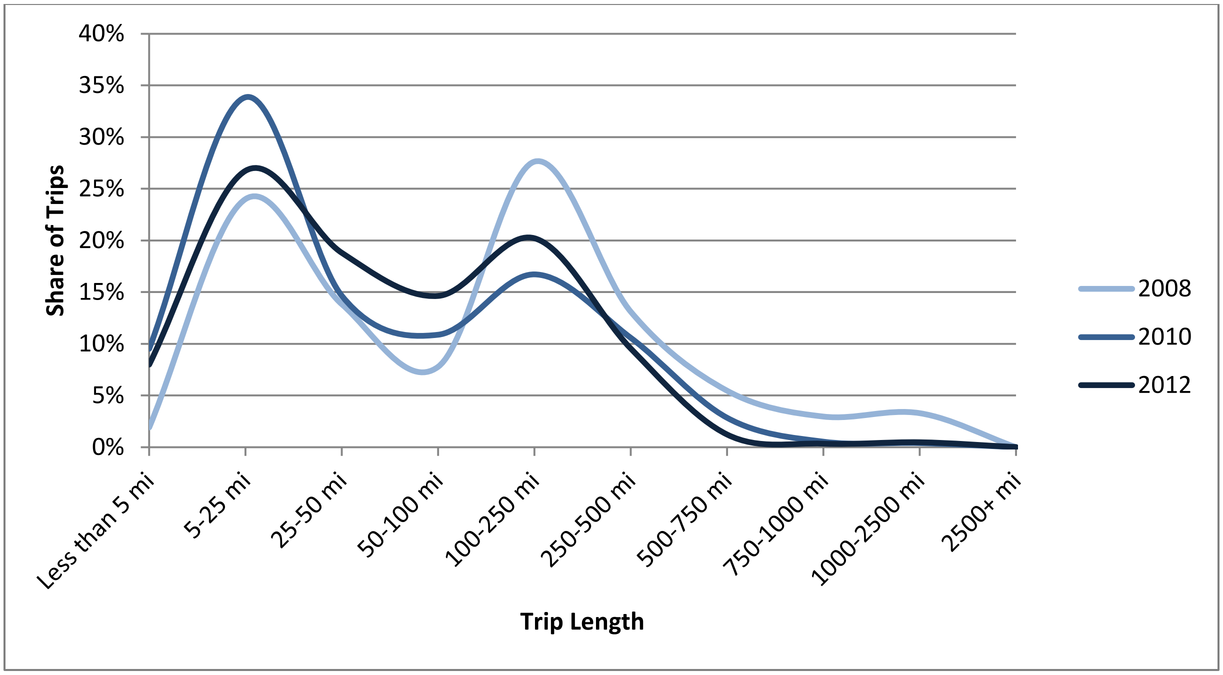


Figure 63: Norfolk Trip Length Distribution by Year

With the port centrally located in an urban area, it is expected that many of the top destinations are in the surrounding counties and cities. As Table 23 shows, this assumption is accurate as the top five destinations are surrounding counties and cities while the number six destination is the home of the port (City of Norfolk). Unlike Savannah, many of the other counties shown in Table 23 are not located in a major metropolitan area, as illustrated in Figure 64. Beyond the Norfolk area, the only other major metropolitan destinations are Chesterfield and New Kent counties (Richmond, VA) and Johnston and Wake counties (Raleigh-Durham, NC). The remaining are generally rural counties along major corridors (I-95, I-64, I-81).

Table 23: Top 20 Port of Norfolk Destinations

Rank	City/County	State	Share of Destinations
1	Chesapeake	VA	15.9%
2	Portsmouth	VA	11.2%
3	Hampton	VA	8.9%
4	Virginia Beach	VA	4.6%
5	Suffolk	VA	3.2%
6	Norfolk	VA	2.6%
7	Bertie	NC	2.6%
8	Chesterfield	VA	2.2%
9	Robeson	NC	2.0%
10	Southampton	VA	1.9%
11	Augusta	VA	1.7%
12	Johnston	NC	1.7%
13	Sussex	DE	1.7%
14	Newport News	VA	1.3%
15	Harnett	NC	1.3%
16	New Kent	VA	1.2%
17	Isle of Wight	VA	1.2%
18	Nash	NC	1.2%
19	Alleghany	VA	1.1%
20	Wake	NC	0.9%

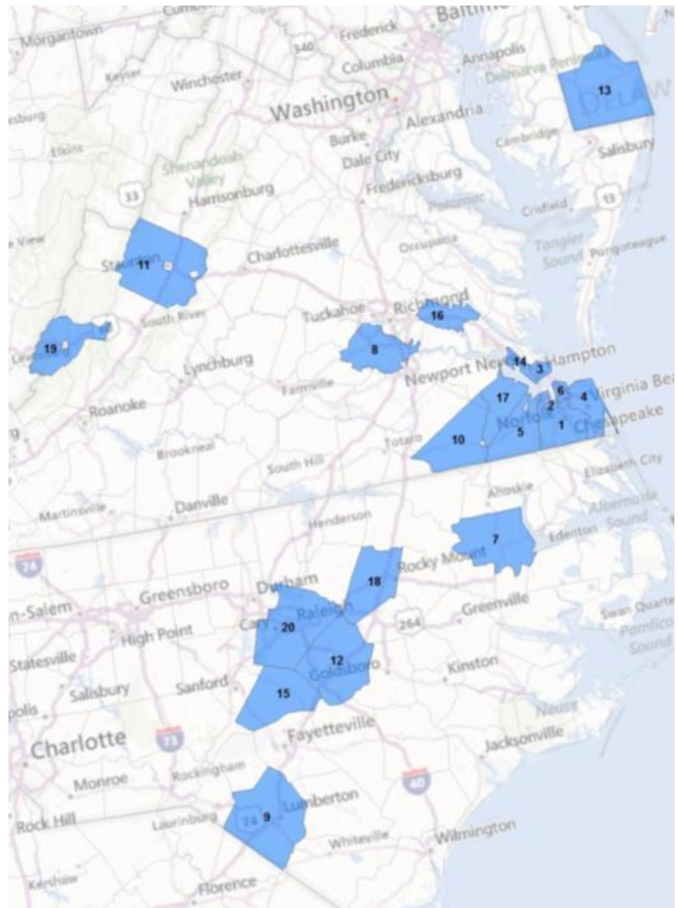


Figure 64: Top 20 Port of Norfolk Destinations

As Figure 65 indicates, truck movement from Norfolk predominately moves west and south, with some northbound movement. Given the proximity of the ports of Baltimore, Philadelphia, and New York/New Jersey to the north, the lack of movement to the northeast is expected. An analysis of the route choices reveals several major routes from the port, including:

- I-64 westbound to I-95 north, I-81 south, and into West Virginia and Kentucky
- US 58 westbound to I-95 southbound
- US 460 westbound to I-95 and I-81
- US 13 northbound to Delaware

A listing of the ten most frequently utilized route segments, in terms of share of total trips, is included in Table 24.

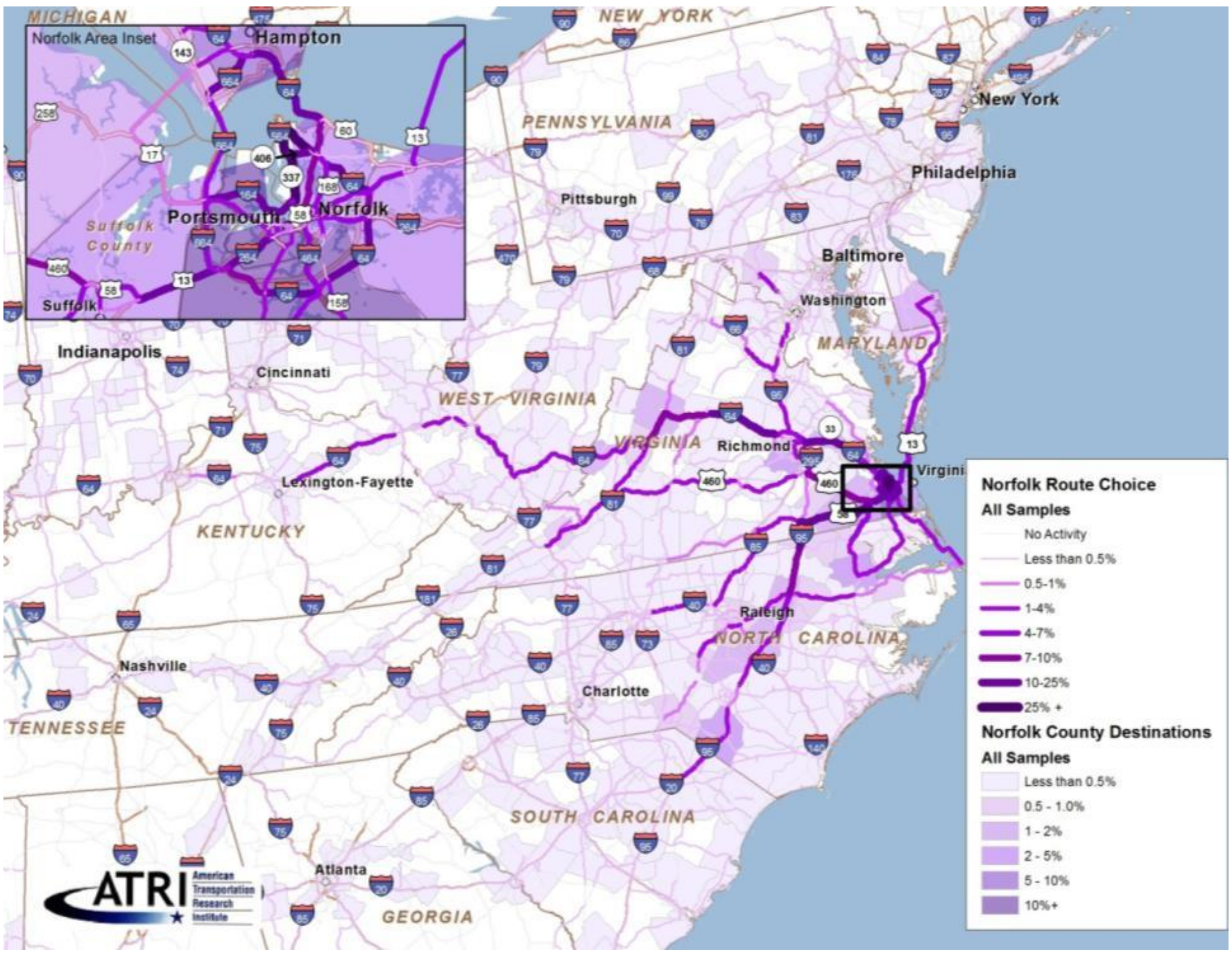


Figure 65: Norfolk Route Choice and Destinations

Table 24: Top 10 Most Utilized Segments - Norfolk

Rank	Route	Location	Share of Total Trips
1	SR 337	I-564 south to US 58 (VA)	51.1%
2	I-564	SR 337 east to I-64 (VA)	45.5%
3	SR 406	SR 337 east to I-564 (VA)	21.7%
4	US 58	US 460 west to I-95 (VA)	20.2%
5	I-64	US 158 north to I-264 (VA)	19.6%
6	US 13	I-664 south to US-58 (VA)	19.3%
7	I-64	US 13 west to SR 168 (VA)	17.6%
8	I-64	US 60 west to I-664 (Hampton Roads Bridge Tunnel) (VA)	17.1%
9	I-64	SR 33 west to I-295 (VA)	15.9%
10	I-664	I-64 south to SR 143 (VA)	15.6%

Similar to the findings in the Savannah analysis, the decrease in trip lengths has led to less utilization of certain corridors outside of the immediate Norfolk region. As Figure 66 illustrates, I-64 westbound, US 58 westbound, and I-95 southbound all experienced declines in utilization by at least 10 percentage points when comparing 2008 to 2012. Conversely, I-64 on the east side of Norfolk experienced a 10 point or more increase in utilization, while US 13 into Delaware also experienced a modest increase. Table 25 and Table 26 contain a list of the segments with the greatest change in utilization.

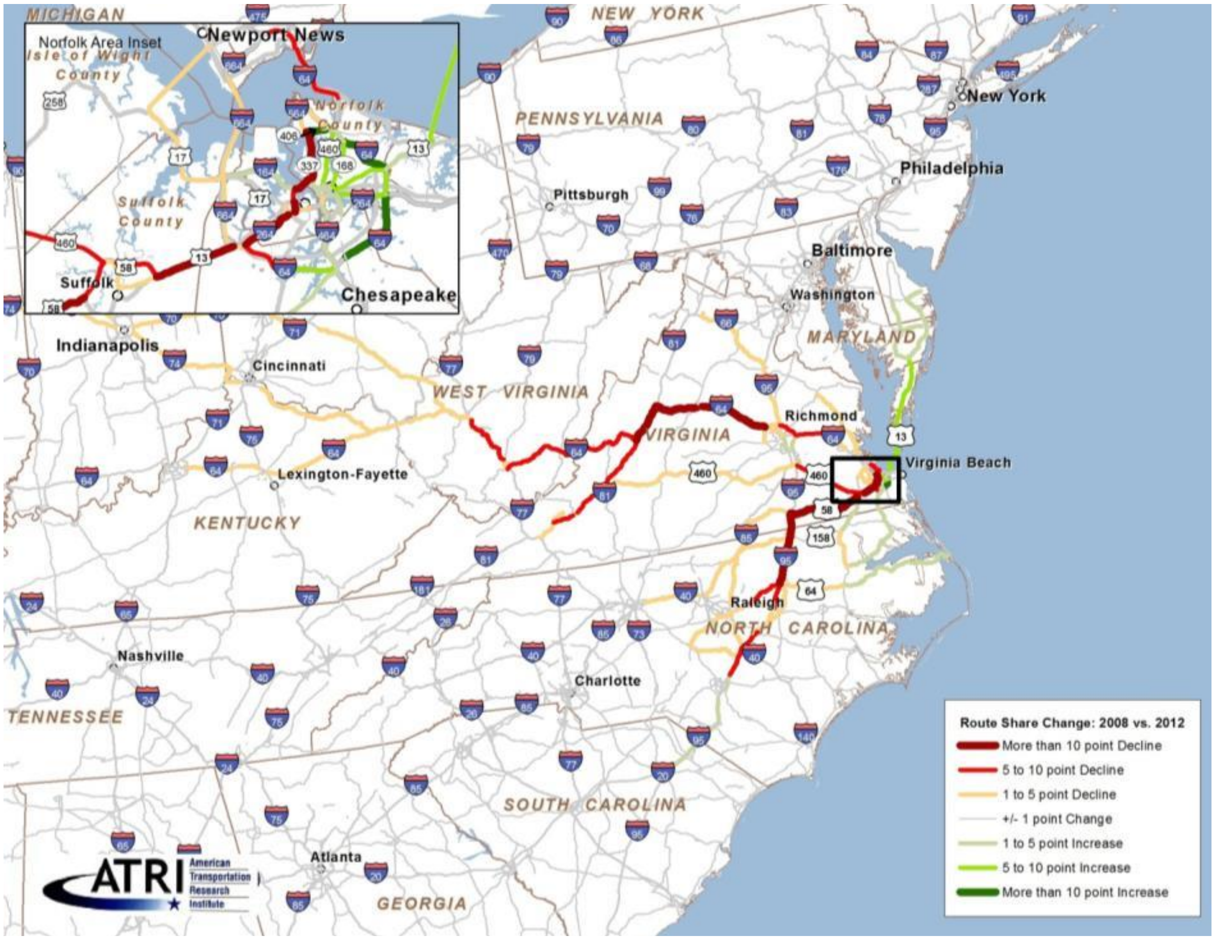


Figure 66: Change in Norfolk Route Utilization

Table 25: Largest Increase in Segment Utilization - Norfolk

Increasing Utilization – Top 5 Corridors					
Rank	**Route**	**Segment**	**2008 Share**	**2012 Share**	**Change in Share 2008 vs. 2012**
1	I-64	US 13 west to SR 168 (VA)	12.9%	32.0%	19.1%
2	SR 406	SR 337 east to I-564 (VA)	16.2%	31.8%	15.7%
3	I-64	US 158 north to I-264 (VA)	15.8%	30.7%	14.9%
4	I-64	I-264 north to US 13 (VA)	4.8%	13.1%	8.3%
5	460	I-64 south to US 58 (VA)	3.9%	10.9%	7.0%

Table 26: Largest Decrease in Segment Utilization - Norfolk

Decreasing Utilization – Top 5 Segments					
Rank	**Route**	**Segment**	**2008 Share**	**2012 Share**	**Change in Share 2008 vs. 2012**
1	US 13	I-664 south to US-58 (VA)	78.3%	9.5%	-68.8%
2	I-264	US 17 south to I-664 (VA)	29.6%	4.7%	-24.9%

Decreasing Utilization – Top 5 Segments					
Rank	**Route**	**Segment**	**2008 Share**	**2012 Share**	**Change in Share 2008 vs. 2012**
3	I-95	US 158 south to US 64 (NC)	21.6%	7.4%	-14.2%
4	I-95	US 58 south to US 158 (NC/VA)	23.7%	9.5%	-14.1%
5	US 58	US 460 west to I-95 (VA)	33.2%	19.2%	-14.0%

Port of New Orleans

The facility analyzed for this study is located along the northern bank of the Mississippi River, south of the New Orleans central business district, as shown in Figure 67. The port is in an urban location, and trucks must travel through the core of New Orleans to reach the major interstate serving the city, I-10. While I-10 is a major east-west corridor, trucks departing the Port of New Orleans must travel out of the metropolitan region before reaching a major north-south interstate.

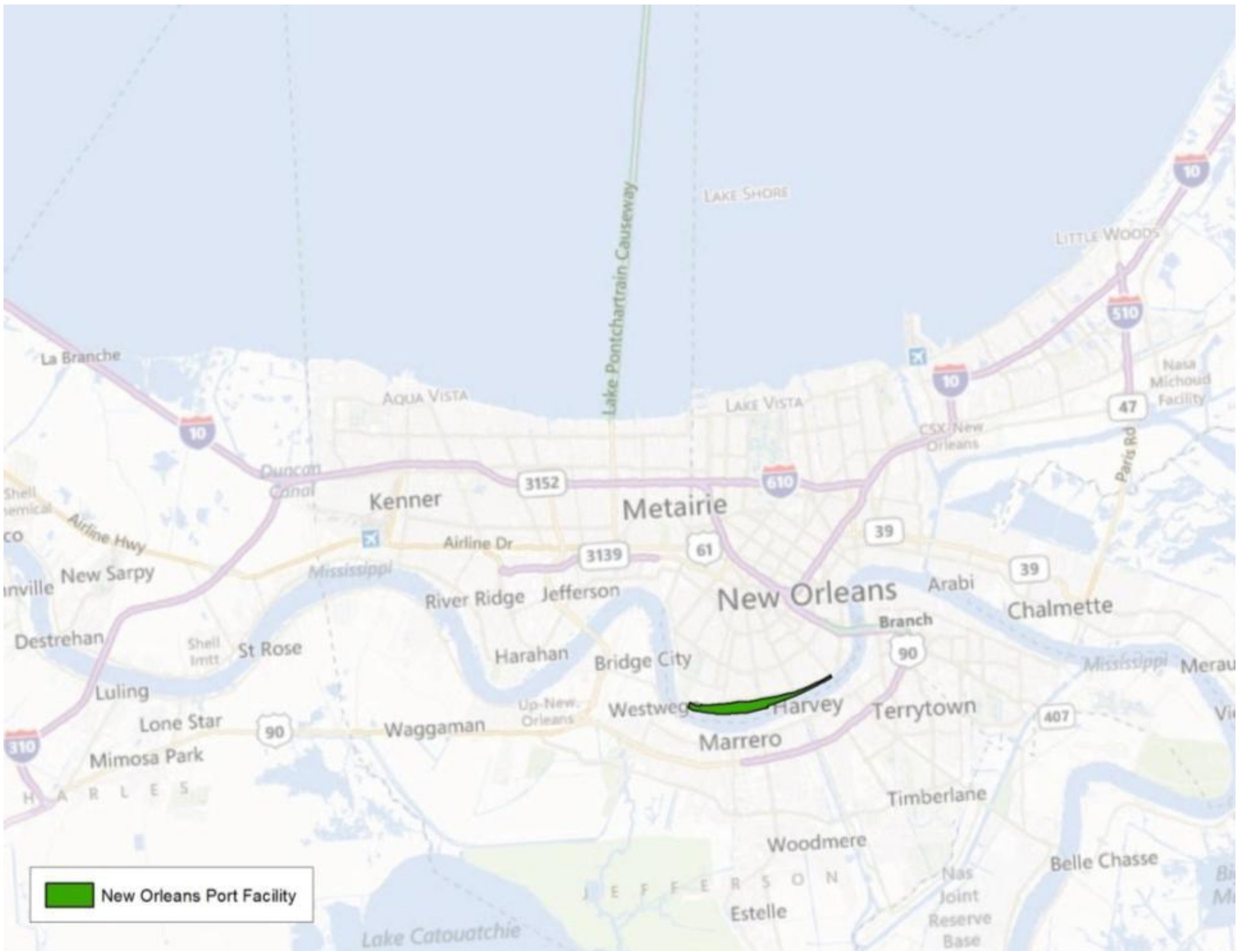


Figure 67: Port of New Orleans

Given the port's location in an urban area with relatively higher land values than the nearby rural areas, it is expected that distribution facilities would be located further from the port compared to what is found in the less urban Savannah metropolitan area. This hypothesis is confirmed when Figure 68 is analyzed, which indicates that New Orleans has a smaller share of short trips (less than 25 miles) than was found in Savannah and Norfolk. Only 25.9 % of New Orleans trips were shorter than 25 miles, and the average trip length of 168.4 miles and median trip length of 117.0 miles are the longest trip lengths of the three ports analyzed. However, Figure 68 also alludes to a declining trip length over the course of the study. When analyzing the trip lengths, the average trip length declined sharply from 280.2 miles in 2008 to 159.6 miles in 2010 before rebounding slightly to 162.0 miles in 2012.

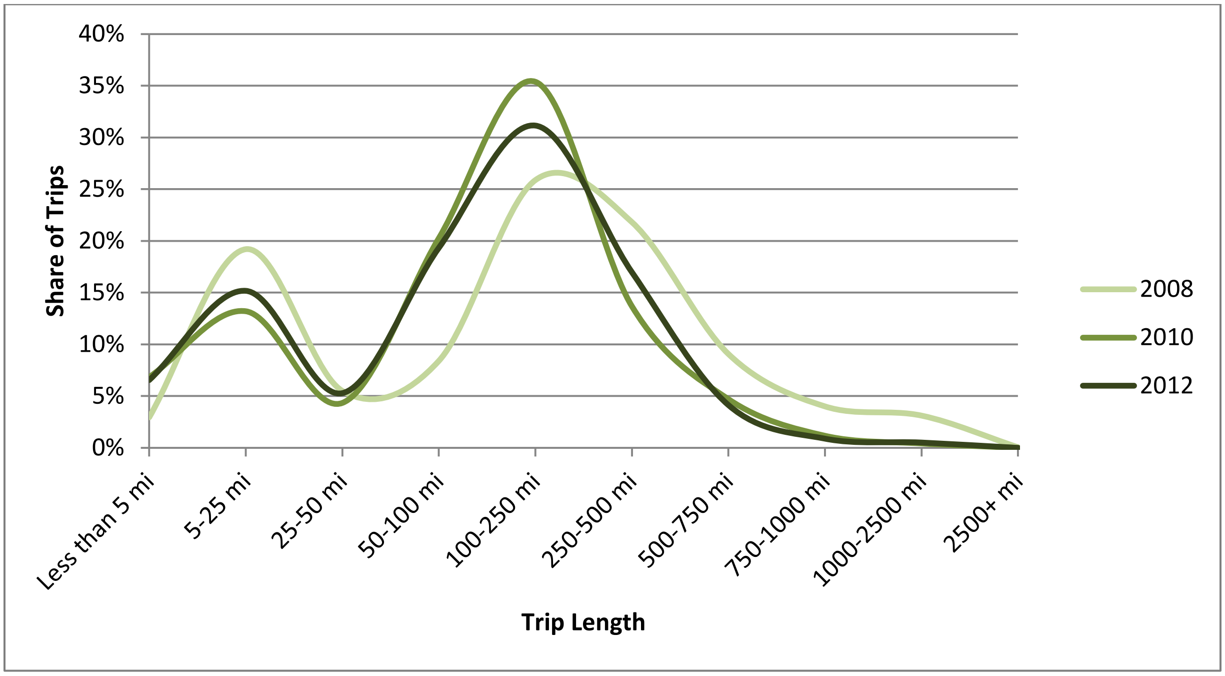


Figure 68: New Orleans Trip Length Distribution by Year

As was the case in Norfolk, the county with the most destinations of New Orleans trips is not the home county of the port, but rather Jefferson Parish, which is a suburban parish west of New Orleans. As Table 27 indicates, Jefferson Parish accounted for over one-third (35.1%) of destinations. Many of the most popular destinations were outside of Louisiana, as shown in Figure 69, with only seven of the top 20 counties located in Louisiana. Other popular destinations were generally near large southern cities, including Gulfport/Biloxi, MS (Harrison, Hancock counties), Jackson, MS (Hinds, Rankin counties), Birmingham, AL (Jefferson County), Mobile, AL (Mobile County), and Atlanta, GA (Carroll County).

Table 27: Top 20 Port of New Orleans Destinations

Rank	County/Parish	State	Share of Destinations
1	Jefferson	LA	35.1%
2	Harrison	MS	18.5%
3	Orleans	LA	9.2%
4	Hinds	MS	3.3%
5	Jefferson	AL	2.1%
6	Mobile	AL	1.6%
7	St. Tammany	LA	1.6%
8	Greene	AL	1.5%
9	Hancock	MS	1.3%
10	St. John the Baptist	LA	1.1%
11	St. Charles	LA	1.1%
12	Tuscaloosa	AL	0.8%
13	Pearl River	MS	0.7%
14	Tangipahoa	LA	0.7%
15	Rankin	MS	0.7%
16	Etowah	AL	0.6%
17	East Baton Rouge	LA	0.6%
18	Warren	KY	0.5%
19	Forrest	MS	0.5%
20	Carroll	GA	0.5%

Figure 69: Top 20 Port of New Orleans Destinations

Given Savannah and Jacksonville's location to the east, and Houston's location to the west, the predominate direction of travel for trucks leaving the New Orleans port is northbound, as illustrated in Figure 70. This is also consistent with the city's historical role as the economic gateway of the Mississippi River. The analysis reveals several heavily travelled corridors, including:

- I-10 eastbound to Biloxi, MS and Mobile, AL continuing on I-65 to Montgomery, AL;
- I-10 eastbound to I-59 northbound to I-20 eastbound toward Birmingham, AL;
- I-55 northbound t toward Memphis, TN; and
- I-10 westbound to I-49 toward Shreveport, LA.

The ten routes with the largest share of utilization are shown in Table 28.

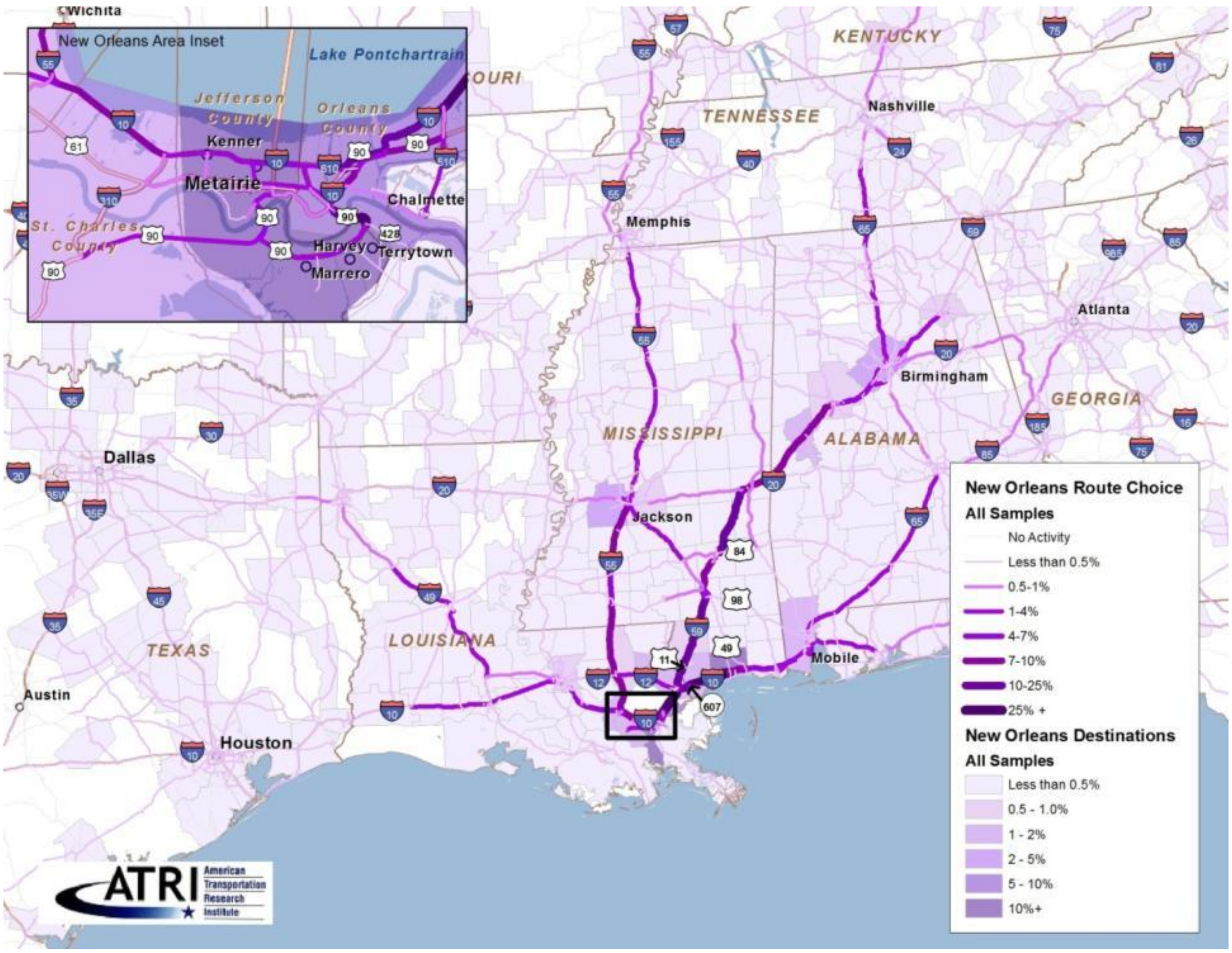


Figure 70: New Orleans Route Choice and Destinations

Table 28: Top 10 Most Utilized Segments – New Orleans

Rank	Route	Location	Share of Total Trips
1	I-10	SR 607 east to US 49 (MS)	43.0%
2	I-10	I-510 east to I-12 (LA)	35.5%
3	US 90	I-10 east to SR 428 (LA)	28.9%
4	US 90	I-610 east to I-10 (LA)	17.6%
5	I-10	US 90 east to I-510 (LA)	14.4%
6	I-10	I-59 east to SR 607 (LA/MS)	13.8%
7	I-59	US 11 north to US 98 (MS)	12.7%
8	I-59	US 84 north to I-20 (MS)	11.1%
9	I-59	I-10 north to US 11 (LA/MS)	11.0%
10	I-59	US 98 north to US 84 (MS)	9.4%

As found with the other ports, there has been a decrease in trip lengths which led to a decrease in utilization of certain corridors. In the case of New Orleans, it appears that I-55 experienced the biggest loss in utilization between 2008 and 2012, as illustrated by Figure 71. I-10 westbound also experienced a decline in share, as did the I-20 corridor. The exception appears to be the I-10 easbtound corridor through Gulfport/Biloxi, MS, which saw a noticeable increase in utilization between 2008 and 2012. The locations with the greatest increases and decreases in utilization are listed in Table 29 and Table 30.

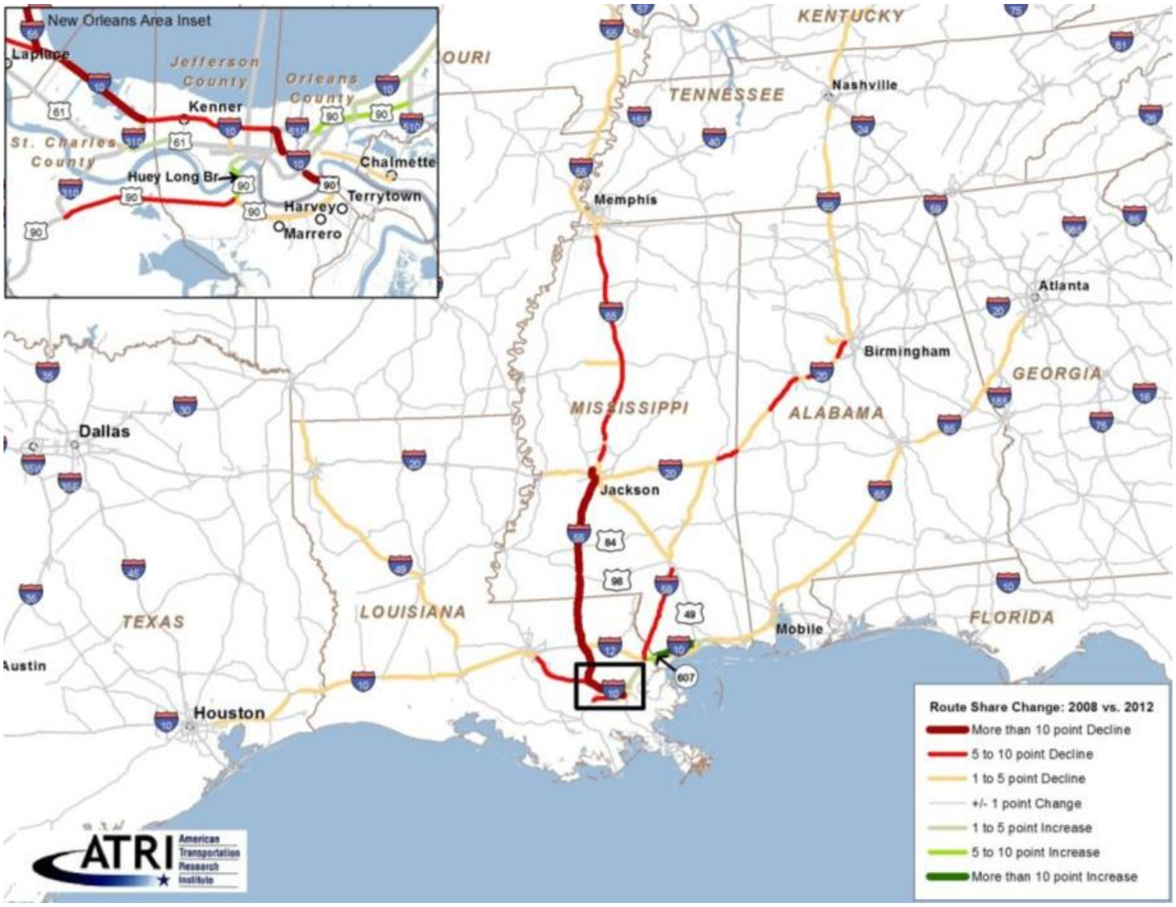


Figure 71: Change in New Orleans Route Utilization

Table 29: Largest Increase in Segment Utilization – New Orleans

Increasing Utilization – Top 5 Corridors					
Rank	Route	Segment	2008 Share	2012 Share	Change in Share 2008 vs. 2012
1	I-10	SR 607 east to US 49 (MS)	14.5%	43.6%	29.1%
2	US 90	I-610 east to I-10 (LA)	12.7%	20.2%	7.5%
3	US 90	I-10 east to I-510 (LA)	1.6%	7.6%	6.1%
4	I-10	I-59 east to SR 607 (LA/MS)	9.3%	15.3%	6.0%
5	US 90	Huey Long Bridge (LA)	1.1%	6.4%	5.3%

Table 30: Largest Decrease in Segment Utilization – New Orleans

Decreasing Utilization – Top 5 Segments					
Rank	Route	Segment	2008 Share	2012 Share	Change in Share 2008 vs. 2012
1	I-55	I-10 north to I-12 (LA)	31.6%	8.3%	-23.3%

Decreasing Utilization – Top 5 Segments					
Rank	Route	Segment	2008 Share	2012 Share	Change in Share 2008 vs. 2012
2	I-55	I-12 north to US 98 (LA/MS)	28.3%	7.6%	-20.7%
3	I-55	US 84 north to I-20 (MS)	26.7%	6.7%	-20.0%
4	I-55	US 98 north to US 84 (MS)	25.9%	6.1%	-19.8%
5	I-10	I-310 west to I-55 (LA)	25.8%	7.0%	-18.9%

Policy Implications

Once a truck leaves a port, vehicle movement appears to be highly influenced by the location of the port. Given the amount of freight that passes through ports, freight warehousing and distribution facilities tend to locate nearby. Generally these facilities have a large footprint and locate in more rural locations where land values are less expensive and traffic congestion is minimal. Therefore, trucks that serve ports in more urbanized locations are more likely to have longer average trip lengths since these key distribution facilities are further away. The analysis revealed that the trucks leaving the Port of Savannah had the shortest average trip length, while trucks leaving the ports of Norfolk and New Orleans had longer average trip lengths. This correlates with the less urban location of Savannah compared to Norfolk and New Orleans.

Across all three ports, average truck trip lengths declined from 2008 to 2012. The sharpest declines were recorded in Norfolk and New Orleans between 2008 and 2010 which coincided with the most severe portion of the recession. It is possible that the recession affected truck travel patterns due to a decline in business and a consolidation of operations. Between 2010 and 2012, as the recession ended and a slow recovery began, trip lengths stabilized and, in some cases, rose slightly.

The decrease in trip lengths also resulted in a decrease in utilization for certain routes leaving the port area, particularly those routes that served longer-distance destinations. Conversely, certain routes that served more proximate destinations saw an increase in utilization.

If the trend of shorter truck trips and destinations closer to the ports continues, it will require upgrades to the local and regional transportation network as more and more trucks utilize these secondary roads to reach key warehousing and distribution facilities. As new logistics facilities locate or expand near ports, investments in important connecting roads will also be necessary.

This route selection portion of the study evaluated the first trip segment that a truck makes after leaving a port. The logistics and distribution centers continue to generate freight traffic to transport the same commodities that came in through the port to storage, warehousing, and retail destinations. These second leg freight trips also rely on the hinterland interstate highway and arterial road network. The following section takes a deeper look at the entire freight region.

Port-to-Destination Performance Analysis from the Megaregion Perspective

Methodology

While the previous section focused on the characteristics of truck trips from each port, this section is designed to study the operational region of trucks once leaving the port analyzing three main characteristics.

- Size of the region and extent of the trucking transportation network
- Ease of trucking mobility in the region
- Availability of truck parking

The first step is to establish a truck operating region for each port. While trucks often travel well over 500 miles for a single leg of a trip, ATRI sought to establish an operating region that represented a reasonable distance that a truck could travel in one working day. According to Hours-of-Service Regulations maintained by the Federal Motor Carrier Safety Administration, the maximum daily driving time for truck drivers is 11 hours (U.S. Department of Transportation, 2013). Given that drivers will have some on-duty time where they are not driving the vehicle, the maximum amount of time a driver would actually be driving is typically closer to 10 hours. Previous work by ATRI has shown the average speed of trucks to be 39.98 miles per hour (American Transportation Research Institute, 2013a), which would translate to a daily operating region of approximately 400 miles (10 hours x 39.98 miles per hour). Given that over 95% of the trips identified in the previous analysis were 400 miles or less, a 400-mile operations range appeared to be an appropriate assumption. Using that threshold, Figure 72 presents the resulting operating regions for each of the three ports.

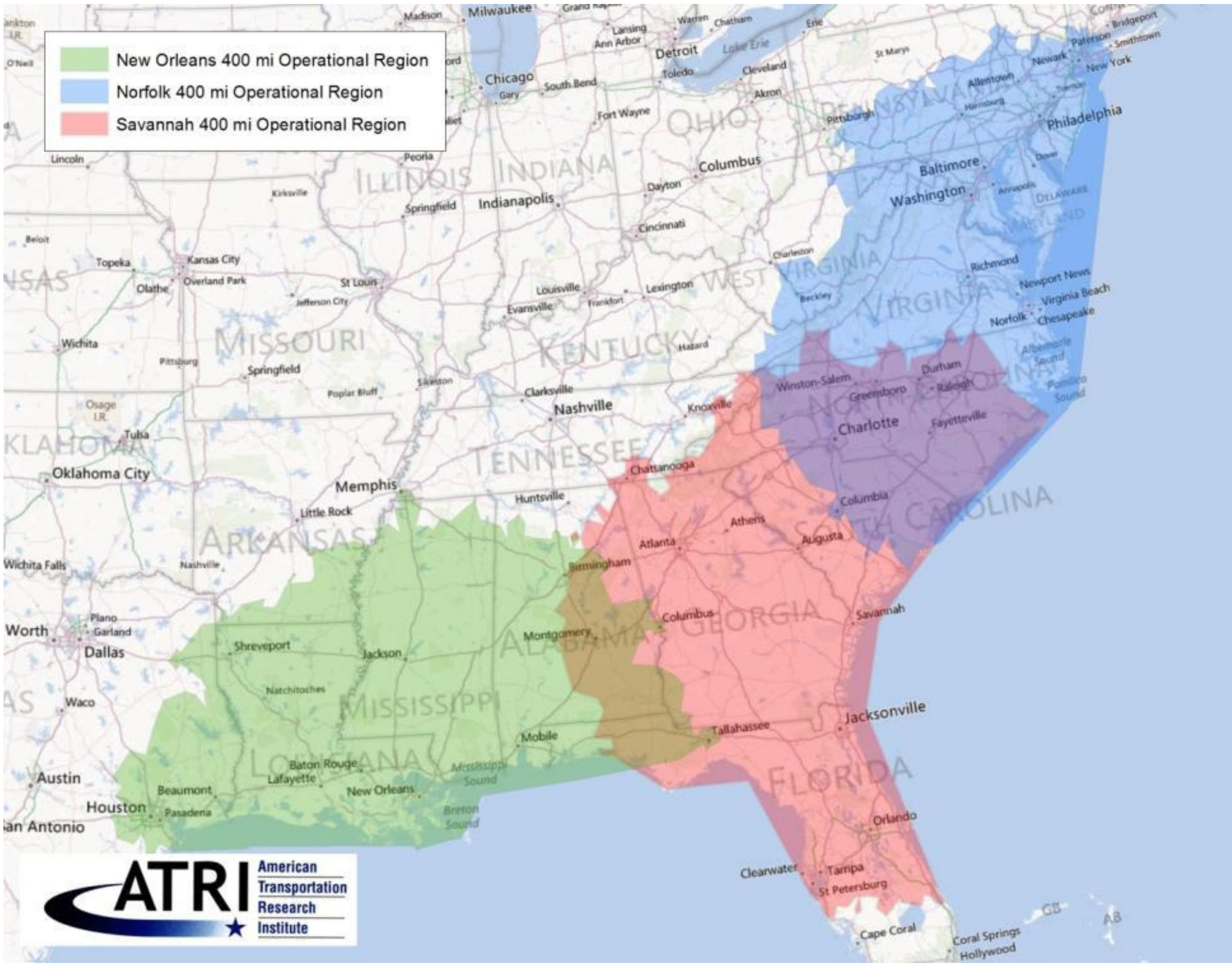


Figure 72: Operational Regions

With the 400-mile regional operation threshold, ATRI then began to link those regions with a variety of different data sources to determine the characteristics of those regions. These data sources included:

- Population data from the Census Bureau at the census tract level (US Census Bureau, 2013)
- Road network data from the Freight Analysis Framework (FAF) (Federal Highway Administration, 2013)
- Federal Highway Administration truck parking facility database
- ATRI's National Corridors Analysis and Speed Tool (NCAST) (American Transportation Research Institute, 2012)

In addition to geospatial analysis, ATRI also conducted a travel time analysis for major routes (each 400 miles in length) that trucks utilize once leaving the port. Building upon the analysis at the beginning of Section V, ATRI selected five of the most heavily utilized interstate highway routes to analyze. Using hourly average speed information in ATRI's NCAST tool, a best-case and worst-case travel time along each 400-mile route was calculated based on departure time. The differential between the two travel times provides a congestion indicator. Large differentials indicate that severe congestion occurs at certain times of day along the corridor. A small differential suggests that there is no time of day when congestion along the corridor increases significantly.

Analysis

The next subsections provide an overview of each region's operations. Following the individual analyses, a combined analysis is presented to compare and contrast the characteristics of each region.

Port of Savannah

The operating region for trucks departing the port of Savannah, shown in Figure 73, covers all or most of Georgia, South Carolina, and North Carolina, as well as northern Florida, far eastern Tennessee, and eastern Alabama. This region, which includes major cities such as Atlanta, Charlotte, Jacksonville, Orlando, and Tampa, is home to approximately 37.8 million residents according to the 2010 Census.

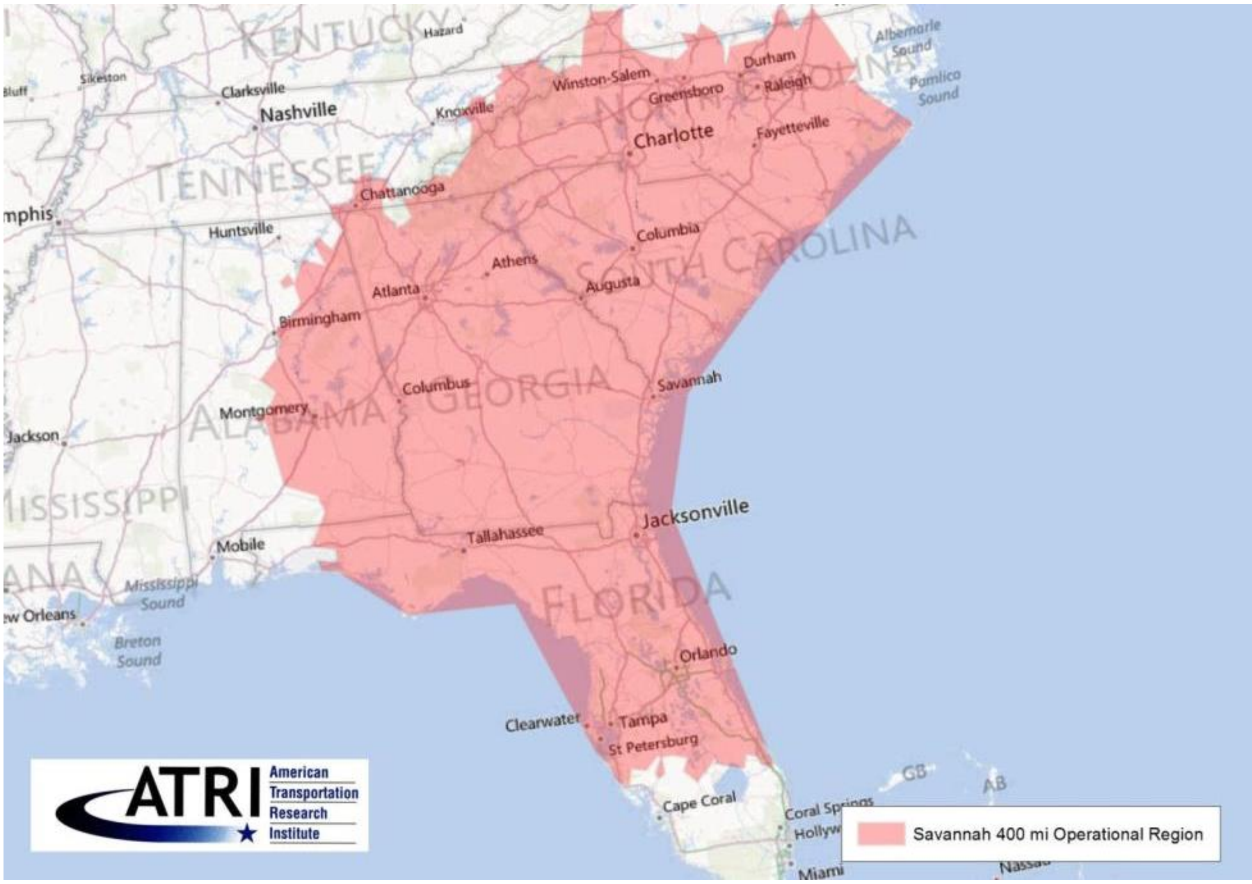


Figure 73: Port of Savannah Operational Region

An analysis of the region's road network reveals an extensive highways network that serves to move freight. The Federal Highway Administration's Freight Analysis Framework (FAF3) is used as a planning tool to study the movement of freight nationally. The routes included in FAF3 are the key roadways used by trucks to transport goods, and are indicative of the scope of the primary truck network in the United States. Within the Savannah region, there are 51,842 centerline miles of FAF3 roads, which is the most of any of the three port regions studied. In 2007, it was estimated that these roads generated 86.2 million miles in truck VMT daily, indicating an average daily volume of 1,663 trucks per centerline mile (daily VMT/centerline mileage). By 2040, daily VMT is expected to nearly double to 171.8 million miles per day.

ATRI selected five heavily travelled interstate routes used by trucks leaving the Port of Savannah to determine congestion levels. The five routes selected are illustrated in Figure 74, each of which is 400 miles in length. These routes are characterized by the highways, urban areas, and average daily truck VMT in 2007 shown in Table 31.

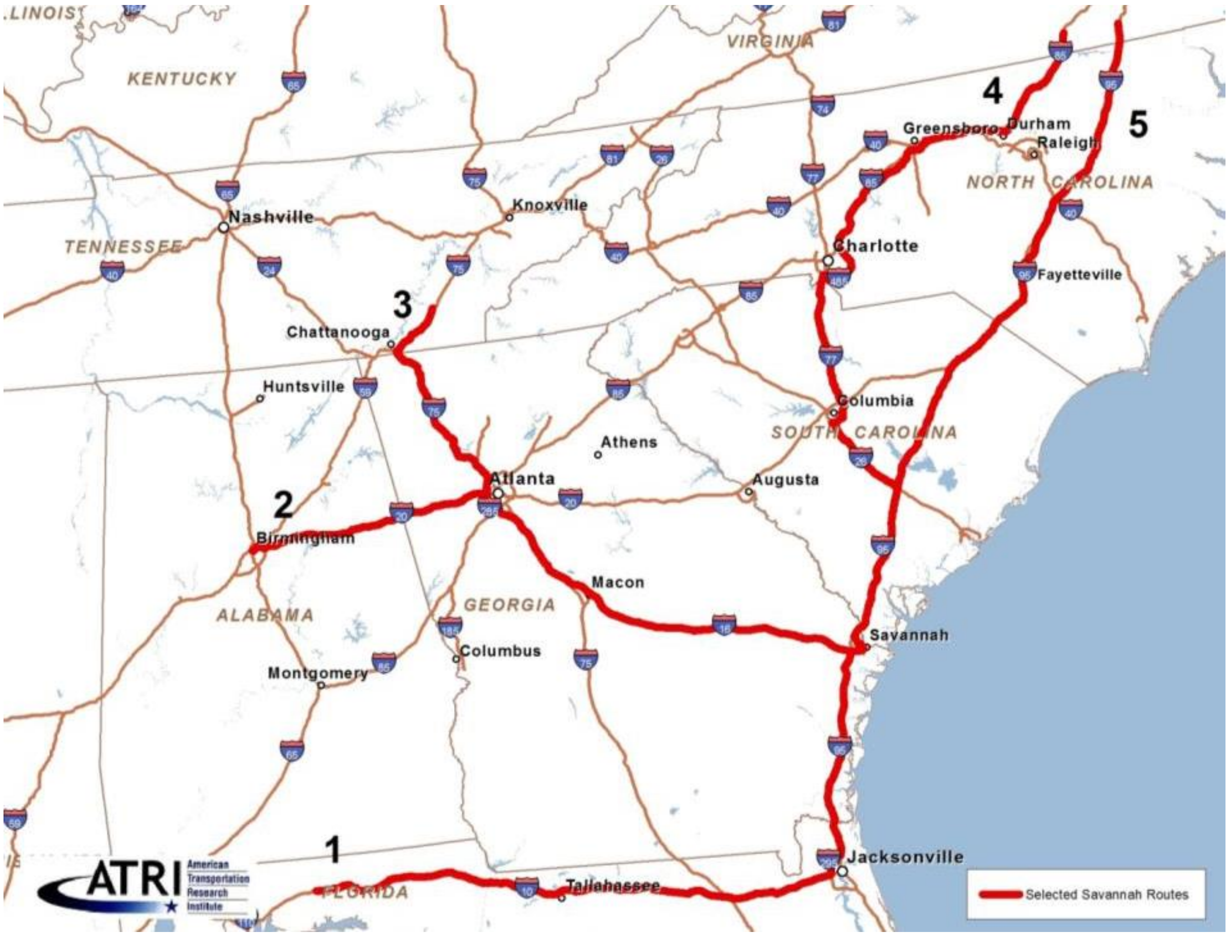


Figure 74: Selected Routes Departing Savannah

Table 31: Profile of Selected Savannah Routes

Route #	Highways	Urban Aras	Average Daily Truck VMT
1	I-95 south to I-10 west	Savannah, GA; Jacksonville, FL; Tallahassee, FL	3,061,749
2	I-16 west to I-285 north to I-20 west	Savannah, GA; Macon, GA; Atlanta, GA; Birmingham, AL	3,876,592

Route #	Highways	Urban Aras	Average Daily Truck VMT
3	I-16 west to I-285 north to I-75 north	Savannah, GA; Macon, GA; Atlanta, GA; Chattanooga, TN; Knoxville, TN	4,280,456
4	I-95 north to I-26 west to I-77 north to I-85 north	Savannah, GA; Columbia, SC; Charlotte, NC; Greensboro, NC; Durham, NC	3,836,883
5	I-95 north	Savannah, GA; Fayetteville, NC	2,668,798

Source: Freight Analysis Framework (FAF3), Federal Highway Administration

ATRI then calculated the minimum and maximum travel times on each road based on average speed data from NCAST and time of departure. The travel time differential between the minimum and maximum travel time indicates how congestion varies during an average day. Table 32 presents the travel times of the five routes and reveals that there is relatively little variation in travel times, suggesting minimal congestion on these routes. Route three has the largest differential, 35:01, likely due to that route's exposure to Atlanta congestion.

Table 32: Travel Time Analysis for Savannah

Route #	Route Name	Average Travel Time	Minimum Travel Time	Maximum Travel Time	Max – Min Differential
1	I-95 S to I-10 W	6:31:30	6:25:55	6:35:20	0:09:25
2	I-16 W to I-20 W	6:39:10	6:33:37	6:48:37	0:14:59
3	I-16 W to I-75 N	6:38:29	6:29:25	7:04:26	0:35:01
4	I-95 N to I-85 N	6:29:53	6:21:36	6:36:16	0:14:40
5	I-95 N	6:24:46	6:20:40	6:30:01	0:09:21

Source: ATRI's National Corridors Analysis and Speed Tool (NCAST) (American Transportation Research Institute, 2012)

ATRI also analyzed the prevalence of truck parking facilities in the Savannah region. Figure 75 shows the location of known truck parking facilities in the region. According to the database, the region has 652 parking facilities, accounting for 36,224 parking spaces, which equates to one parking space for every 2,380 daily miles travelled. ATRI also conducted a similar analysis along the five routes shown in Figure 74. As Table 33 indicates, Route 1 has the most favorable ratio of parking spaces to daily truck VMT (one space per 867 miles) while Route 2 had the least favorable ratio (one space per 1,507 miles).

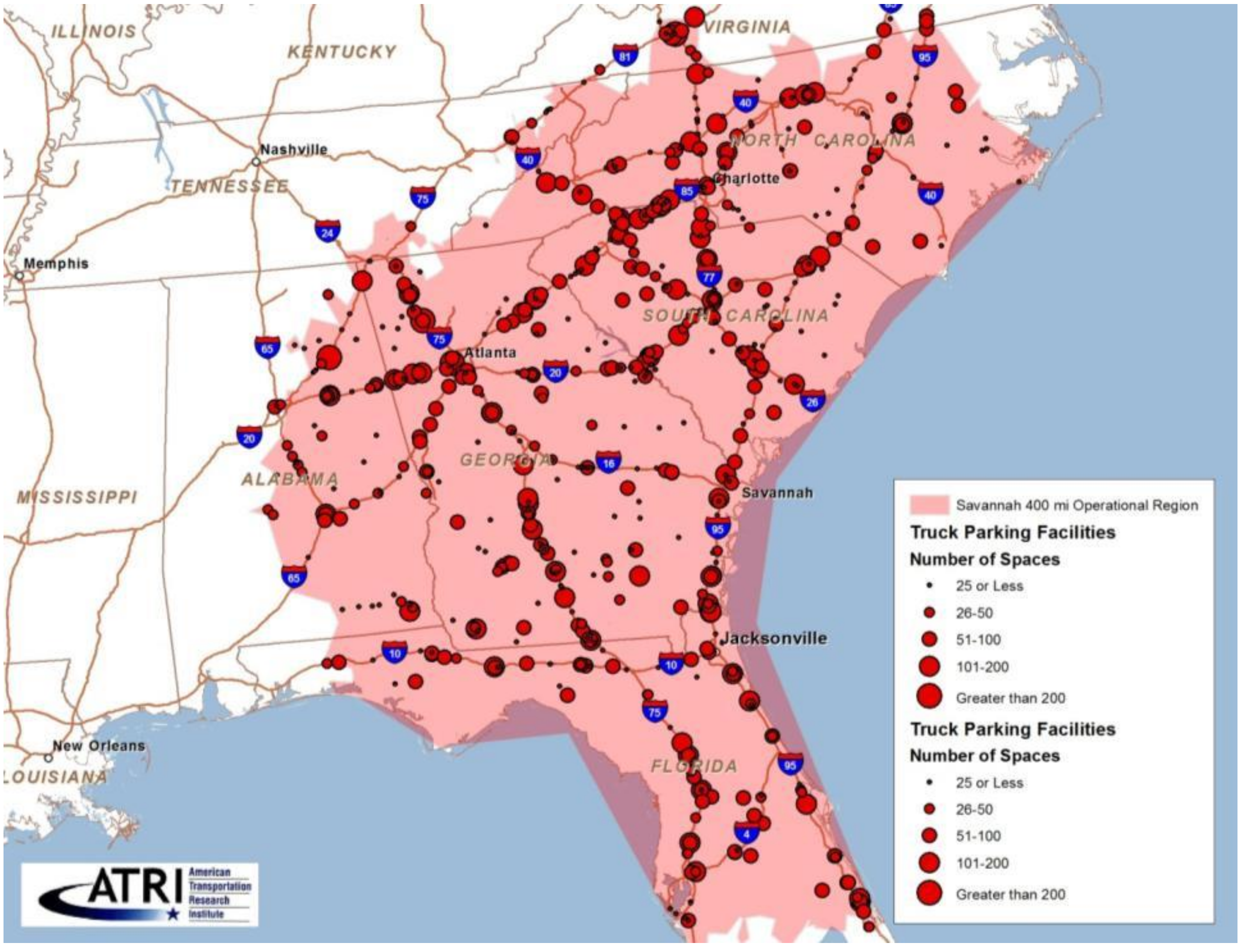


Figure 75: Truck Parking Facilities in the Savannah Operational Region

Table 33: Parking Characteristics along Selected Routes Departing Savannah

Route #	Route Name	Number of Spaces	Total Daily VMT	Truck Miles per Space
1	I-95 S to I-10 W	3,531	3,061,749	867
2	I-16 W to I-20 W	2,572	3,876,592	1,507
3	I-16 W to I-75 N	2,954	4,280,456	1,449
4	I-95 N to I-85 N	3,574	3,836,883	1,074
5	I-95 N	2,898	2,668,798	921

Source: Freight Analysis Framework (FAF3), Federal Highway Administration; Federal Highway Administration truck parking facility database

Port of Norfolk

As shown in Figure 76, Norfolk's truck region extends along the eastern seaboard from New York City to Columbia, SC and westward to Pittsburgh, PA and West Virginia. This region, which includes some of the nation's largest cities, is home to approximately 56.2 million residents according to the 2010 Census, which is by far the largest population of any of the three port regions studied.

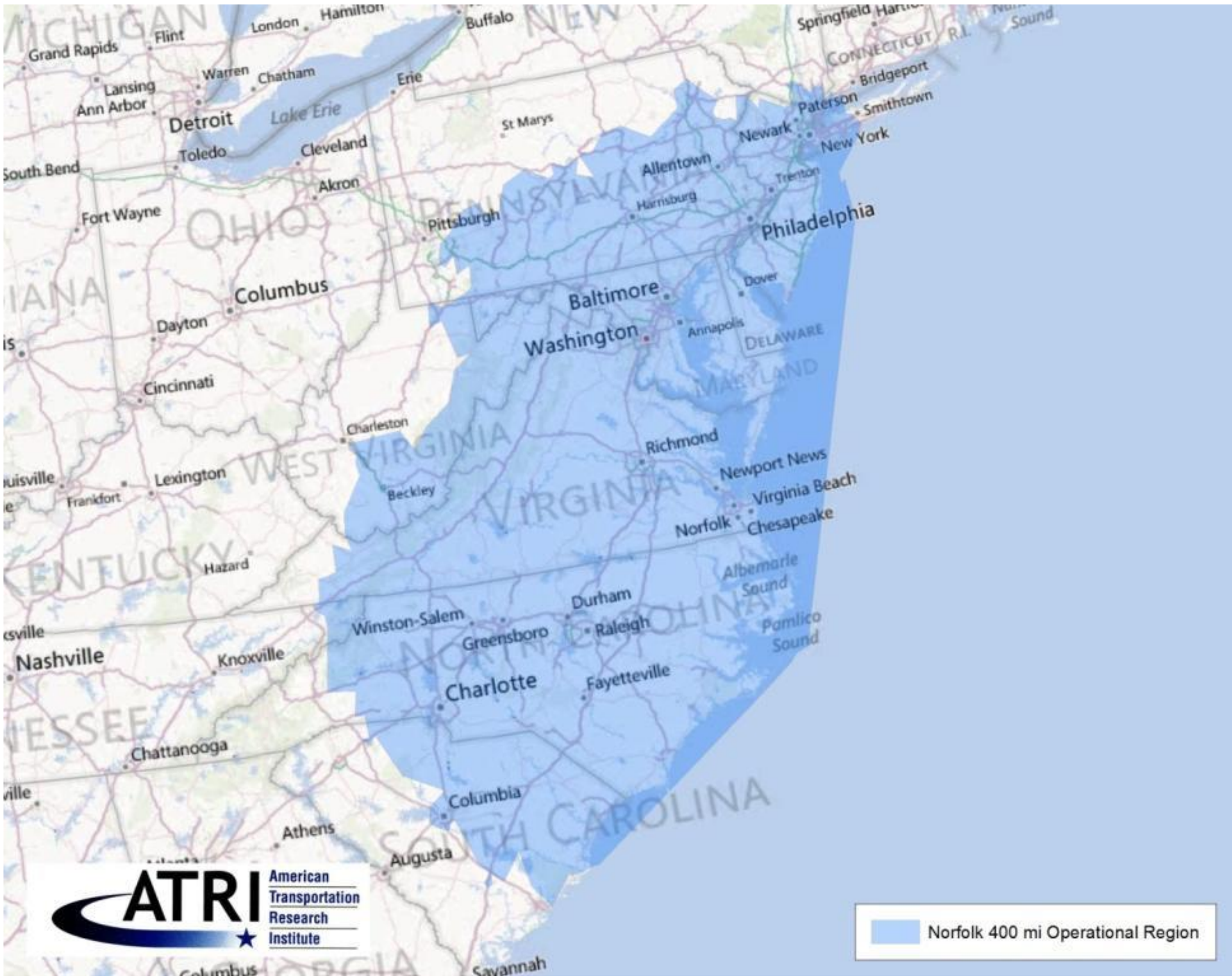


Figure 76: Port of Norfolk Operational Region

Interestingly, despite the region's higher population, it contains fewer FAF3 centerline miles than the Savannah truck region (43,445 centerline miles compared to 51,842 centerline miles respectively). However, the 2007 daily truck VMT in the Norfolk region is larger than that of the Savannah region (91.1 million miles per day, versus 86.2 million miles), which indicates that the Norfolk region is more congested. On average, each mile of FAF3 roadway was used by 2,097 trucks per day, compared to only 1,663 trucks in Savannah. By 2040, truck VMT in the Norfolk region is expected to increase to 167.3 million miles per day.

A travel time analysis of five key routes confirms that the Norfolk region is subjected to more congestion than the Savannah region. Figure 77 displays the five routes selected for analysis while Table 34 presents the highways, urban areas, and average daily truck VMT for each route.

Figure 77: Selected Routes Departing Norfolk

Table 34: Profile of Selected Norfolk Routes

Route #	Highways	Urban Aras	Average Daily Truck VMT
1	US 58 west to I-95 south	Norfolk, VA; Fayetteville, NC	2,285,909
2	US 460 west to I-85 south to I-40 west	Norfolk, VA; Durham, NC; Greensboro, NC; Winston-Salem, NC	2,815,943
3	I-64 west to I-295 north to I-64 west to I-81 south	Norfolk, VA; Richmond, VA	3,404,109
4	I-64 west to I-295 north to I-64 west	Norfolk, VA; Richmond, VA; Charleston, WV	2,089,478
5	I-64 west to I-95 north (incl. I-295 in VA, I-895 in MD, I-295 in NJ, and I-195 in NJ)	Norfolk, VA; Richmond, VA; Washington, DC; Baltimore, MD; Philadelphia, PA	4,998,452

Source: Freight Analysis Framework (FAF3), Federal Highway Administration

Table 35 presents the results of the route travel time analysis. The Norfolk differentials tend to be larger than the Savannah differentials. Route 5, which traverses Washington, DC, Baltimore, and Philadelphia has the largest differential of any route in the three-port analysis (1:21:04).

Table 35: Travel Time Analysis for Norfolk

Route #	Route Name	Average Travel Time	Minimum Travel Time	Maximum Travel Time	Max – Min Differential
1	US 58 W to I-95 S	6:35:52	6:28:03	6:56:38	0:28:35
2	US 460 W to I-85 S	6:49:04	6:41:52	7:07:20	0:25:28
3	I-64 W to I-81 S	6:47:12	6:33:30	7:13:13	0:39:43
4	I-64 W	6:57:57	6:46:07	7:26:39	0:40:32
5	I-64 W to I-95 N	7:13:28	6:40:57	8:02:02	1:21:04

Source: ATRI's National Corridors Analysis and Speed Tool (NCAST) (American Transportation Research Institute, 2012)

Truck parking appears to be less prevalent in the Norfolk truck region. Despite the higher VMT, the region has fewer truck parking facilities than the Savannah region. According to the truck parking database, the region has 468 parking facilities (shown in Figure 78) with 26,582 parking spaces. This equates to one truck parking space for every 3,428 daily truck miles travelled (compared to 2,380 miles per space in the Savannah region). A parking analysis was also conducted for the five routes shown in Figure 77. As Table 36 indicates, Route 1 had the most favorable ratio of parking spaces to daily truck VMT (1 space per 826 miles) while Route 5 had the least favorable ratio (1 space per 1,713 miles).

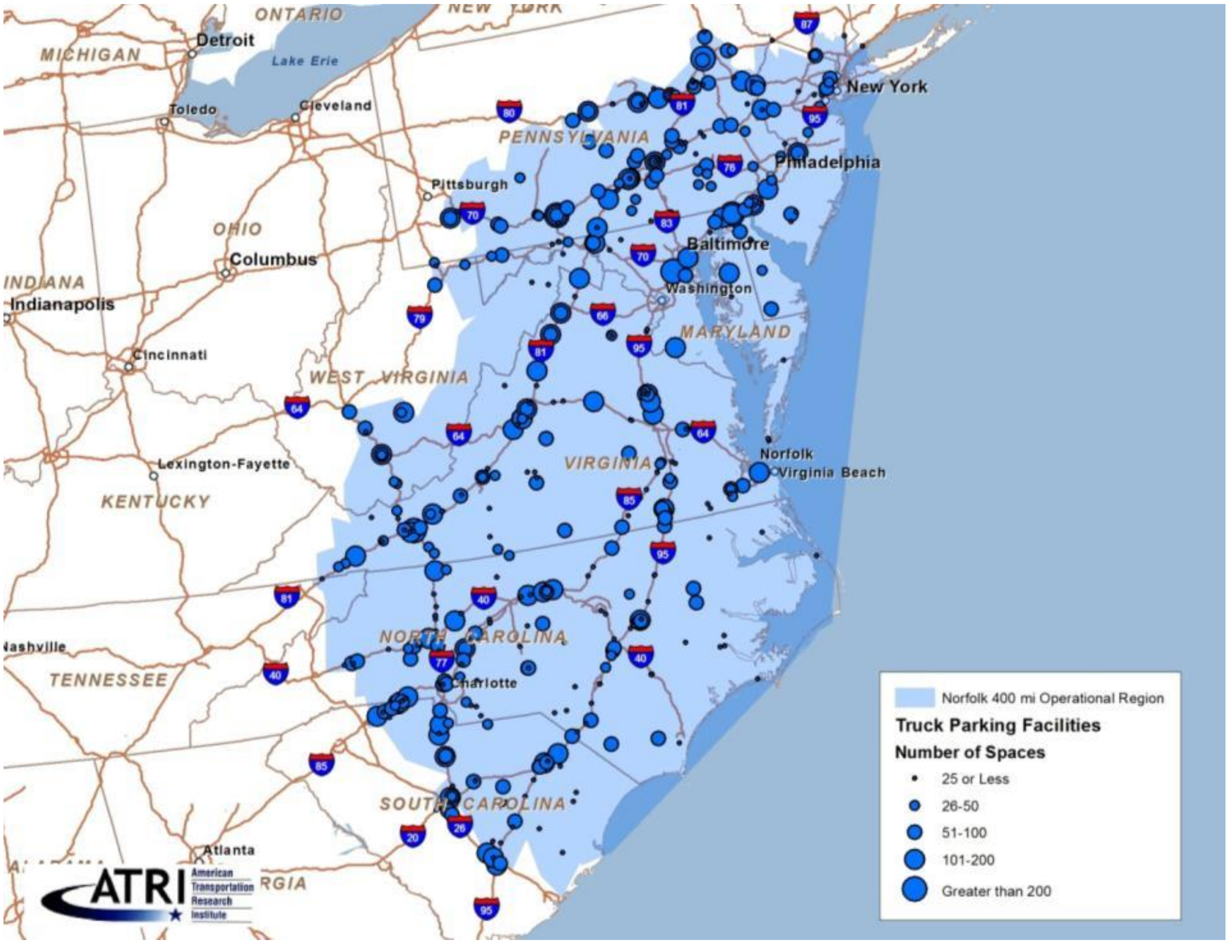


Figure 78: Truck Parking Facilities in the Norfolk Operational Region

Table 36: Parking Characteristics along Selected Routes Departing Norfolk

Route #	Route Name	Number of Spaces	Total Daily VMT	Truck Miles per Space
1	US 58 W to I-95 S	2,768	2,285,909	826
2	US 460 W to I-85 S	2,335	2,815,943	1,206
3	I-64 W to I-81 S	2,497	3,404,109	1,363
4	I-64 W	1,378	2,089,478	1,516
5	I-64 W to I-95 N	2,918	4,998,452	1,713

Source: Freight Analysis Framework (FAF3), Federal Highway Administration; Federal Highway Administration truck parking facility database

Port of New Orleans

The operating region for trucks departing the port of New Orleans extends along the Gulf Coast from Houston, TX to Tallahassee, FL and north to Memphis, TN (Figure 79). Of the three regions studied, the New Orleans region has the smallest population at 19.7 million residents in 2010.

Figure 79: Port of New Orleans Operational Region

Commensurate with the region's smaller population, it also has fewer FAF3 centerline miles (33,875 centerline miles, the least of the three regions). In 2007, it was estimated that these roads accounted for 54.4 million miles in daily truck VMT which, again, is the smallest of the three regions. The average truck volume per mile was also the lowest at 1,606 trucks per mile per day (slightly below Savannah, which was 1,663 trucks per mile per day). However, this region is expected to see the largest percentage increase in VMT over the next few decades, according to FAF3 projections. By 2040, the daily VMT is expected to more than double to 119.0 million miles per day, which is a 119 % increase over 2007 levels.

The five routes selected for the New Orleans travel time analysis are shown in Figure 80. These routes are characterized by the highways, urban areas, and average daily truck VMT shown in Table 37.

Figure 80: Selected Routes Departing New Orleans

Table 37: Profile of Selected New Orleans Routes

Route #	Highways	Urban Areas	Average Daily Truck VMT
1	I-10 west to I-49 north to I-20 west	New Orleans, LA; Baton Rouge, LA; Shreveport, LA	2,959,799
2	I-10 west to I-55 north	New Orleans, LA; Jackson, MS; Memphis, TN	1,737,887
3	I-10 east to I-59 north to I-65 north	New Orleans, LA; Birmingham, AL	2,993,810
4	I-10 east to I-65 north to I-85 north	New Orleans, LA; Mobile, AL; Montgomery, AL	3,064,909
5	I-10 east	New Orleans, LA; Mobile, AL; Tallahassee, FL	2,915,876

Source: Freight Analysis Framework (FAF3), Federal Highway Administration

Table 38 presents the five routes' travel times. Given the lower VMT figures for the region, it was expected that region's congestion would be minimal. Nevertheless, travel time differentials remained generally larger than in the Savannah region. It appears that even with the region's semi-rural nature, the Port of New Orleans' urban location is likely subjecting trucks to congestion when leaving the port. The routes' travel time differentials are similar, which suggests that the source of the congestion is near to the port. All trucks would be subjected to the congestion when leaving, regardless of final destination. A review of the NCAST average speeds find that such a scenario is indeed occurring. The key road connecting the port to I-10 generally experiences speeds between 40 and 45 miles per hour during overnight hours. However, average speeds drop as low as 15 miles per hour during the afternoon.

Table 38: Travel Time Analysis for New Orleans

Route #	Route Name	Average Travel Time	Minimum Travel Time	Maximum Travel Time	Max – Min Differential
1	I-10 W to I-49 N	6:42:10	6:30:25	7:04:00	0:33:35
2	I-10 W to I-55 N	6:36:45	6:27:28	6:59:39	0:32:10
3	I-10 E to I-59 N	6:31:28	6:25:05	6:49:42	0:24:37
4	I-10 E to I-85 N	6:31:16	6:23:23	6:50:05	0:26:42
5	I-10 E	6:31:36	6:23:47	6:52:57	0:29:11

Source: ATRI's National Corridors Analysis and Speed Tool (NCAST) (American Transportation Research Institute, 2012)

Of the three regions, truck parking appears to be most plentiful in the New Orleans region, relative to truck VMT. According to the truck parking database, the region has 572 parking facilities (shown in Figure 81**Error! Reference source not found.**) with 29,714 parking spaces. This equates to one truck parking space for every 1,831 daily truck miles travelled on the FAF. A similar parking analysis was also performed for the five routes shown in Table 39. As Table 39 shows, Route 2 had the most favorable ratio of parking spaces to daily truck VMT (1 space per 744 miles) while Route 4 had the least favorable ratio (1 space per 1,485 miles).

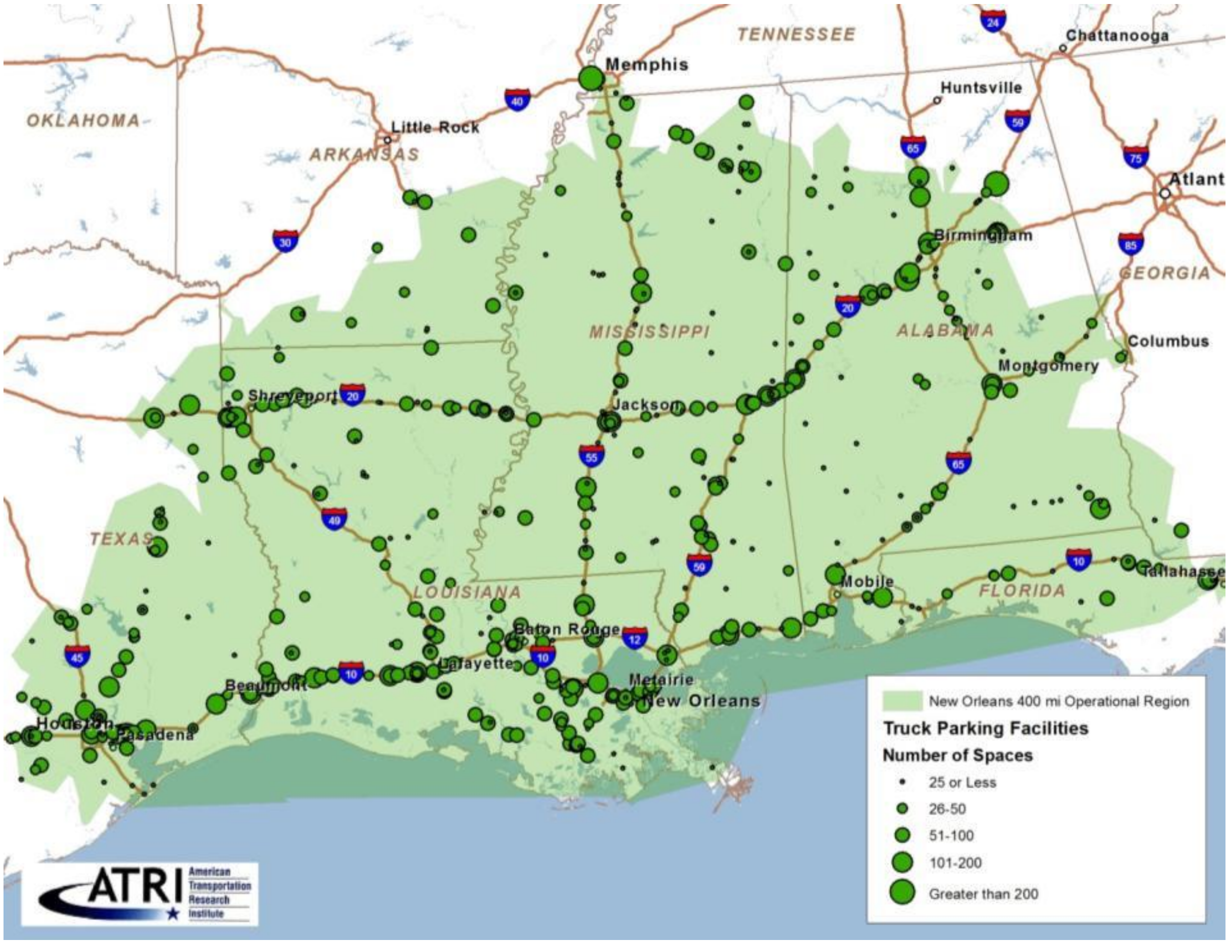


Figure 81: Truck Parking Facilities in the New Orleans Operational Region

Table 39: Parking Characteristics along Selected Routes Departing New Orleans

Route #	Route Name	Number of Spaces	Total Daily VMT	Truck Miles per Space
1	I-10 W to I-49 N	2,395	2,959,799	1,236
2	I-10 W to I-55 N	2,337	1,737,887	744
3	I-10 E to I-59 N	3,417	2,993,810	876
4	I-10 E to I-85 N	2,064	3,064,909	1,485
5	I-10 E	2,377	2,915,876	1,227

Source: Freight Analysis Framework (FAF3), Federal Highway Administration; Federal Highway Administration truck parking facility database

Comparative Analysis

Each of the three regions exhibits different characteristics, as demonstrated by Table 40. Norfolk's region overlaps with some of the heavily populated northeastern cities, which gives it the largest population of the three regions. While that population density translates to more destinations to ship freight to, it also equates to more congestion on the roadways. The Norfolk region has the highest average number of trucks per FAF3 centerline mile (i.e. highest average volume) as well as the greatest travel time differentials.

By contrast, New Orleans is the least populated of the three regions and has the lowest daily truck VMT and the lowest average number of trucks per FAF3 centerline mile. However, the port's location in a large urban area negatively effects congestion, giving that region the second-highest average travel time differential.

The Savannah operating region has a population that is larger than New Orleans' population but smaller than Norfolk's. However, Savannah has the largest network of FAF3 roads and is projected to have the largest daily VMT by 2040 according to FAF3. That larger network will allow the region to more effectively absorb additional truck trips in the future. Even with rapid VMT growth, Savannah will have the lowest number of trucks per centerline mile in 2040 (assuming that the 2007 FAF3 network remains constant). Congestion does not appear to be much of an issue in the region, as the travel time differentials are lowest in Savannah compared to the other two regions.

Table 40: Summary of Comparative Indicators by Operating Region

Metric	Savannah	Norfolk	New Orleans
2010 Population	37,754,646	56,192,993	19,746,132
2007 Centerline FAF miles	51,842	43,445	33,875
2007 Daily Truck VMT (mi)	86,197,813	91,110,816	54,405,780
2040 Daily Truck VMT (mi)	171,846,415	167,288,926	119,038,226
2007 Average Number of Trucks per Centerline Mile	1,663	2,097	1,606
2040 Average Number of Trucks per Centerline Mile	3,315	3,851	3,514
2012 Average Travel Time Differential (hh:mm:ss)	00:16:41	00:43:05	00:29:15
2012 Smallest Travel Time Differential (hh:mm:ss)	00:08:50	00:25:28	00:24:37
2012 Largest Travel Time Differential (hh:mm:ss)	00:26:55	01:21:04	00:33:35
Number of Parking Facilities	652	468	572
Number of Truck Parking Spaces	36,224	26,582	29,714
Daily Truck VMT per Parking Space (mi)	2,380	3,428	1,831

In terms of truck parking, the Norfolk region has the most competition for truck parking spaces, while New Orleans has the least competition. In the Norfolk region, there is one space for every 3,428 miles travelled, while that figure is much lower in the New Orleans region (one space for every 1,831 miles travelled). However, the supply versus demand dynamics can vary in each region by highway corridor. Table 41 presents the ratio of truck parking spaces to daily truck VMT for the five routes selected for study in each region. Norfolk contains the two routes with the worst ratios (Route Five: I-95 north, Route Four: I-64 west), while New Orleans has the two routes with the best ratios (Route Two: I-55 north, Route Three: I-59 north)

Table 41: Comparison of Parking Ratios for Selected Routes (Number of Daily Truck Miles Travelled per Parking Space)

Route #	Savannah	Norfolk	New Orleans
1	867	826	1,236
2	1,507	1,206	744
3	1,449	1,363	876
4	1,074	1,516	1,485
5	921	1,713	1,227

As previously discussed, truck parking is very important for the safe and efficient movement of freight by truck. With truck VMT projected to increase substantially in all three of the regions, it will be essential to not only increase roadway capacity, but also truck parking capacity. As Table 42 indicates, a substantial investment in truck parking will be necessary over the next few decades to maintain the current level of service on the 15 corridors analyzed in this study. However, it is important to note that these figures are only based on maintaining the current level of service, and some of these routes may already be underserved. This is evidenced by an annual trucking industry survey by ATRI which found that a truck parking shortage was the sixth most critical issue facing the trucking industry in 2013 (American Transportation Research Institute, 2013b).

Table 42: Number of Additional Truck Parking Spaces needed by 2040 to Maintain Current Level of Service

Route #	Savannah	Norfolk	New Orleans
1	3,737	2,872	2,650
2	2,962	1,880	5,920
3	2,773	4,969	5,567
4	3,458	1,374	2,177
5	3,394	1,980	2,594

Policy Implications

Each of the three megaregions is characterized by a different operating context. Both the Norfolk and New Orleans ports are located in large urban areas that subject all trucks leaving the port to congestion at certain times of the day. However, once trucks leave New Orleans, there is very little congestion in the rest of the region. In contrast, trucks leaving Norfolk continue to experience congestion, particularly for those trucks travelling north toward the Mid-Atlantic States. Savannah has a somewhat different operating environment. While trucks do experience congestion in larger urban areas such as Atlanta and Charlotte, there is comparatively little congestion near the port, which provides trucks with more flexibility to avoid congested locations.

Freight mobility is highly dependent on the route that trucks utilize, as evidenced by the varying travel time differentials, truck volumes, and truck parking availability along each route. The analysis presented in this report is critical for understanding the environment in which trucks must operate once they leave a port terminal and how route choice can affect mobility. Population density, road density, traffic volumes, congestion, and truck parking all play important roles in determining the efficiency and safety of trucking movements. Given the projected increases in regional VMT and additional activity expected at port facilities, it will be necessary to address infrastructure design, capacity, and safety issues at a regional scale in order to maintain economic competitiveness.

Truck freight is expected to steadily grow nationwide into the future. The Government Accountability Office (2008) forecasted an average 2.1% annual truck tonnage growth rate between 2002 and 2035. The Freight Analysis Framework (FAF3) forecasts an annualized average of 1.7% tonnage growth between 2012 and 2040 (Federal Highway Administration, 2013). The American Trucking Association (ATA) forecasts truckload tonnage growth of 3.2% between 2014 and 2018, slowing to 1.1% through 2024. ATA expects less-than-truckload tonnage to grow slightly faster than truckload tonnage (Berman, 2013). Less-than-truckload shipments combine loads from multiple shippers into a single trailer rather than dedicating a complete trailer to each load.

The Georgia Department of Transportation examines truck tonnage growth through different economic and freight forecasts. The Georgia Statewide Freight and Logistics Plan reflects the Georgia Department of Transportation's freight forecasts and goals. (Georgia Department of Transportation, 2013c). ATA forecasts 2.2% growth between 2009 and 2021, which is almost identical to the 2.3% growth rate forecasted by Moody's Analytics between 2009 and 2050. Global Insight's TRANSEARCH provides a conservative estimate for Georgia truck tonnage, growing at just 1.5% annually from 2007 to 2050. Overall, these findings show that truck tonnage in the United States is likely to increase on average by between 1% and 2% for the foreseeable future, but that growth in some regions will surpass the national baseline. As truck volume increases around ports do to the Panama Canal expansion and other factors, ports, local governments, and states must maintain and update their primary freight routes to accommodate the traffic or risk costly delays.

SECTION VI. IMPACTS OF THE PANAMA CANAL EXPANSION ON FREIGHT MOVEMENT

Modeling the Panama Canal Expansion Impacts

Analytical Approach

This section estimates the amount by which the Panama Canal expansion is likely to increase cargo movements at the Ports of Savannah, Hampton Roads / Norfolk, and New Orleans. The port-specific cargo projections are innovative in their own right because they outline a methodology for estimating the Panama Canal expansion's effects on port cargo throughput. Moreover, the projections will serve as a foundation for the economic impact analysis undertaken in Section VII.

Assumptions

The analysis assumes that most macroeconomic conditions and supply chain configurations remain constant through the projection period. The model accepts that trade volume at each port will be affected exclusively by growth in demand for commodities at each county and by the Panama Canal expansion. Specifically, the forecasts assume that –

1. Global trade channels will remain open at similar cost and reliability as experienced today, which precludes persistent disruptions due to severe weather or international conflict.
2. There will be no other major changes to the global freight network (e.g., new trade routes through a Nicaraguan Canal, an Arctic passage, improved transcontinental rail service) or major economic changes (e.g., sudden increase in Asian labor costs or energy costs, both of which would change medium- to long-term production locations).
3. Growth in commodity demand is independent of canal capacity.
4. Demand is proportional to freight-shed purchasing power. Freight-shed refers to the region whose commodity demand is fulfilled by trade volumes entering at a particular port. Freight-sheds were identified based on truck GPS data in Section V.
5. The road network has adequate capacity to accommodate truck volumes.
6. The ratio of incoming cargo transported by different modes is constant and is pegged to each port's 2011 mode ratio.
7. Cargo that traverses the Panama Canal has the same mode split after being offloaded at a port as all cargo offloaded at that port.

Port Activity Growth

The year 2040 was selected as the forecast year to maximize the canal expansions visible effects and to make results as closely aligned with state and metropolitan transportation planning timelines as possible. The Panama Canal expansion's effects are likely to be felt progressively. Most shippers and ocean carriers are locked into five-to-ten-year contracts with ports and importers, which means that freight route choice will require several years to adapt. Moreover, states and metropolitan planning organizations are required by federal statue to plan for transportation with at least a 20 year horizon (*Moving Ahead for Progress in the 21st Century Act*, 2012).

Cargo from both the Panama Canal and other trade routes come together at each port. The research team estimated the fraction of traffic from the Panama Canal at each port by examining the amount of cargo from different countries of origin. Table 43 shows the estimated fraction of cargo that traverses the Panama Canal prior to arrival at the port.

Table 43: Panama Share at Ports

Port	Fraction of Panama Volume
New Orleans	0.75
Norfolk	0.50
Savannah	0.65

The researchers derived the equation that estimates each port's 2040 cargo tonnage as follows.

$$V_{2040} = V_{P,2040} + V_{NP,2040}$$

where

$$V_P + V_{NP} = V$$
$$V_{P,2040} = \alpha \times \beta \times V_{P,2013}$$
$$V_{NP,2040} = \beta \times V_{NP,2013}$$

and

V, $V_{P,t}$, $V_{NP,t}$ = the total container volume at the port, container volume from Panama Canal to the port, and container volume not from Panama to the port, respectively

$$\alpha = \text{Growth due to Panama Canal expansion}$$
$$\beta = \text{Bureau of Economic Analysis growth in demand factor}$$
$$\mathrm{V} = \text{Total freight volume at the port}$$
$$\mathrm{V_P} = \text{Freight volume at the port via Panama}$$
$$\mathrm{V_{NP}} = V - V_P$$
$$t = \text{Truck share proportion}$$
$$\mathrm{P} = \text{Panama Canal share proportion}$$
$$\mathrm{NP} = \text{Non - Panama Canal share proportion}$$

The research team estimated the percentage of cargo weight transported by truck from each port (t) based on data from the Maritime Administration. As previously stated, it is assumed that the percentage of cargo transported by truck will remain constant between 2013 and 2040. Table 44 shows mode ratios.

Table 44: Truck Rail Shares

Port - Truck Share	Tonnage Percent (2011)	Ton-Mile Percent (2011)	Percent 2011 Value (Millions of Dollars)	Percent Current Value (Millions of Dollars)
New Orleans	58	50	55	54
Norfolk	92	98	100	100
Savannah	96	91	98	98

The equation showing derivation of the cargo tonnage moved from ports by truck is shown below.

$$V_{2040,t} = V_{2013}[p\alpha\beta + (1-p)\beta] \times t$$

Economic Growth Factor

The port-specific cargo projections account for forecasted macroeconomic changes, namely growth in consumer demand for commodities. Growth in commodity demand is assumed to be directly proportional to average state per capita income. Changes in per capita income approximate a population's changing purchasing power. Table 45 below shows the income growth rates used. The 2013 to 2040 growth rates are derived from the compound annual growth rate provided by the Bureau of Economic Analysis from 2011 to 2013 and 2003 to 2013. The research team calculated a ten-year compound growth rate. The ten year growth rate is assumed to be the same for the time horizon chosen for this study (Bureau of Economic Analysis, 2014).

Table 45: Growth in Demand due to Economic Growth

FIPS Code	State	Growth Factor
1	Alabama	2.3
2	Alaska	2.7
4	Arizona	2.0
5	Arkansas	2.5
6	California	2.2
8	Colorado	2.1
9	Connecticut	2.4
10	Delaware	1.9
11	District of Columbia	3.4
12	Florida	2.1
13	Georgia	1.8
15	Hawaii	2.7
16	Idaho	2.0
17	Illinois	2.2
18	Indiana	2.0

FIPS Code	State	Growth Factor
19	Iowa	3.0
20	Kansas	2.6
21	Kentucky	2.3
22	Louisiana	3.4
23	Maine	2.3
24	Maryland	2.4
25	Massachusetts	2.5
26	Michigan	1.8
27	Minnesota	2.2
28	Mississippi	2.7
29	Missouri	2.1
30	Montana	2.8
31	Nebraska	2.5
32	Nevada	1.5
33	New England	2.5
34	New Hampshire	2.4
35	New Jersey	2.3
36	New York	2.9
37	North Carolina	2.1
38	North Dakota	5.5
39	Ohio	2.1
40	Oklahoma	2.9
41	Oregon	2.1
42	Pennsylvania	2.4
44	Rhode Island	2.4
45	South Carolina	2.1
46	South Dakota	2.8
47	Tennessee	2.1
48	Texas	2.7
49	Utah	2.4
50	Vermont	2.6
51	Virginia	2.3
53	Washington	2.3
54	West Virginia	2.7
55	Wisconsin	2.2
56	Wyoming	3.2

Growth Factor Due to Canal Expansion

The Panama Canal expansion may spur cargo increases at East and Gulf Coast ports by either of the following two dynamics.

1. Intermodal route shift to regions in the middle of North America from West Coast of the United States to the East and Gulf Coasts. This represents a westward shift of the cost equivalency line, which makes East and Gulf Coast ports more attractive import locations for the center of the country.
2. Higher trade volumes to cross coasts between the Americas (i.e., travel from the South American West Coast to the North American Gulf and East Coast).

The first factor, intermodal route shift, requires intermodal cost, travel time tradeoffs, customer preferences of various regions of North America, and a mode-route choice - discrete choice models of freight customers. The second factor, trade between South and North America, is an induced demand factor without precedent. As no models exist for understanding intermodal route shift and inter-American trade volumes, the projections instead rely on four broad scenarios of the Panama Canal expansion's effects on global shipping. The scenarios implicitly account for the canal's competitiveness compared with other routes. Each scenario assigns the expanded canal a share in increasing canal volumes compared with a non-expanded canal by the factors in Table 46. Scenario 1 assumes that the expanded Panama Canal does not divert any traffic from West Coast to East and Gulf Coast ports, Scenario 2 assumes low diversion, Scenario 3 assumes moderate diversion, and Scenario 4 assumes high diversion.

Table 46: Scenarios

Scenarios	Panama Factor
1 - No impact	1.0
2 - Little Impact	1.3
3 - Moderate Impact	1.6
4 - High Impact	2.0

The research team checked port and roadway volume projections against capacity to ensure that the model did not project volume beyond a freight facility's ability to handle. Port projections were obtained from the Maritime Administration, as shown in Table 47 below. Trucks were allocated onto available road capacity by scaling forecasted volumes by the Panama Canal expansion factors in Table 46. Many of the truck corridors have sufficient capacity to accommodate additional trucks, so it was not necessary to assign trucks to routes while iteratively adjusting for capacity constraints

Table 47: Ports – Capacities

Port	State	Coast	Calls	Capacity by Deadweights
New Orleans	LA	Gulf Coast	2,942	141,360,610
Norfolk	VA	Atlantic	3,671	216,323,007
Savannah	GA	Atlantic	2,731	134,564,763

Source: U.S. Maritime Administration (n.d.), Vessel Calls at U.S. Ports, 2011

Base Year (2013) to Year 2040

2013 is the analysis base year. However, FAF3 data was only available for 2011. The model required input data showing the tonnage of commodities that entered each region by water and were moved inland by truck. Therefore, the 2013 base year was calculated by scaling 2011 tonnage using a Bureau of Economic Analysis (2014) economic growth factor from 2011 and 2013. This established 2013 base port tonnage.

The 2040 projections involved first scaling down the 2013 data to 2010, and then projecting forward three decades to 2040. 2013 data is preferable for 2010 data as a starting point because it incorporates the most recent actual data possible into the forecasts. The same Bureau of Economic Analysis growth factors were used to scale down 2013 base tonnage to year 2010. The cargo tonnage was then scaled up with an equation from 2010 to 2040, listed below. The equation uses a ten-year growth percentage that is constant from decade to decade. The percentage is based on economic growth from 2003 to 2013.

The following equations were used to scale port freight tonnage.

2011 to 2013: $V_{2013} = V_{2011} \times \left(1 + r_{11\text{–}13\text{–}annual}\right)^2$

- *Establishes 2013 base year*

2013 to 2010: $V_{2010} = V_{2013} \div \left(1 + r_{10\text{–}13\text{–}annual}\right)^3$

- *Preliminary step for 2010 to 2040 equation*

2010 to 2040: $V_{2040} = V_{2010} \times \left(1 + r_{03\text{–}13\text{–}tenyr}\right)^3$

- Establishes 2040 project year

where

$V_{[year]}$ = Port volume in a given year

$R_{11\text{-}13\text{-}annual}$ = Annual growth rate between 2011 and 2013

$R_{10\text{-}13\text{-}annual}$ = Annual growth rate between 2010 and 2013

$R_{03\text{-}13\text{-}tenyr}$ = Ten year growth rate between 2003 and 2013

Projected Freight Volumes for 2040

The Port of Savannah's cargo volume increases significantly under all scenarios. Scenario 4 shows a 65% cargo increase over Scenario 1, the no-impact scenario. The port is not likely to surpass capacity due to the canal expansion. Under the Scenario 4, the Port of Savannah will still retain at least 20 million tons of usable capacity. Moreover, under scenario 1, approximately half of the port's potential capacity will remain available.

This suggests that the present capacity of the Port of Savannah will be sufficient to accommodate increased flow resulting from the Panama Expansion under all scenarios. Increasing the port's capacity and improving infrastructure will reduce congestion. However, the forecast assumes that port capacity will remain sufficient to meet demand. This may require executing long-term expansion projects. It is important to note that cargo handling is not evenly spread through a week at each port, but rather ebbs and flows based on vessel call schedules. Additional capacity will allow the Port of Savannah to respond to high throughput periods without excess congestion. Table 48 displays commodity movement projections through the Port of Savannah for different year 2040 scenarios.

Table 48: Savannah - Projected Volumes 2040

Savannah (Thousands of Tons Tons)							
Mode	**Percent**	**2011**	**2013**	**2040 – 1.0**	**2040 - 1.3**	**2040 - 1.6**	**2040 – 2.0**
Truck	63.9%	18,639	19,629	44,950	53,715	62,480	74,167
Multiple modes & mail	6.8%	1,996	2,102	4,814	5,753	6,691	7,943
No domestic mode	2.4%	695	732	1,676	2,002	2,329	2,765
Other and unknown	1.8%	533	561	1,285	1,536	1,786	2,121
Pipeline	22.2%	6,470	6,814	15,603	18,646	21,688	25,745
Rail	2.9%	848	893	2,045	2,444	2,843	3,374
Water	0.0%	5	5	11	13	16	18
Sum	**100.0%**	**29,186**	**30,735**	**70,384**	**84,108**	**97,833**	**116,133**

Scenario 4 increases the Port of Hampton Roads / Norfolk's cargo throughput by 50% compared with Scenario 1. Capacity is not expected to be a major issues for Norfolk since under the Scenario 4—the high-impact scenario—the capacity will remain less than half of the available capacity, assuming that capacity will be spread among the multiple terminals in the Hampton Roads that all operate under the Virginia Port Authority. The present capacity of the Port of Norfolk is likely to remain unsaturated even under the impact of the increased flow resulting from the Panama Canal expansion. Increasing the capacity further will reduce congestion. Table 49 displays commodity movement projections by mode that the Port of Hampton Roads / Norfolk for different year-2040 scenarios.

Table 49: Norfolk – Projected Volumes 2040

Norfolk (Thousands of Tons)							
Mode	Percent	**2011**	**2013**	**2040 – 1.0**	**2040 - 1.3**	**2040 - 1.6**	**2040 – 2.0**
Truck	57.4%	9,121	9,605	21,995	25,295	28,594	32,993
Multiple modes & mail	17.0%	2,704	2,848	6,521	7,499	8,478	9,782
No domestic mode	18.2%	2,896	3,049	6,983	8,030	9,077	10,474

Norfolk (Thousands of Tons)							
Mode	Percent	**2011**	**2013**	**2040 – 1.0**	**2040 - 1.3**	**2040 - 1.6**	**2040 – 2.0**
Other and unknown	2.5%	398	419	960	1,104	1,248	1,440
Pipeline	0.0%	-	-	-	-	-	-
Rail	4.8%	761	802	1,836	2,111	2,387	2,754
Water	0.0%	3	3	7	8	9	10
Sum	**100.0%**	**15,883**	**16,726**	**38,302**	**44,047**	**49,792**	**57,453**

The Port of New Orleans will have higher absolute tonnage traffic than either Savannah or Norfolk. Moreover, the canal expansion is expected to significantly impact the port, increasing cargo throughput by approximately 75%. Unlike Norfolk and Savannah, the Port of New Orleans may experience more cargo demand than it has the capacity to accommodate. Under the Scenario 1 (no impact), there is already a risk of traffic being higher than the port's capacity. Moreover, it would be very challenging for the port to respond to the very high cargo demand forecasted under Scenario 4 without significant new capacity. The present capacity of the Port of New Orleans is unlikely to be able to accommodate increased freight volume related to the Panama Canal expansion. Table 50 contains commodity movement projections by mode for the Port of New Orleans for different year 2040 scenarios.

Table 50: New Orleans – Projected Volumes 2040

New Orleans (Thousands of Tons)							
Mode	**Percent**	**2011**	**2013**	**2040 – 1.0**	**2040 - 1.3**	**2040 - 1.6**	**2040 – 2.0**
Truck	14.7%	23,541	24,791	56,771	69,544	82,317	99,348
Multiple modes & mail	6.6%	10,653	11,219	25,692	31,472	37,253	44,960
No domestic mode	25.7%	41,245	43,435	99,466	121,845	144,225	174,065
Other and unknown	0.8%	1,323	1,393	3,190	3,907	4,625	5,582
Pipeline	35.9%	57,651	60,711	139,029	170,311	201,592	243,301
Rail	5.3%	8,524	8,976	20,556	25,181	29,806	35,972
Water	11.1%	17,764	18,707	42,839	52,478	62,117	74,969
Sum	**100.0%**	**160,701**	**169,232**	**387,541**	**474,738**	**561,934**	**678,197**

Conversion of Tonnage to Truck Volumes

The projected freight volumes at each port under different scenarios obtained above are expressed in kilo tons, which are equal to one thousand metric tons. The cargo weights were converted into an equivalent number of trucks following the FAF3 truck conversion procedures from the document *FAF3 Freight Traffic Analysis* (Battelle, 2011a). Converting cargo tonnage to trucks depends on truck configuration, body type, and commodities. The conversion itself involved the following three steps.

1. **Allocating Commodities to Truck Configurations:** Tonnage was allocated to different truck configurations based on the distance between the port county and the destination county. Table 51, Table 52, and Table 53 describe the truck configurations, show body type prevalence, and show their allocation based on travel distance. Truck trailers account for the vast majority of trucks on medium- and long-distance hauls.

Table 51: Truck Configurations

Truck Configurations		
Group	**Abbreviation**	**Description**
1	SU	Single Unit Trucks
2	TT	Truck plus Trailer Combinations
3	CS	Tractor plus Semitrailer Combinations
4	DBL	Tractor plus Double Trailer Combinations
5	TPT	Tractor plus Triple Trailer Combinations

Table 52 Truck Body Types

Truck-Body Types		
Body	**Truck Fleet**	**Description**
1	37.7%	Dry Van
2	24.4%	Flat Bed
3	14.7%	Bulk
4	8.2%	Reefer
5	8.0%	Tank
6	2.1%	Logging
7	1.7%	Livestock
8	0.9%	Automobile
9	2.3%	Other

Table 53 Truck Allocation Factors

Truck Allocation Factors						
Minimum Range (miles)	**Maximum Range (miles)**	**Single Unit**	**Truck Trailer**	**Combination Semitrailer**	**Combination Double**	**Combination Triple**
0	50	0.793201	0.070139	0.130465	0.006179	0.000017
51	100	0.577445	0.058172	0.344653	0.019608	0
101	200	0.313468	0.045762	0.565269	0.074434	0.000452
201	500	0.142467	0.027288	0.751628	0.075218	0.002031
501	10,000	0.06466	0.0149	0.879727	0.034143	0.004225

2. **Estimating Average Payloads:** The research team selected the commodity type based on our requirement (43 - unknown freight) using *FAF3 Freight Traffic Analysis,* Appendix B (Battelle, 2011c).

3. **Converting Tonnage to Equivalent Trucks:** For each truck configuration, an analysis was conducted using the conversion method detailed in *FAF3 Freight Traffic Analysis*, Appendix A (Battelle, 2011b). Multiplying each truck configuration's tonnage with the corresponding body type's volume produced equivalent truck volumes for each truck body type. The method used factors for commodity 42, "commodity unknown," as detailed in *FAF3 Freight Traffic Analysis*, Appendix B (Battelle, 2011c). Table 54 shows the conversion factors used.

Table 54 Equivalent Loaded Trucks

Truck Type	Auto	Livestock	Bulk	Flatbed	Tank	Day Van	Reefer	Logging	Other
SU	0	0	0.00215	0.01208	0.02291	0.00117	0	0	0.00181
TT	0	0	0	0.00708	0.05154	0.00145	0	0	0
CS	0	0	0	0.0015	0.03183	0.00323	0	0	0
DBL	0	0	0	0	0	0	0	0	0
TPT	0	0	0	0	0	0	0	0	0

The previous conversion does not account for empty trucks. Empty trucks move from one place to another without a cargo load for reasons that may include staging to pick up a load elsewhere. Empty trucks can be expressed as a fraction of other truck traffic. Table 55 gives the empty truck factors to be used depending on the shipping type as provided by *FAF3 Freight Traffic Analysis*.

Table 55 Empty Truck Factors

	Empty Truck Factors				
Body Type	**Single Unit**	**Truck Trailer**	**Combination Semitrailer**	**Combination Double**	**Combination Triple**
Domestic and Sea-Port Shipping					
Dry Van	0.00	0.00	0.14	0.00	0.00
Flat Bed	0.00	0.00	0.20	0.16	0.00
Bulk	0.21	0.14	0.20	0.20	0.06
Reefer	0.14	0.16	0.16	0.20	0.03
Tank	0.17	0.18	0.20	0.20	0.00
Logging	0.12	0.07	0.10	0.04	0.07
Livestock	0.10	0.08	0.09	0.13	0.00
Automobile	0.24	0.21	0.20	0.13	0.00
Other	0.10	0.06	0.25	0.00	0.00
Land Border Shipping					
Dry Van	0.00	0.00	0.28	0.00	0.00
Flat Bed	0.00	0.00	0.40	0.32	0.00
Bulk	0.42	0.28	0.40	0.40	0.12
Reefer	0.28	0.32	0.32	0.40	0.06
Tank	0.34	0.36	0.40	0.40	0.00
Logging	0.24	0.14	0.20	0.08	0.14
Livestock	0.20	0.16	0.18	0.26	0.00
Automobile	0.48	0.42	0.40	0.26	0.00
Other	0.20	0.12	0.50	0.00	0.00

The empty truck factors are applied for each county in the freight-shed to obtain the total port-related truck volumes. Table 56 displays total daily truck volumes moving out of the different ports. The road network around Savannah and New Orleans will face most of the impact due to expansion.

Table 56 Total Daily Truck Volumes From Ports Under Different Scenarios

Port	2040 – 1.0	2040 - 1.3	2040 - 1.6	2040 – 2.0
New Orleans	6,953	8,517	10,081	12,167
Norfolk	2,667	3,066	3,466	4,000
Savannah	5,530	6,608	7,687	9,124

Link Volumes on Truck Corridors

In the previous section, the destination volumes of freight in trucks have been estimated. Using the Georgia Department of Transportation Statewide Travel Demand Model as a base, the research team allocated each scenario's truck volume onto the state's road network. The loaded road network indicates some roadway effects related to the canal expansion. The maps are shown in Appendix 6. The proportion of volumes on different links for each destination county volume is obtained from the representative freight-shed in Section V.

Conclusion

This section's primary contribution is to calculate the number of additional trucks that will travel from each of the three ports to destination counties under the four Panama Canal expansion impact scenarios. Section VII uses the county tables to estimate the canal's economic impact on each county.

The analysis also allows for several other findings. The Port of New Orleans is the busiest of the three ports and is also most likely to face capacity constraints related to the canal expansion. The capacity constraint could present other ports in the same region with the opportunity to divert vessels to their own facilities. By contrast, port deepening and expansion in Norfolk and Savannah will allow the ports to accommodate new vessel types and ease port congestion.

SECTION VII. REGIONAL ECONOMIC IMPACTS ANALYSIS

Conceptual Framework

Cargo movement's economic and social impacts are greatest in origin and destination counties where cargo is loaded, offloaded, transferred, processed, and sold. Increasing cargo throughput in ocean ports will cause ripple effects on destination counties through the economic activity that freight responds to and induces. Elected officials, residents, and business owners may wish to understand how cargo growth at the Port of Savannah will affect the rest of Georgia's counties. This section models cargo's local economic benefits in destination counties with input-output models that capture cargo effects on local economic activity and cross-sectorial economic multipliers. The models respond to multiple scenarios of canal expansion effects and economic growth.

Methodology of Estimating the Economic Impact of Increase in Truck Volume due to Panama Expansion

The economic impact of increased supply of commodities related to the Panama Canal expansion can be quantified with several related datasets. The methodology developed for this estimation is illustrated in Figure 82. The economic impact builds upon previously estimated truck and commodity movement from the Port of Savannah to all the counties in Georgia; described in the previous section. This section accounts for only positive economic benefits which are expected due to the Panama Canal expansion, not accounting for negative impacts of increased congestion, potential crashes, and pollution.

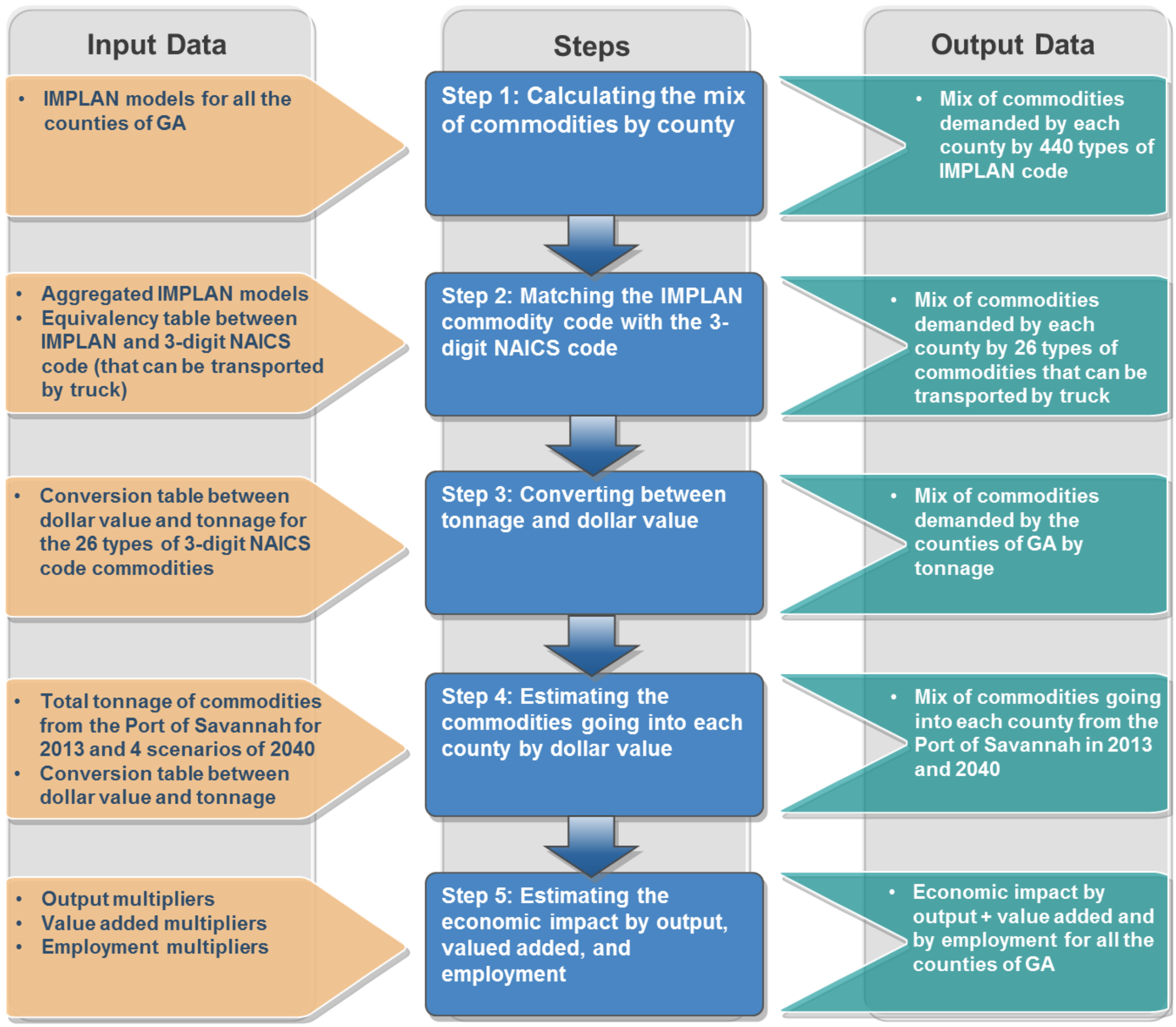


Figure 82: Flow Chart of Estimating the Economic Impact of the Panama Canal Expansion on Georgia

<u>Step 1: Extracting the Dollar Value of Commodities Demanded by Georgia Counties from IMPLAN Models</u>

Section VI provided an estimate of total tonnage transported from the Port of Savannah to each county in Georgia, and the expected growth in tonnage under various scenarios as a result of the Panama Canal expansion. Estimating the economic impact of this change in tonnage flow requires disaggregation of the data in commodity-specific port-to-county components. To perform the disaggregation, detailed data on county-level commodity demand from IMPLAN was used to conduct the analysis (IMPLAN Group, 2013). The IMPLAN database is built on an input-output dollar flow table, which accounts for all dollar flows between industrial sectors of the economy at a specified geographic level. In this study, IMPLAN models of commodity demand were developed for all Georgia counties.

Step 2: Matching the IMPLAN Commodity Code with the Three-digit NAICS Code

The IMPLAN model results provided the total dollar value of demand for 440 commodity types imported into each of the 159 counties in Georgia in 2010. To simplify the estimation of economic impacts of the 440 commodities, the dataset was aggregated to 80 commodities that correspond with the Census Bureau's North American Industry Classification System (NAICS) three-digit codes. The process also made the resulting commodity flow data consistent with other analysis in the rest of this study.

Step 3: Matching the Commodities Tonnage with Dollar Values

The output from the IMPLAN models is measured in commodity dollar value, thus it was necessary to convert the estimated total commodity tonnage transported to each county, estimated in Section VI, into dollar values to be consistent with the IMPLAN output. The 80 three-digit NIACS-based commodity flows to each Georgia county were reduced to just 26 commodities that are exclusively transported by truck. The dollar value of the 26 types of commodities for which there is demand in each of the 159 Georgia counties was transformed into tonnage based on 2010 commodity price data. Then, the demand for each of the 26 commodities carried by truck to each county was derived to estimate the specific composition of each county's incoming freight from the Port of Savannah. Next, the total commodity tonnage transported to each county by truck was multiplied by the commodity shares to produce county-specific commodity tonnage for each of the 26 commodities. Commodity tonnage was then converted to dollar values, to derive the monetary value of the 26 commodity types for which there is demand in each of Georgia's 159 counties

Step 4: Estimating the Dollar Value of Commodities Going into the Georgia Counties from the Port of Savannah for Different Scenarios

It was assumed that each commodity's demand distribution at the county-level remains constant over the forecast period. The base state is the freight distribution in 2010, scaled to 2013 values. To restate from Section VI, Scenario 1 represents the projected change in commodity demand in 2040 without the Panama Canal expansion. Scenario 2 through Scenario 4 represent three projected 2040 conditions assuming the Panama Canal expansion will bring about little, moderate, and high demand for commodities and truck flows, respectively. The difference between each of the four scenarios in year 2040 and the base state is the difference in dollar values of the 26 commodity types flowing the counties by truck.

Step 5: Estimating the Economic Impact of Increased Commodities Going into the Georgia Counties due to the Panama Expansion

The last step is to estimate the economic impact of the Panama Canal expansion on each of Georgia's counties by applying commodity-specific economic multipliers from IMPLAN. Economic multipliers measure the total production requirements in the study area for every unit of production that serves final demand (IMPLAN Group, 2013). This study applies multipliers for output, value added, and employment in each Georgia county by applying each of the three sets of multipliers to the dollar value of the 26 commodity types from Step 4. The final result not only estimates the county-level economic impact in terms of output, value added, and employment, but also provides an estimate of the total economic impact for each county and the value projected to result directly from the Panama Canal expansion.

Economic Impact Analysis Results

County Economic Impact of Output and Value Added

Economic impact in terms of changes to economic output represents the value of industry production, given the dollar values of specific commodities imported into each county. A change in value added is the difference between an industry's or an establishment's total output and the cost of its intermediate input, which consists of employee compensation, taxes on production and imports less subsidies, and gross operating surplus (IMPLAN Group, 2013). The sum of output and value added effects is a measure of the direct, indirect, and induced economic impacts brought about by an increase in imports of commodities, stemming from an increase in demand due to the Panama Canal expansion.

Figure 83 shows the output and value added county-level economic impacts of commodity flows, for 2013 and the four 2040 growth scenarios. The analysis shows that under Scenario 1, which is the "no build" scenario for 2040, the growth in commodity movement from the Port of Savannah to each county by truck and resulting economic impact will almost double from the 2013 baseline. Scenarios 2 through 4 show that as the total commodity volume imported through the Port of Savannah increases, economic impacts will be significant for counties adjacent to the port, such as Chatham, Glynn, and Liberty and for the economies of the counties in the Atlanta metropolitan area, such as Fulton, Gwinnett, Cobb, and DeKalb. Each of these counties could benefit in excess of billion dollars annually by 2040.

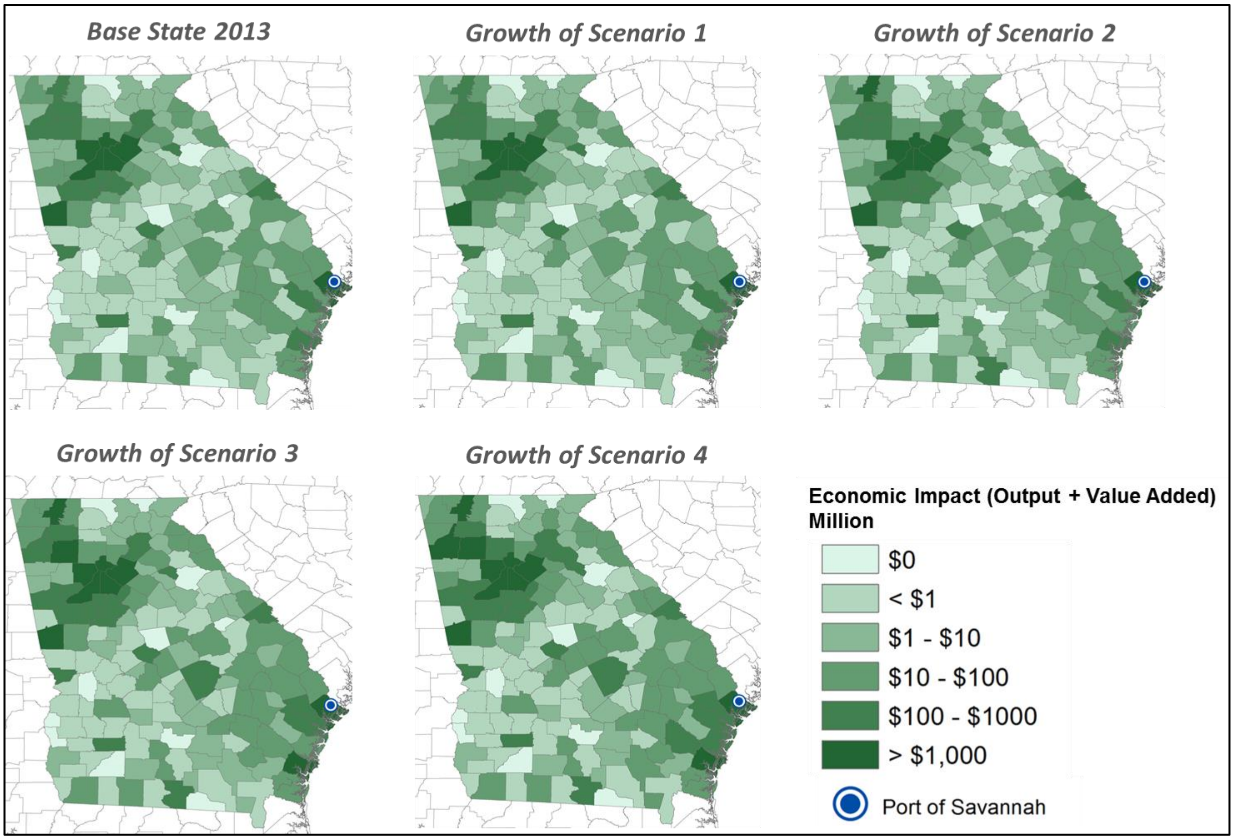


Figure 83: Economic Impact of Output and Value Added by County for the Base State in 2013 and Four Scenarios in 2040

Table 57 lists the 25 counties that will experience the most significant economic impact in terms of output and value added due to increasing imports through the Port of Savannah and Figure 84 maps out those counties under Scenario 2. The table illustrates the potentially high level of impact at the county-level, an expansion of the canal could induce. Statewide, the annual economic impact of imports by 2040 is estimated to be approximately $35 billion assuming in Scenario 2 that the canal expansion has a minimal impact. The economy grows substantially assuming either a moderate or high impact with an approximate total economic impact of $44 billion and $57 billion respectively.

The counties in Georgia that will benefit the most from a Panama Canal expansion are concentrated around Atlanta and the Port of Savannah. If the canal expansion's impact is minimal, seven Georgia counties will experience an economic impact greater than a billion dollars. Under the high-impact scenario, that number increases to ten counties.

Table 57: Top 25 County in Terms of Output and Value Added From Panama Canal Expansion

County Economic Impact (Output + Value Added) from Panama Canal Expansion (In Million) - Top 25						
Rank	**County**	**Base 2013**	**Growth of Scenario1**	**Growth of Scenario2**	**Growth of Scenario3**	**Growth of Scenario4**
	State Total	***$21,071***	***$26,440***	***$35,705***	***$44,967***	***$57,320***
1	**Fulton**	$4,570	$5,734	$7,744	$9,753	$12,432

County Economic Impact (Output + Value Added) from Panama Canal Expansion (In Million) - Top 25						
Rank	**County**	**Base 2013**	**Growth of Scenario1**	**Growth of Scenario2**	**Growth of Scenario3**	**Growth of Scenario4**
2	**Gwinnett**	$4,032	$5,059	$6,832	$8,604	$10,967
3	**Chatham**	$3,641	$4,569	$6,170	$7,771	$9,906
4	**Troup**	$1,389	$1,743	$2,353	$2,964	$3,778
5	**Cobb**	$1,062	$1,332	$1,799	$2,265	$2,888
6	**DeKalb**	$1,050	$1,318	$1,779	$2,241	$2,856
7	**Whitfield**	$648	$812	$1,097	$1,382	$1,761
8	**Bartow**	$518	$650	$877	$1,105	$1,408
9	**Glynn**	$479	$600	$811	$1,021	$1,302
10	**Floyd**	$383	$481	$649	$818	$1,042
11	**Hall**	$269	$338	$456	$575	$733
12	**Richmond**	$254	$319	$431	$543	$692
13	**Henry**	$246	$308	$416	$524	$668
14	**Gordon**	$207	$259	$350	$441	$562
15	**Muscogee**	$203	$255	$344	$433	$552
16	**Liberty**	$176	$221	$298	$376	$479
17	**Bibb**	$162	$203	$275	$346	$441
18	**Clayton**	$121	$152	$205	$259	$330
19	**Fayette**	$120	$151	$204	$257	$327
20	**Coweta**	$118	$148	$200	$252	$322
21	**Dougherty**	$104	$130	$176	$222	$283
22	**Clarke**	$101	$126	$171	$215	$274
23	**Douglas**	$76	$95	$129	$162	$207
24	**Spalding**	$75	$94	$127	$160	$204
25	**Lowndes**	$62	$77	$104	$131	$167

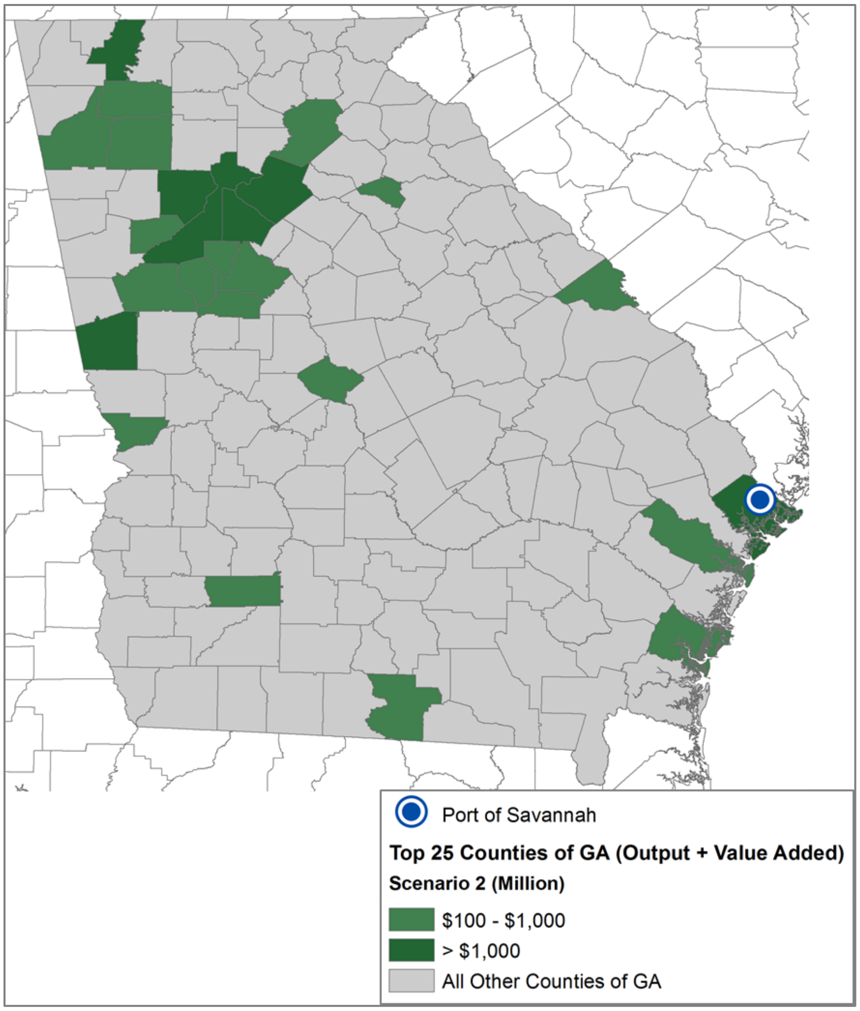


Figure 84: Top 25 Counties of Output and Value Added in Scenario 2

Table 58 lists the top 10 industry sectors that will experience the greatest economic impact in terms of the sum of output and value added as a result of the Panama Canal expansion. As shown in the table, the top 10 industrial sectors benefiting from an expansion are primarily associated with farming, forestry, food, and textiles.

Table 58: Top 10 Most Impacted Industry Sectors by Output and Value Added

Top 10 Industry Sectors Impacted by Output and Value Added (In Million)						
Rank	Industry Sector	Base 2013	Growth of Scenario1	Growth of Scenario2	Growth of Scenario3	Growth of Scenario4
1	Crop Farming	$2,688	$3,373	$4,555	$5,736	$7,312
2	Livestock	$2,183	$2,740	$3,700	$4,659	$5,939
3	Forestry & Logging	$2,092	$2,626	$3,546	$4,465	$5,692
4	Ag & Forestry Svcs	$1,967	$2,468	$3,333	$4,198	$5,352
5	Mining	$1,965	$2,466	$3,330	$4,194	$5,346
6	Food products	$1,886	$2,367	$3,196	$4,025	$5,131

Top 10 Industry Sectors Impacted by Output and Value Added (In Million)						
Rank	Industry Sector	Base 2013	Growth of Scenario1	Growth of Scenario2	Growth of Scenario3	Growth of Scenario4
7	**Beverage & Tobacco**	$1,476	$1,853	$2,502	$3,151	$4,016
8	**Textile Mills**	$1,434	$1,799	$2,429	$3,060	$3,900
9	**Textile Products**	$961	$1,206	$1,628	$2,051	$2,614
10	**Leather & Allied**	$785	$985	$1,331	$1,676	$2,136

Table 59 lists the top five counties in Georgia in terms of their growth in output and value added due to Panama Canal expansion and the corresponding top five industrial sectors that will be most impacted. While the commodity specific impacts to each county are unique, there are similarities in commodity-based impacts among the counties. Food products, chemical manufacturing, miscellaneous manufacturing, computers and other electronics, publishing industries, and petroleum and coal products are among the sectors that will have the greatest economic impact for the top-five. Among these six major sectors, only food products are among the top 10 industry sectors statewide.

Table 59: Top 5 Counties and Their Top 5 Industry Sectors in Terms of Output and Value Added

Rank	County	Top 5 Industry Sectors		Output + Value Added (In Millions)				
				2013	Growth of Scenario 1	Growth of Scenario 2	Growth of Scenario 3	Growth of Scenario 4
1	Fulton	1	Food products	$721	$904	$1,221	$1,538	$1,961
		2	Petroleum & coal prod	$623	$782	$1,056	$1,330	$1,696
		3	Computer & oth electron	$504	$632	$854	$1,076	$1,371
		4	Chemical Manufacturing	$467	$586	$792	$997	$1,271
		5	Miscellaneous mfg	$422	$529	$715	$900	$1,148
2	Gwinnett	1	Chemical Manufacturing	$553	$694	$938	$1,181	$1,505
		2	Food products	$528	$663	$895	$1,128	$1,437
		3	Computer & oth electron	$496	$622	$840	$1,058	$1,349
		4	Miscellaneous mfg	$397	$498	$673	$848	$1,081
		5	Publishing industries	$355	$446	$602	$758	$966
3	Chatham	1	Transportation eqpmt	$858	$1,077	$1,454	$1,832	$2,335
		2	Food products	$481	$603	$815	$1,026	$1,308
		3	Petroleum & coal prod	$453	$569	$768	$967	$1,233
		4	Publishing industries	$353	$442	$597	$752	$959
		5	Miscellaneous mfg	$315	$395	$533	$672	$856
4	Troup	1	Transportation eqpmt	$197	$248	$334	$421	$537

Rank	County	Top 5 Industry Sectors		Output + Value Added (In Millions) 2013	Growth of Scenario 1	Growth of Scenario 2	Growth of Scenario 3	Growth of Scenario 4
		2	Publishing industries	$197	$247	$333	$420	$535
		3	Textile Products	$191	$239	$323	$407	$519
		4	Petroleum & coal prod	$134	$169	$228	$287	$365
		5	Food products	$116	$146	$197	$248	$316
5	Cobb	1	Food products	$168	$211	$285	$359	$182
		2	Chemical Manufacturing	$129	$162	$219	$276	$253
		3	Miscellaneous mfg	$107	$134	$181	$227	$244
		4	Publishing industries	$93	$117	$158	$199	$233
		5	Textile Products	$90	$113	$152	$191	$458

County Economic Impact of Employment

In addition to output and value added impacts, another important measure of economic impact is employment growth. As Table 60 shows, if the Panama Canal expansion did not occur, Georgia would still gain about 10 thousand net jobs related directly to the 26 truck-shipped commodities by 2040. However, the Panama Canal expansion is expected to spur the creation of over 26 thousand new jobs by 2040 with just a minimal impact. Moreover, under the moderate and high impact scenarios an additional 43 thousand and 66 thousand more jobs are estimated in 2040, respectively. The top 25 counties in terms of job growth are around the port and in the metro Atlanta area, as shown in Figure 85.

Table 60: Top 25 County in Terms of Increase in Employment From Panama Canal Expansion

County Economic Impact (Employment) from Panama Canal Expansion - Top 25						
Rank	County	Base 2013	Growth of Scenario1	Growth of Scenario2	Growth of Scenario3	Growth of Scenario4
	State Total	***38,556***	***9,823***	***26,777***	***43,725***	***66,328***
1	**Gwinnett**	7,249	1,847	5,034	8,220	12,470
2	**Fulton**	7,159	1,824	4,972	8,118	12,315
3	**Chatham**	5,314	1,354	3,691	6,027	9,142
4	**Troup**	4,080	1,040	2,834	4,627	7,020
5	**DeKalb**	2,378	606	1,651	2,696	4,090
6	**Cobb**	1,657	422	1,151	1,879	2,850
7	**Whitfield**	1,173	299	815	1,330	2,018
8	**Liberty**	980	250	681	1,112	1,686
9	**Floyd**	814	207	566	923	1,401
10	**Glynn**	765	195	532	868	1,317
11	**Bartow**	670	171	465	760	1,152

County Economic Impact (Employment) from Panama Canal Expansion - Top 25						
Rank	**County**	**Base 2013**	**Growth of Scenario1**	**Growth of Scenario2**	**Growth of Scenario3**	**Growth of Scenario4**
12	**Richmond**	570	145	396	646	980
13	**Gordon**	508	129	353	576	874
14	**Hall**	455	116	316	516	783
15	**Bibb**	386	98	268	438	665
16	**Henry**	382	97	265	433	657
17	**Coweta**	292	74	203	331	502
18	**Muscogee**	274	70	191	311	472
19	**Fayette**	193	49	134	219	331
20	**Clarke**	186	47	129	211	320
21	**Dougherty**	171	44	119	194	294
22	**Clayton**	164	42	114	186	282
23	**Effingham**	155	40	108	176	267
24	**Laurens**	154	39	107	174	264
25	**Bryan**	134	34	93	151	230

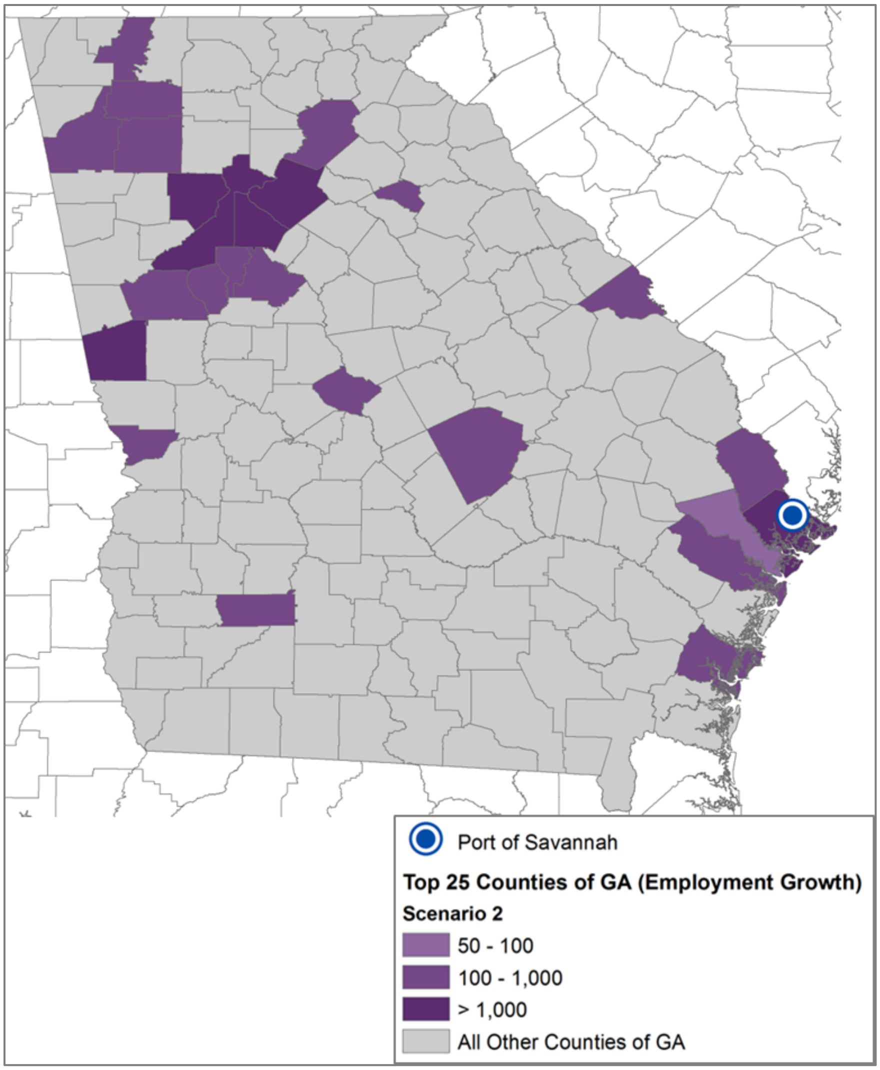


Figure 85: Top 25 Counties of Growth of Employment in Scenario 2

Table 61 provides a list of the top 10 industrial sectors that will bring about the greatest net employment growth. Industrial sectors related to farming, forestry, food, and textile will also see job increases. Moreover, other industries like publishing, miscellaneous manufacturing, and furniture production—industries that are heavily reliant on commodities and labor—are likely to generate the most new employment.

Table 61: Top 10 Most Impacted Industry Sectors by Employment

Top 10 Industry Sectors Impacted by Employment						
Rank	**Description**	**Base 2013**	**Growth of Scenario1**	**Growth of Scenario2**	**Growth of Scenario3**	**Growth of Scenario4**
1	**Publishing industries**	5,290	1,348	3,674	5,999	9,100
2	**Textile Products**	4,818	1,228	3,346	5,464	8,289
3	**Miscellaneous mfg**	4,241	1,080	2,945	4,809	7,295

Top 10 Industry Sectors Impacted by Employment						
Rank	Description	Base 2013	Growth of Scenario1	Growth of Scenario2	Growth of Scenario3	Growth of Scenario4
4	Ag & Forestry Svcs	3,410	869	2,368	3,867	5,866
5	Crop Farming	3,076	784	2,136	3,488	5,292
6	Transportation eqpmt	2,478	631	1,721	2,810	4,262
7	Livestock	2,291	584	1,591	2,598	3,941
8	Furniture & related prod	2,230	568	1,549	2,529	3,836
9	Food products	2,049	522	1,423	2,324	3,526
10	Computer & oth electron	1,867	476	1,297	2,118	3,212

Table 62 lists the top five counties in terms of employment growth due to the Panama Canal expansion along with each of their five most impacted industrial sectors. The five counties are almost the same five counties in terms of economic impact of output and value added shown in Table 59, except that DeKalb is now among the top five instead of Cobb. The five counties also share great similarity among their top five industry sectors. Miscellaneous manufacturing, textile products, publishing industries tend to be the sectors that will be impacted most by the canal expansion. These three industrial sectors are also the top three most impacted industrial sectors statewide.

Table 62: Top 5 Counties and their Top 5 Industry Sectors in Terms of Employment

Rank	County	Top 5 Industry Sectors		Employment				
				2013	Growth of Scenario 1	Growth of Scenario 2	Growth of Scenario 3	Growth of Scenario 4
1	Gwinnett	1	Miscellaneous mfg	1,094	279	760	1,240	1,882
		2	Publishing industries	914	233	635	1,036	1,572
		3	Computer & oth electron	908	231	631	1,030	1,562
		4	Textile Products	786	200	546	891	1,352
		5	Furniture & related prod	782	199	543	886	1,345
2	Fulton	1	Miscellaneous mfg	1,019	260	708	1,156	1,753
		2	Publishing industries	818	208	568	927	1,407
		3	Food products	760	194	528	861	1,307
		4	Computer & oth electron	702	179	487	796	1,207
		5	Textile Products	664	169	461	753	1,142

Rank	County	Top 5 Industry Sectors		Employment 2013	Growth of Scenario 1	Growth of Scenario 2	Growth of Scenario 3	Growth of Scenario 4
3	Chatham	1	Transportation eqpmt	1,240	316	861	1,407	2,134
		2	Publishing industries	984	251	684	1,116	1,694
		3	Miscellaneous mfg	854	218	593	969	1,470
		4	Textile Products	793	202	551	899	1,364
		5	Food products	350	89	243	397	602
4	Troup	1	Ag & Forestry Svcs	1,782	454	1,237	2,020	3,065
		2	Textile Products	542	138	376	614	932
		3	Livestock	426	109	296	483	733
		4	Publishing industries	346	88	240	392	595
		5	Crop Farming	342	87	238	388	589
5	DeKalb	1	Livestock	498	127	346	564	856
		2	Miscellaneous mfg	347	89	241	394	598
		3	Publishing industries	337	86	234	383	580
		4	Textile Products	307	78	213	348	528
		5	Furniture & related prod	154	39	107	174	264

Impact of Commodity Movement on the Major Truck Corridors in Georgia

The Panama Canal expansion will have a significant impact on the state's transportation network, particularly along major truck routes. Figure 86 shows how the daily volume of commodities carried by truck on different roads will increase under each of the growth scenarios. A large proportion of the major routes will gain more than 100 thousand tons of commodities daily, even under minimal impact scenarios.

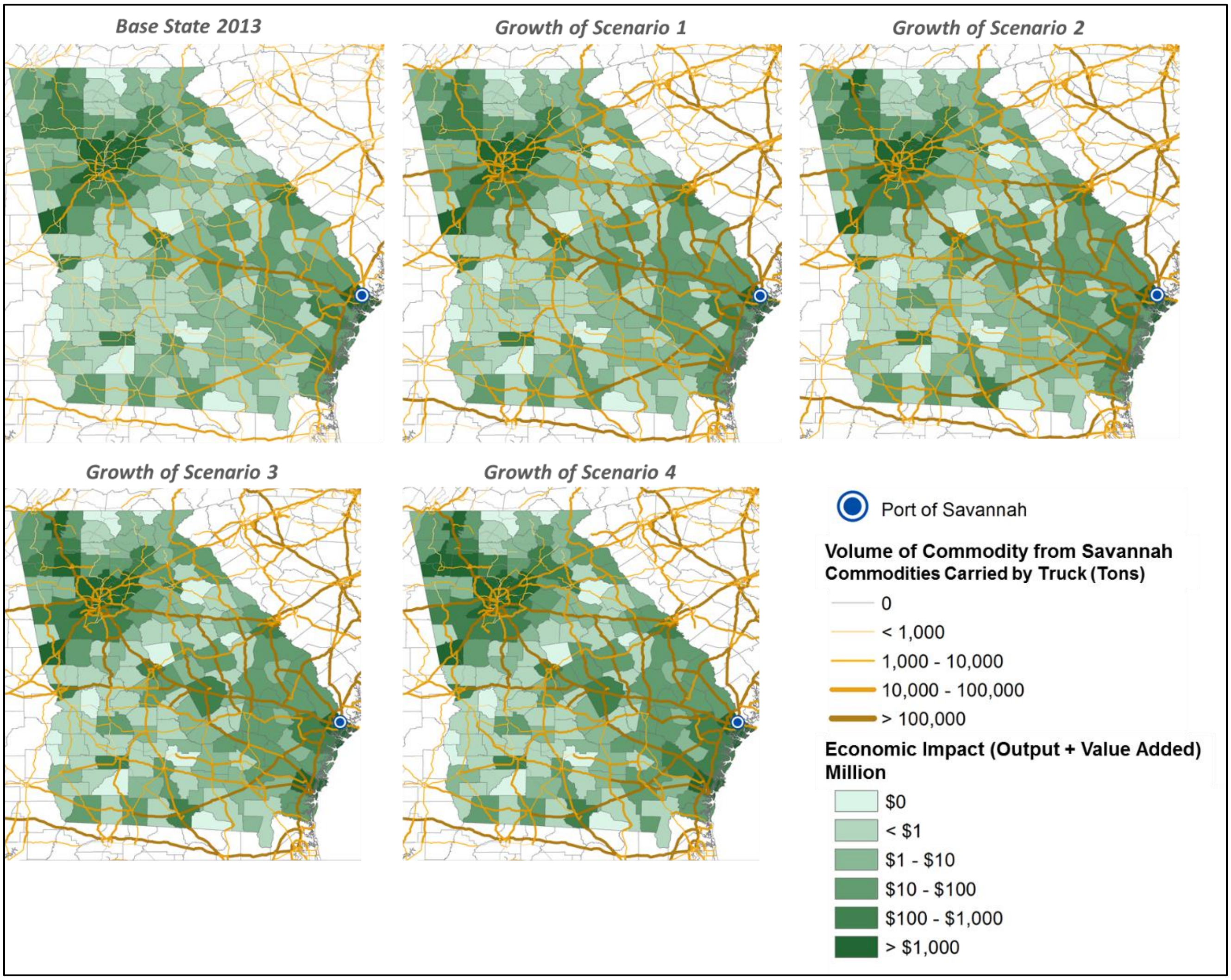


Figure 86: Daily Route Volume of Commodities Transported by Truck due to the Impact of Panama Canal Expansion

Figure 87 shows the major truck corridors statewide by their shares of commodity tonnage. The commodities considered here originate from the Port of Savannah, and freight is assigned to each road segment such that commodity volumes decrease as distance from the port increases. Decreasing commodity volumes represent trucks that have reached their destination. The four major truck routes originating from the Port of Savannah are: 1) Interstate 16 to the Atlanta metropolitan area; 2) State Route 21 to the City of Augusta; 3) Interstate 95 and US Route 17 to Brunswick; and 4) US Route 17 (US Route 82) and US Route 84 to a series of mid-sized cities, including Jesup, Waycross, Valdosta, and Thomasville.

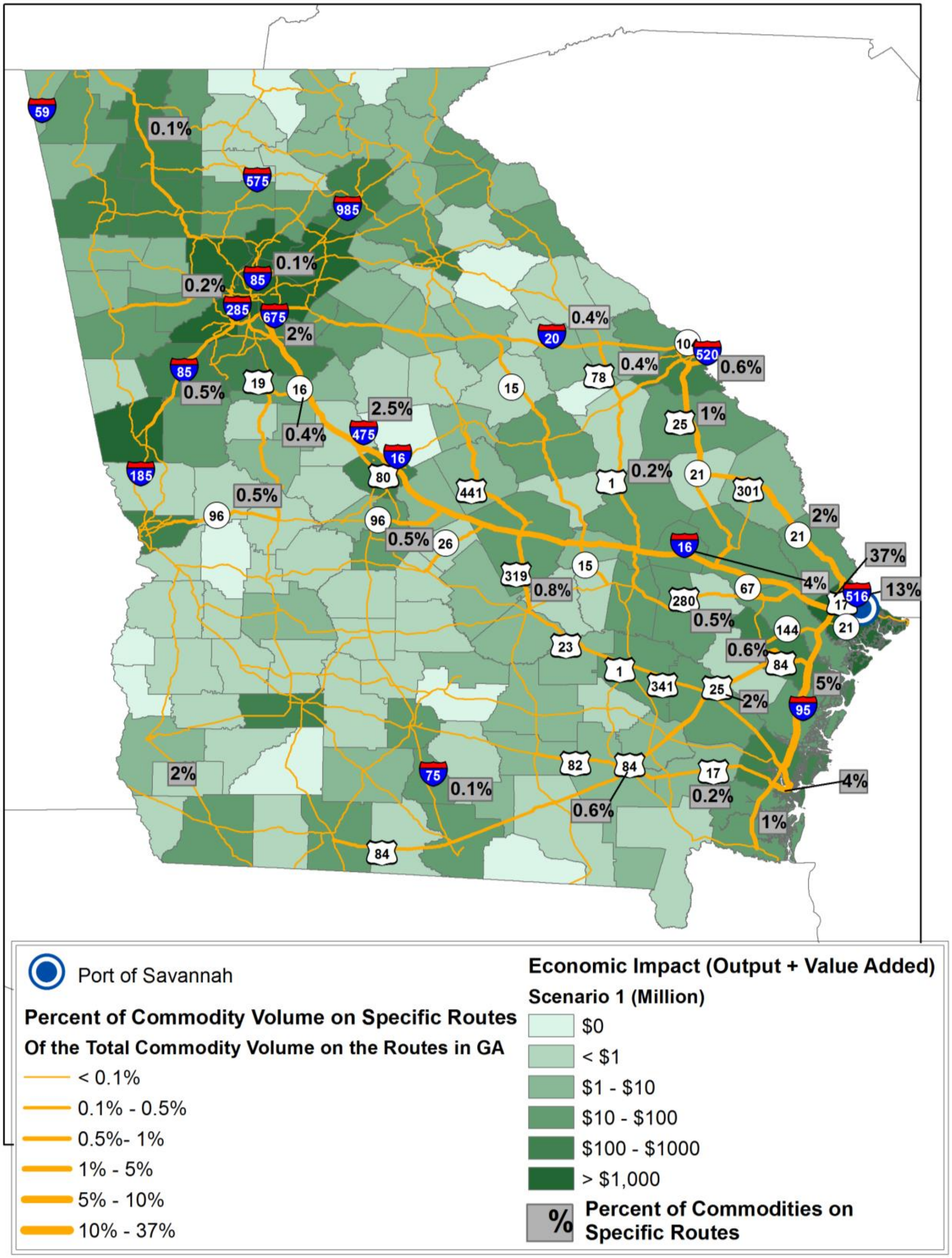


Figure 87: Important Truck Routes in Georgia by Their Shares of Tonnage of Commodities

There is a clear relationship between economic benefits in each county and the major freight routes that pass through the county. Figure 88 identifies the major trucking routes from the Port of Savannah and the counties that are traversed by the route. These major facilities include route that go to Atlanta, Augusta, Brunswick, and Thomasville. These cities are situated in counties that are among those that are estimated to be the most economically impacted by the Panama Canal expansion.

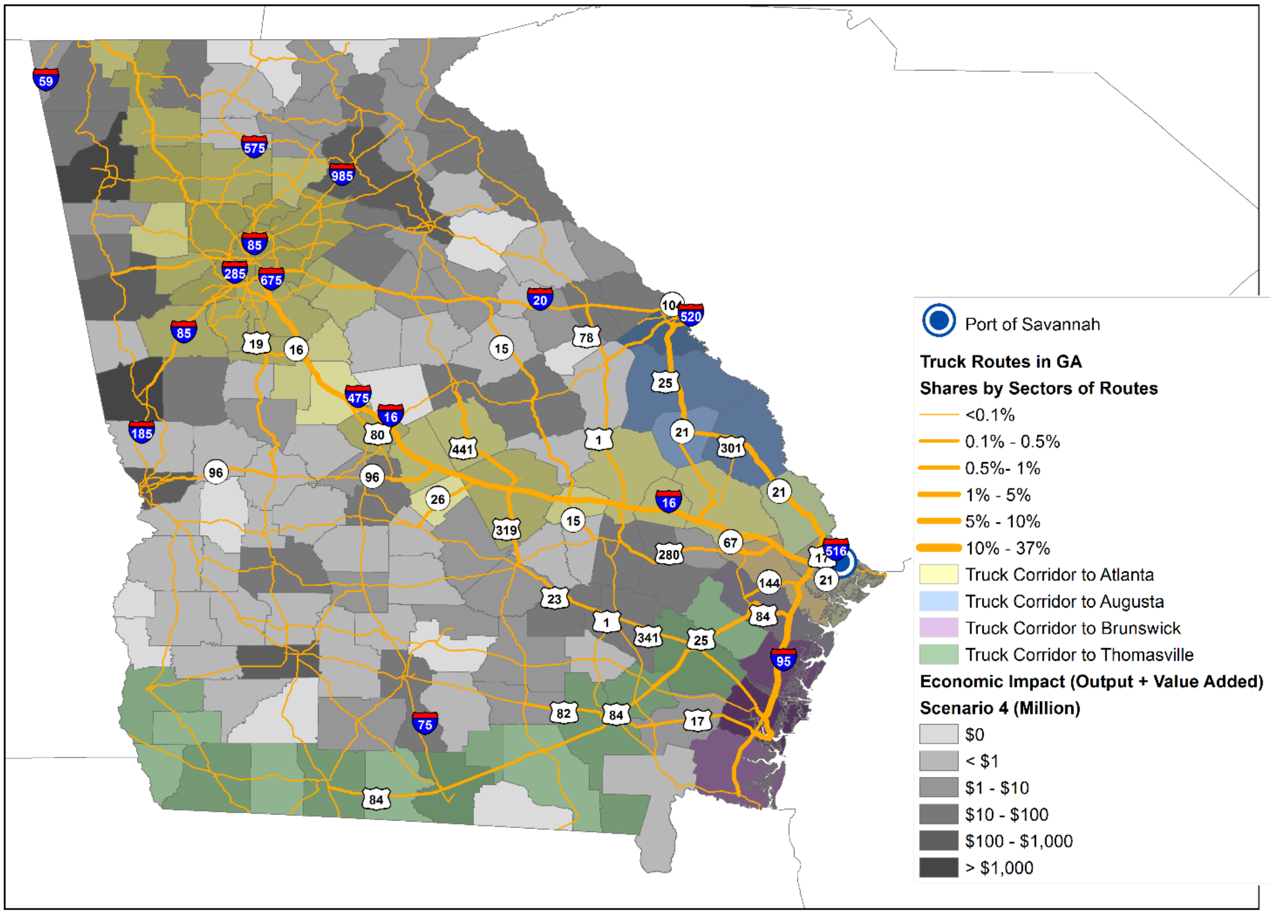


Figure 88: Map of the Counties Covered by the Three Major Truck Corridors by Economic Impact

Table 63 summarizes the economic impact of output and value added of the counties traversed by the four major truck routes. The counties covered by the routes to Atlanta make up a large portion of Georgia's total economic impact. The counties covered by the other three corridors are likewise substantially impacted economically.

Table 63: Counties Covered by the Three Major Truck Corridors by Economic Impact

Major Truck Corridors from Savannah	Number of Counties Traversed	Output + Value Added – 2013 (In Millions)	Output + Value Added - S1 (In Millions)	Output + Value Added - S2 (In Millions)	Output + Value Added – S3 (In Millions)	Output + Value Added - S4 (In Millions)
To Atlanta	34	13,380	16,789	22,673	28,554	36,398
To Augusta	5	310	388	524	660	842
To Brunswick	5	760	953	1,287	1,621	2,066

Major Truck Corridors from Savannah	Number of Counties Traversed	Output + Value Added – 2013 (In Millions)	Output + Value Added - S1 (In Millions)	Output + Value Added - S2 (In Millions)	Output + Value Added – S3 (In Millions)	Output + Value Added - S4 (In Millions)
To Thomasville	15	341	428	578	728	928
State Total	**159**	**21,071**	**26,440**	**35,705**	**44,967**	**57,320**

Figure 89 compares the major truck corridors designated in the Georgia Statewide Freight and Logistic Plan to those identified in this study as important truck routes from the Port of Savannah under the scenarios for year 2040 (Georgia Department of Transportation, 2013b). The routes that are completely green are important truck routes estimated to carry at least an additional 10,000 tons of daily commodities due the canal expansion (under Scenario 2, which is the minimal impact scenario) *but are not included in the statewide plan*. The truck route from the Port of Savannah to Augusta following State Route 21 and US Route 25, carries 2% of all commodities whose trip origin is at the port. The two routes likely carry substantially more port-related cargo when commodities that were first processed in distribution centers nearby the port are added, which could not be estimated from the GPS data. However, neither State Route 21 nor US Route 25 are included among the major truck corridors included in the Statewide Freight and Logistic Plan. Another important corridor missing from the plan is US Route 341 and US Route 23, which links Brunswick, Jesup, Baxley, and McRae in the southeastern part of the state. Although its volume compared with other state freight corridors is relatively small, US Route 341 and US Route 23 combine with US Route 319 to provide the primary transportation links into the Brunswick – McRae corridor. US Route 341 and US Route 23 carrying 0.2% commodities coming directly from the Port of Savannah by truck and likely significantly more when commodities from the port that are processed in Chatham County warehouses are included. The truck corridors that play important role in local economic development and opportunity that may merit additional state and local attention and investment.

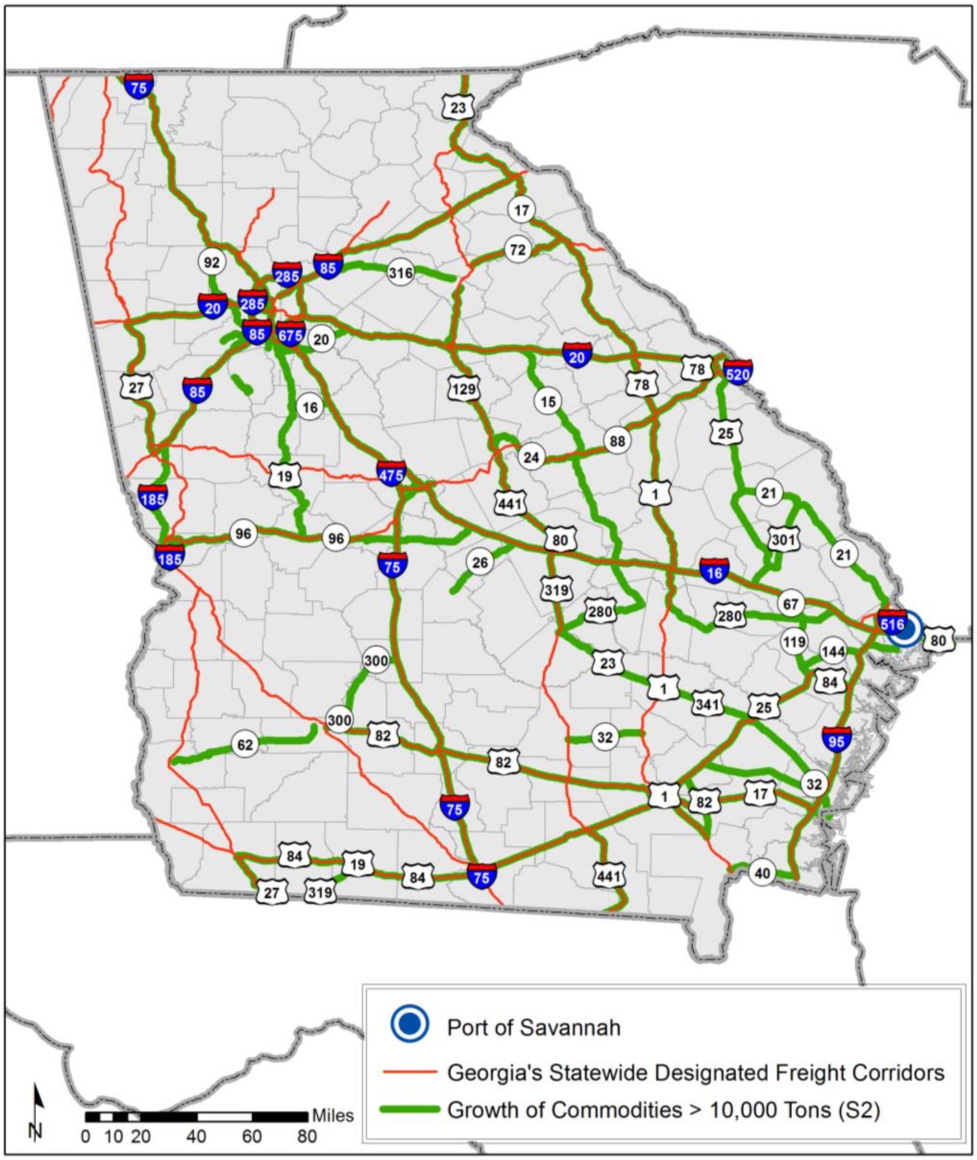


Figure 89: Comparison Between the Most Impacted Truck Corridors and the Major Truck Corridors Designated by the Statewide Plan

Figure 90 shows the interstate highways in Georgia by their share of the growth in commodities transported by truck from the Port of Savannah due to the Panama Canal expansion. The highway around the port itself will take on large proportions of the commodity increases, including I-516 and I-95. Statewide, the route that includes I-16 and I-475 linking the port to the Atlanta metropolitan area is projected to carry a substantially increased portion of commodities.

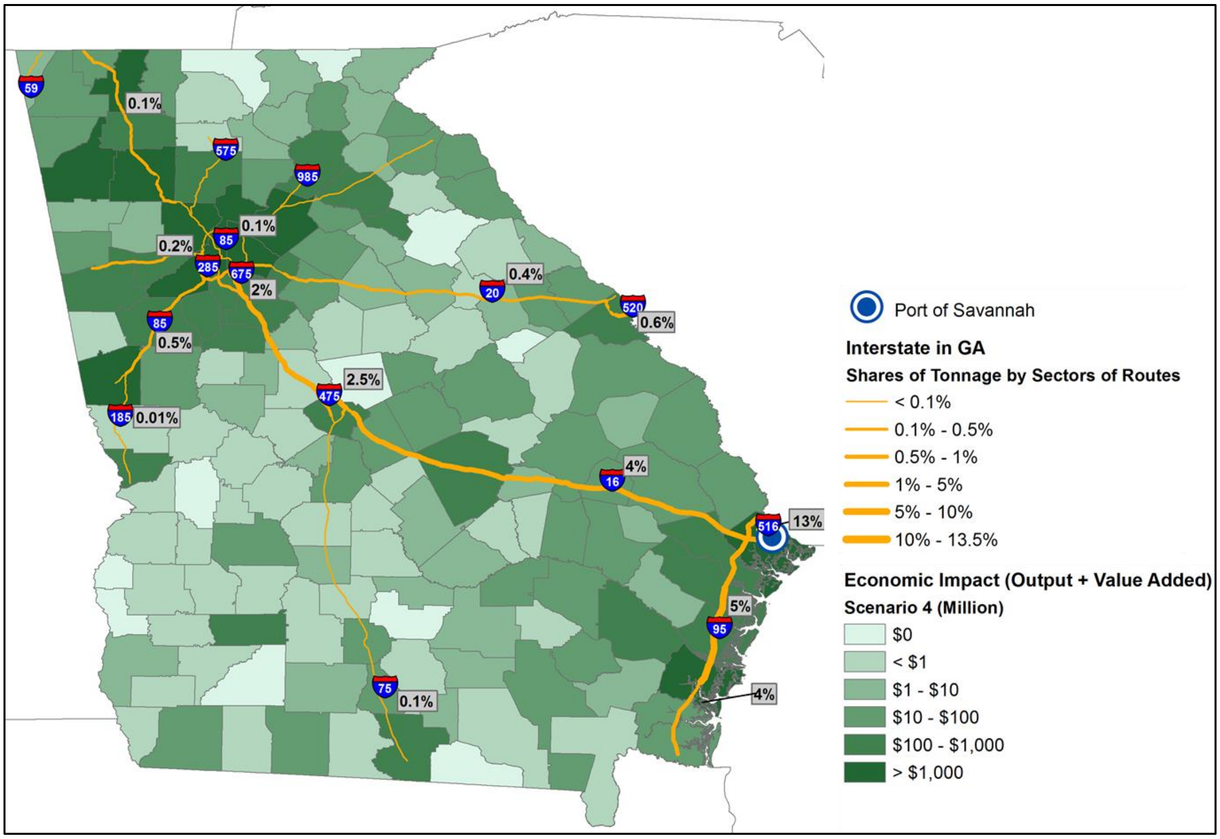


Figure 90: Interstate Truck Routes in Georgia by Their Shares of Tonnage of Commodities

Figure 91 shows the interstates in Georgia that are designated by the Federal Highway Administration to be part of the new national Primary Freight Network which is a draft version (Federal Highway Administration, 2014). The figure shows each interstate's share of the increase in commodities transported from the Port of Savannah due to the canal expansion. All of the interstates that are projected to experience a significant increase in commodity movement from the Port of Savannah have been designated as components of the Primary Freight Network.

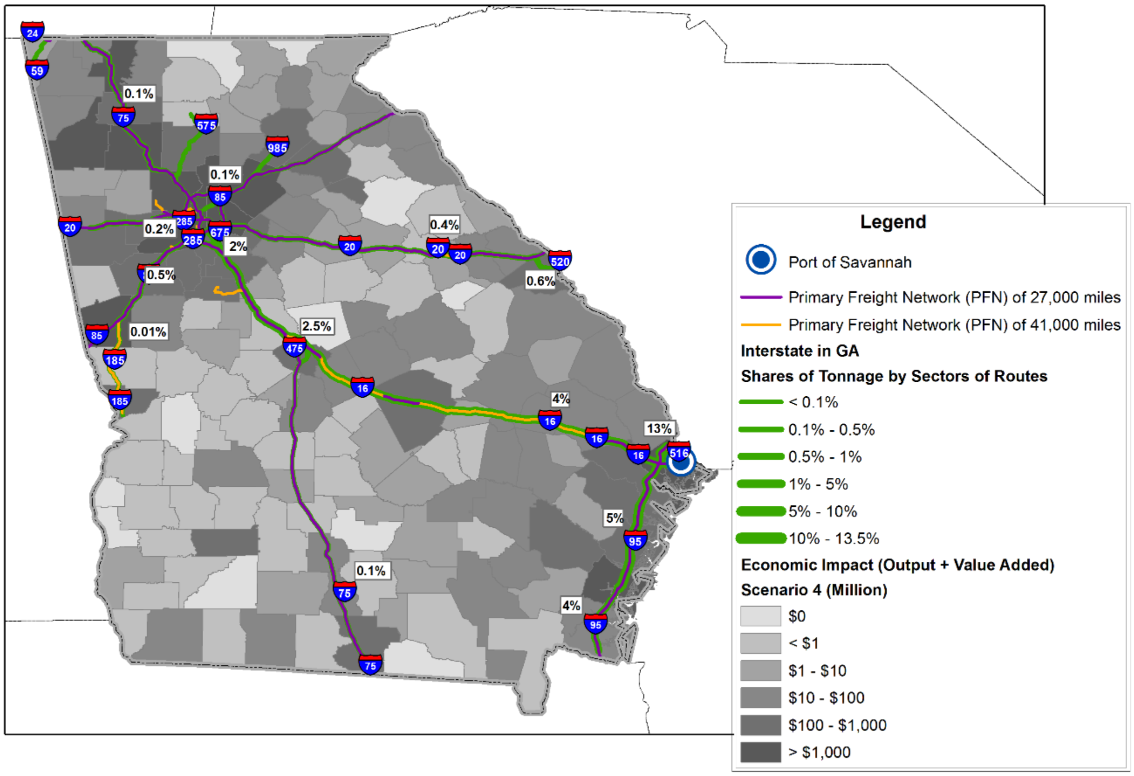


Figure 91: Primary Freight Network by the Shares of Tonnage of Commodities from the Port of Savannah

The Panama Canal expansion is likely to increase commodity movement through the Port of Savannah, which has the potential to cause social benefits through its positive economic impact on Georgia counties. This section incorporates projected commodity movements for four different year 2040 scenarios and the input-output economic modeling techniques to estimate the economic impact derived from the increased commodity movements due the canal expansion. The industry sectors that will be most significantly affected in terms of output and value added are associated with farming, forestry, food product, and textiles, which are important compositions of the economic base of the state of Georgia. The industry sectors that will see the greatest employment increase due the canal expansion include publishing, textile, miscellaneous manufacturing, and computer and other electronics, which are more labor-intense and are already quickly growing in Georgia.

Well-functioning roadways will help the state accommodate the between $21 billion and $57 billion dollars and between 38 thousand and 66 thousand jobs in canal-related economic windfall that is projected through 2040. The county-level economic analysis reveals that the dollar and employment impact concentrates in the counties adjacent to the Port of Savannah and in metropolitan Atlanta. Nonetheless, it is important that the Georgia Statewide Freight and Logistics Plan also accommodate small routes and rural areas' port connectivity and economic opportunity.

Georgia's Freight Corridor Network prepare the state well to accommodate the port-related truck movements that are expended to significantly grow through 2040. The route-level analysis identifies the four major truck corridors from the Port of Savannah, three of which are already designated freight corridors. The four major truck routes will account for over half of the total economic impact brought by the canal expansion. However, the analysis also identified two additional corridors that may merit statewide attention between Savannah and Augusta, and between Brunswick and McRae because they carry a relatively high percentage of direct port traffic, larger percentage of secondary port traffic, and are the primary transportation links for their respective region to the port. In each case, a statewide approach is important to address state, county, and local action to address transportation needs. Transportation infrastructure that relates to the Port of Savannah is particularly important to avoid forming bottlenecks of the potential economic growth.

Section VIII: CONCLUSION

Review of Research Question and Methodology

Global supply chains are changing in ways that will influence port operations along America's East Coast and Gulf Coast. Global trade and national economies are recovering after the declines of the global economic downturn, shipyards are filling orders for a new generation of outsized cargo ships, and the Panama Canal is nearing completion of its first new locks since the canal's opening a century ago. These trends are likely to increase the size of vessels calling on East and Gulf Coast ports and their total demand for cargo throughput. While many ports are making significant infrastructure investments in response to the forecasted demand, much less attention has been paid to the road network that accommodates a large portion of inland cargo movement.

As cargo volumes grow, changes in transportation costs and conditions pose a risk to quality of life. Traffic congestion could force freight onto relatively inefficient routes. Overcrowding and insufficient driver rest areas could increase the number of avoidable accidents. This study analyzed the challenges posed by the changing freight environment to answer three primary questions.

1. How much will the demand for cargo throughput increase at selected ports due to economic growth and the Panama Canal expansion?
2. On what roads may level of service degrade as a result of an increase port-related truck based freight movement?
3. What is the potential economic benefit to each of the 159 Georgia counties from the Panama Canal expansion?

This report addressed the three primary research questions and supporting secondary questions through a series of approaches that incorporated a vast amount of data analyzed with a variety of techniques. The analysis includes a literature review on the current impacts of the Panama Canal, a review of techniques used to conduct economic impact analysis, and a broad examination of truck safety issues. A thorough review was conducted of existing ocean shipping, port operations, and truck movement conditions.

Disaggregate truck movement data derived from GPS units installed in trucks was used to capture truck movement patterns from the three study ports at different times of the year. This aided in projecting Panama Canal-related growth around each of the three port's expanding freight sheds. The data were used to estimate changes in trucking activity on each roadway, to measure increases in corridor specific traffic congestion, and to identify potential bottlenecks. Finally, using the information gathered on changes in port-related goods movement and truck activity, economic impact forecasts were developed for each Georgia county based on the projected freight growth under different scenarios.

The research team drew the following major findings from its analysis.

Shipping Volumes

Finding 1: Cargo throughput at any individual port depends on a myriad of local, national, and global factors.

There is a variety of factors that influence cargo shipping volumes at individual ports. Many of the factors depend on policies and non-transparent decision making processes. This makes it difficult if not altogether impossible to predict a port's absolute change in cargo throughput with complete accuracy. A thorough review of the literature helped to identify many factors that influence cargo shipping volumes at ports, including—

- **Port infrastructure improvements and deepening**. The baseline analysis identified ports in Norfolk, Baltimore, Miami, and New York / New Jersey as having completed or in a stage approaching completion of port expansion projects. Dredging to deepen the port in Savannah is currently underway. Many other ports are in the early planning stages to accommodate post-Panamax ships.
- **Future energy costs**. The attractiveness of off-shore production compared with domestic production depends on transportation and labor costs. Higher energy prices could favor domestic production. Moreover, high energy costs favor the Panama Canal route for shipments between East Asia and the eastern U.S. compared with the faster but more expensive intermodal route. East and Gulf Coast ports benefit under energy prices that are high enough to favor trans-Panama shipment without stifling global trade.
- **Relative labor costs in different parts of the world**. Rising labor costs in Northeast Asia—notably China—have spurred some companies to shift production to lower-cost locations, typically in Southeast Asia, South Asia, or Latin America. Production relocation reconfigure corresponding supply chains.
- **Trade barriers.** Tariffs and regulatory trade barriers have fallen in recent decades. A reversal of the trend could hold back global trade.
- **Panama Canal transit fees**. The attraction of the Panama Canal route compared with the intermodal route is based on differential costs. Water remains an economical transportation method, making an all water route cheaper and slower than a route using water and land transportation. The water route's continued price competitiveness depends on the Panama Canal Authority keeping fees reasonable.
- **Ocean carrier reconfiguration**. Ocean carriers allocate their ships to maximize profitability. At intervals, changing conditions force ocean carriers to make revolutionary changes to their shipping routes to rationalize their operations. While predicted revolutions have not yet occurred, conditions in the shipping industry may prompt ocean carriers to change their route configuration differently than most forecasts have assumed.
- **West Coast ports' reaction**. Some West Coast ports have taken steps to improve service and hold onto traffic that could otherwise divert through the canal. Simultaneously, ports in Mexico's and Canada's west coast are offering rail connections to eastern U.S. destinations. The ability of ports, truckers, and railroads to retain customers remains undetermined.

Freight forecasts must necessarily use ranges to account for uncertainties. The research team created four different scenarios that implicitly account for uncertainties in the canal's ability to divert traffic. The assumption is made that the remaining uncertainties are constant.

Truck Volumes

Finding 1: Several scenarios of freight demand show the Panama Canal expansion will likely have a significant impact on truck traffic.

The amount of freight traffic diverted from West Coast ports by the Panama Canal expansion will have a significant impact on truck traffic from the three ports analyzed in the report. To better understand the potential impacts of such a diversion, three freight demand scenarios were developed to model freight-shed impacts. A low-impact scenario forecasts a truck volume increase of 15% at Norfolk, 19% at Savannah, and 22% at New Orleans. A high-impact scenario forecasts an increase in truck traffic from the Port of Norfolk of up to 50%, 65% at the Port of Savannah, and 75% at the Port of New Orleans; compared to a scenario where the Panama Canal expansion does not occur. Under the full range of scenarios, the Panama Canal will have a significant impact on the demand for truck-based freight, which will increase the traffic volume on many freight corridors.

Finding 2: Rail will be most competitive with trucks on corridors with a high levels of congestion.

Intermodal rail shipping may be a viable strategy to mitigate forecasted congestion. There are several roadways around ports that already experience high volume-to-capacity ratios (congestion) that are forecasted to have substantial port-related traffic growth through 2040. The following identifies the major freight corridors for each of the three ports examined in this report.

Port of Savannah
- I-95 north and south from Savannah, GA
- I-75 between Macon, GA and Knoxville, TN
- Atlanta-area interstates
- I-26 between I-95 and Spartanburg, SC

Port of Norfolk
- I-64 between Norfolk and Richmond, VA
- I-95 between Richmond, VA and Philadelphia, PA
- I-95 south of Virginia – North Carolina border
- Interstates and state roads in the area of Washington DC and Baltimore

Port of New Orleans
- Interstates around New Orleans, LA
- I-10 west to Houston, TX (moderately severe) and east to Pensacola, FL (very severe)
- I-55 between Brookhaven and Jackson, MS
- I-20 east of Meridian, MS
- Interstates around Houston

Rail may be particularly important at the Port of New Orleans for several reasons. First, GPS truck data shows that congestion in the New Orleans area is already hindering truck movement compared with Norfolk and Savannah. Moreover, New Orleans is home to six class I railroads, compared with just two in both Savannah and Norfolk. Finally, New Orleans’ commodity mix favors bulk cargo. Bulk cargo often has a lower value by weight than containerized cargo, meaning that transportation cost is more important relative to transportation speed compared with higher value-per-weight goods. Rail likely still has a major role to play in moving containers from Savannah and Norfolk, as evidenced by the construction of an inland port linked with the Norfolk area in Front Royal Virginia and the decision to build an inland port in Cordele, GA with a direct Savannah rail link.

Bottlenecks

Finding 1: Highways around the Savannah port are better prepared for canal-related growth than either Norfolk or New Orleans.

The Federal FAF3 forecast for the Savannah area show a lower daily truck-miles-to-roadway-capacity ratio than Norfolk or New Orleans. The FAF3 forecast shows the Savannah port area will have a ratio of truck VMT to centerline roadway miles of about 3,315. Compared to a ratio 3,514 in New Orleans and 3,851 in Norfolk, Savannah has significantly more existing centerline capacity to accommodate expect growth. This places Savannah in a better position to address port-related congestion.

Finding 2: Bottlenecks exist around all three ports with increased levels of congestion expected.

The worst bottlenecks for the Port of Savannah are located around the metropolitan areas that major truck corridors pass through. Norfolk’s worst bottlenecks occur on bridges and in tunnels around the port, as well as nearby urban areas. The worst congestion for New Orleans occurs directly around the port, which affects all trucking routes.

Georgia experiences the worst congestion around metro Atlanta. However, by 2040, Atlanta area congestion is forecasted to be much more severe, and congestion will spread to rural truck routes, including I-20, the length of I-75, I-95, and several state routes (Figure 92). According to the Georgia Statewide Freight and Logistics Plan, key future congested interstate corridors include: I-85 north of Atlanta, I-85 south of Atlanta, I-75 between Atlanta and Macon, I-75 between Atlanta and Tennessee, I-20 outside of the Atlanta metropolitan region, a few segments of I-95 in the Savannah metropolitan region. Capacity will have to increase throughout Georgia to accommodate port-related truck growth. Figure 92 shows the likely bottlenecks in Georgia using not only FAF3 but also the Georgia Statewide Freight and Logistics Plan where a robust statewide analysis was conducted.

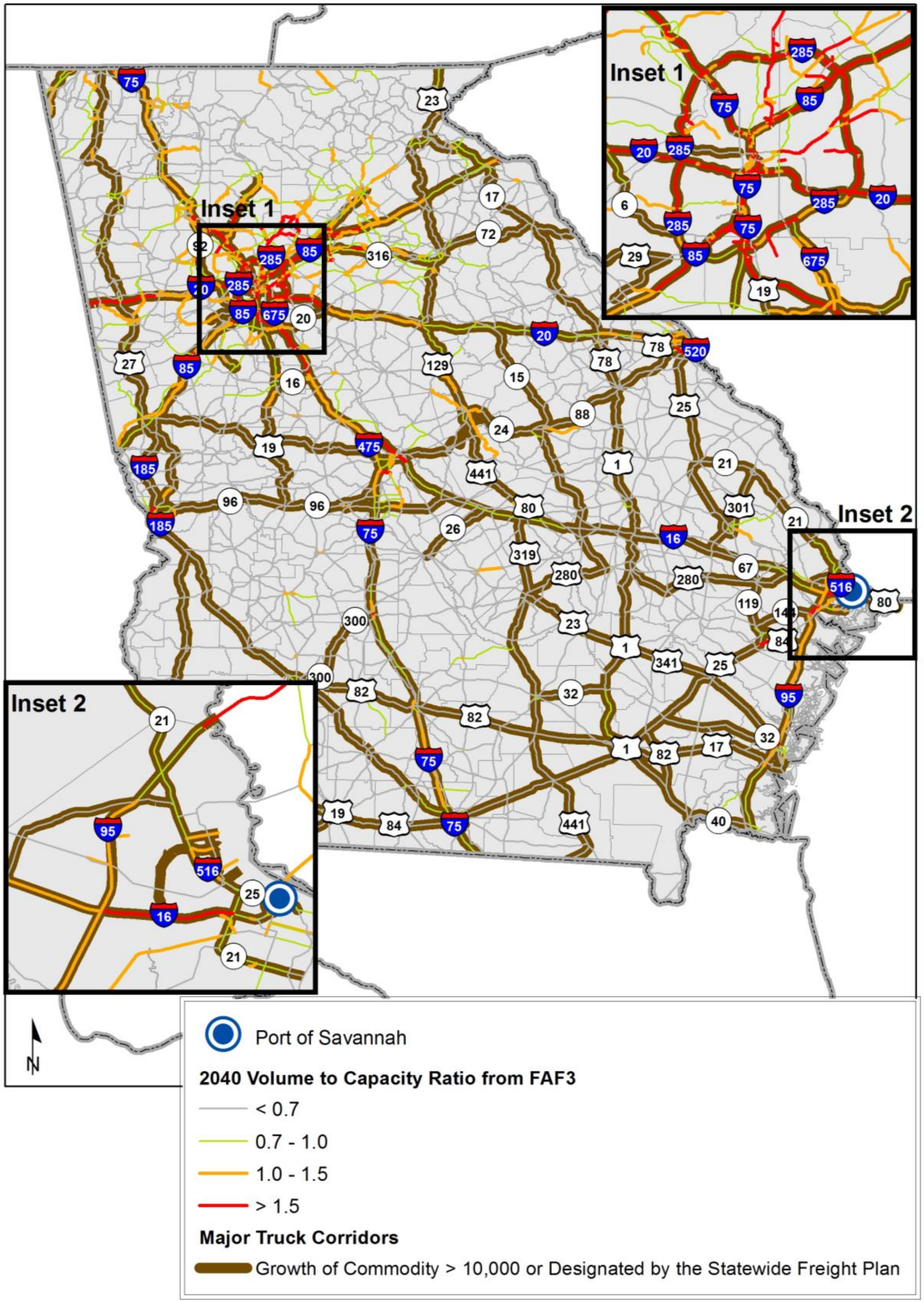


Figure 92: 2040 Congestion in Georgia

Finding 3: Most major Georgia freight routes are currently designated freight corridors; others may need to be added.

Most of the primary freight routes from the Port of Savannah are already designated freight routes by the Georgia Department of Transportation (see Figure 93). The most notable exception is US Route 25 corridor between Savannah and Augusta, which may merit consideration as a future state freight routes. State Route 21 carries 2% of all trucks that leave the Port of Savannah, and US Route 25 carries 1% of all trucks. Each route doubtlessly carries additional freight that is processed in warehouses near the port prior to onward movement. As for State Route 25, the Jimmy Deloach Extension project (now under construction) will provide a new route for Port-related trucks directly to/from I-95 and the Port -- alleviating much truck traffic from State Routes 21 and 25. Finally, the route is the primary connection between the Port of Savannah and the Augusta metro area, which is Georgia’s second largest metropolitan area. The route is particularly important since there is no direct interstate highway connection between the two regions.

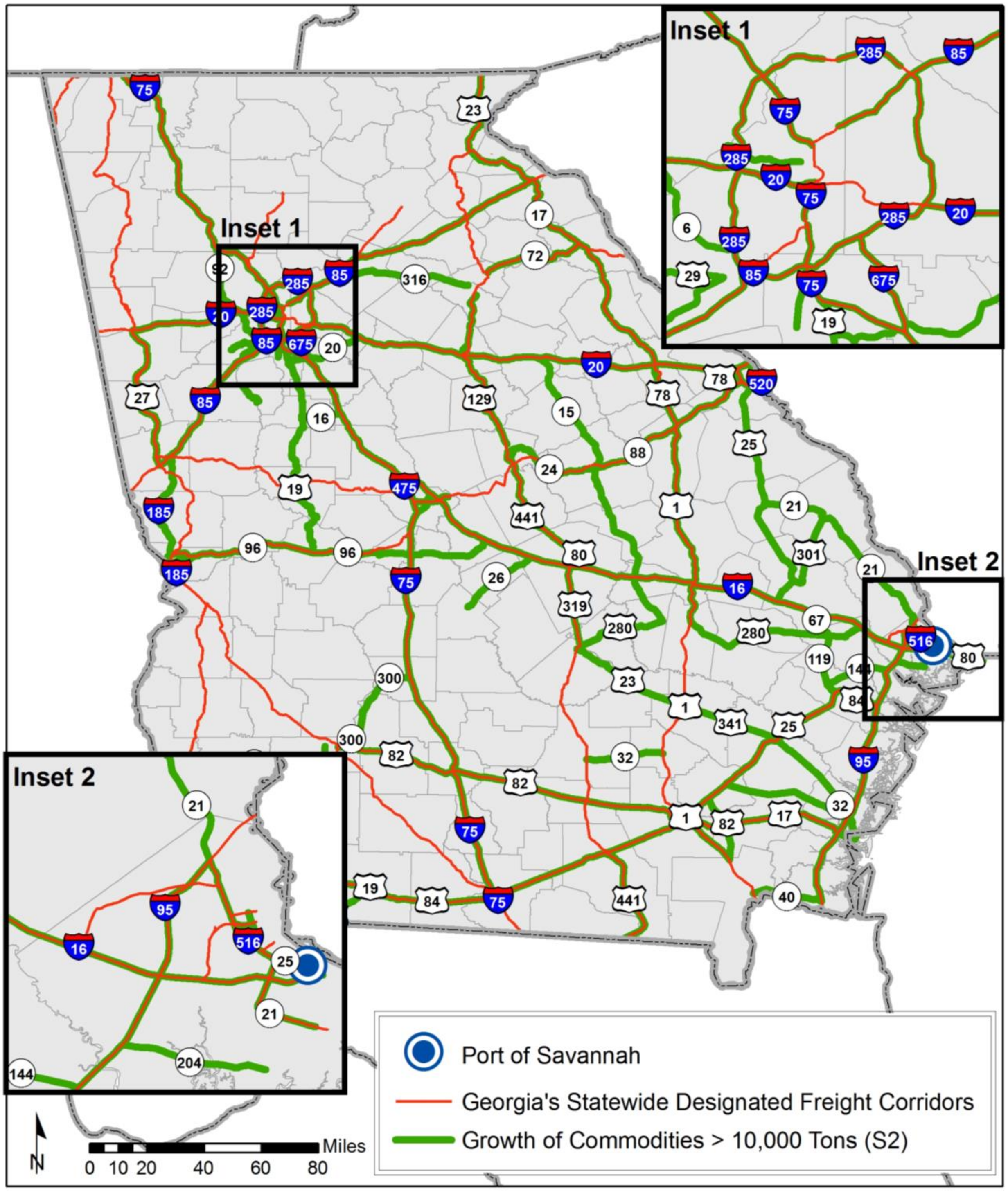


Figure 93: Comparison between the Most Impacted Truck Corridors and the Major Truck Corridors Designated by the Statewide Plan

Parking Needs and Safety

Finding 1: The availability of truck parking may be a safety concern as freight traffic grows.

When truck parking per truck VMT along each port's five main routes was examined, it revealed that New Orleans has the most spaces per mile and Norfolk the fewest. However, the New Orleans area is forecasted to experience some of the greatest canal-related growth, which may degrade its ability to adequately provide driver rest areas in its region. Table 64 below shows the average number of truck VMT per truck parking space along major corridors in each port's operating area.

Table 64: Truck Parking on Each Port's Largest Truck Routes

Port	Weighted Average of Truck VMT per Truck Parking Space (5 Largest Truck Routes)
New Orleans	1,086
Norfolk	1,311
Savannah	1,141

Source: Center for Quality Growth and Regional Development, Freight Analysis Framework (FAF), Federal Highway Administration truck parking facility database

Finding 2: Georgia is least equipped with truck parking compared to surrounding states.

The five largest truck routes by VMT to and from the Port of Savannah (shown in Table 67), are primarily in Georgia (route 2 Routes along I-16 and I-20; and route 3 along I-16 and I-17) and have the highest ratio of truck VMT to parking space. By contrast, routes with major portions in Florida (route 1) and the Carolinas (routes 4 and 5) have a third fewer daily truck miles per parking space. This means that trucks traveling from Savannah through Florida, North Carolina, and South Carolina are likely to find parking spaces for required rest more easily than trucks traveling through Georgia. Moreover, the Georgia Statewide Freight and Logistics Plan also analyzed truck parking in Georgia. When this report's analysis is combined with the Georgia Statewide Freight and Logistics Plan, it suggests that Georgia's most severe parking shortages may be on I-16 between Savannah and Macon, and on I-75 between Atlanta and Macon. The Georgia Statewide Freight and Logistics Plan found inadequate parking on I-16 and I-75 between Atlanta and Macon. Both interstates are part of the routes 2 and 3 (identified previously and in Source: Center for Quality Growth and Regional Development, U.S. Census Bureau, County Business Patterns, 2011

Table 67 below), which confirms the inadequacy of available parking.

Table 67: Truck Parking on the Port of Savannah's Largest Truck Routes

Route Number	States	Route Name	Truck Miles per Space
1	GA and FL	I-95 S to I-10 W	867

Route Number	States	Route Name	Truck Miles per Space
2	GA and AL	I-16 W to I-20 W	1,507
3	GA and TN	I-16 W to I-75 N	1,449
4	SC and NC	I-95 N to I-85 N	1,074
5	SC and NC	I-95 N	921

Source: Center for Quality Growth and Regional Development, Freight Analysis Framework (FAF), Federal Highway Administration truck parking facility database

Finding 3: Each corridor in each megaregion will require additional parking to maintain the current level of service.

The high impact scenarios developed in this study show that hundreds of new truck parking spaces will be needed to accommodate truck movement related to the Panama Canal expansion. New Orleans' operating area will require the highest absolute number of new spaces to maintain current level of service. Savannah's operating area will require an intermediate number, and Norfolk's a lower number. Routes along Savannah will require new parking spaces to deal with increased freight from economic growth. The effects of Panama Canal expansion are on the order of several dozen truck spaces per freight corridor

Finding 4: Growing freight volumes may affect truck-related accident rates far from the port generating the traffic.

Interactions between trucks and passenger cars can be dangerous because of their very different operating characteristics. The growing cargo through the Port of Savannah will increase truck volumes in the Savannah area and along major corridors, including those far from the port that carry significant automotive traffic. I-285 is a truck bypass route for I-20, I-75, I-675, and I-85, and GA400. Moreover, I-285 carries significant local passenger traffic and is particularly important. The Georgia Statewide Freight and Logistics Plan found the most truck accidents around I-285, ostensibly because of the mixing of truck and car volume. Two of the port's five largest truck routes pass through I-285, which will increase port-related truck traffic accordingly.

Economic Impact

Finding 1: Primary benefactors are counties surrounding the Port of Savannah and major population centers

The moderate impact scenarios (Scenario 3) developed in this study show the Panama Canal expansion is expected to result in a $7.7 billion impact in Chatham County alone (the home county of the Port of Savannah). The canal expansion will have a major impact on metro Atlanta counties, including $9.8 billion in Fulton, $8.6 billion in Gwinnett, $2.3 billion in Cobb, and $2.2 billion in DeKalb (up from $3.6 billion, $4.0 billion, $1.1 billion, and $1.1 billion respectively in 2013). Smaller cities will also benefit from increased freight activity. Troup County in western Georgia is forecasted to experience up to $3.0 billion in canal-related activity (up from $1.4 billion in 2014), with an impact of $1.4 billion in Whitfield County and a $1.0 billion impact in

Glynn County. The moderate impact scenario also forecasts 43,725 jobs by 2040 for the state, following a similar distribution across the counties as the economic impact.

Finding 2: Panama Canal expansion will potentially have an economic impact of over $35 billion by 2040 in Georgia.

Without the Panama Canal expansion the Port of Savannah will add up to $26 billion to the state's economy by 2040. With the canal expansion, even the smallest impact will add $36 billion to the state economy (Scenario 2). A large impact (Scenario 4) will add up to $57 billion.

Recommendations

The Georgia Department of Transportation can undertake key actions to ensure that roadways carrying cargo to and from the Port of Savannah retain a high level of service.

I. Address Bottlenecks

1. **Expand capacity on some key roadways.**
   Major truck routes from the Port of Savannah use I-95, I-16, I-75, I-20, and I-285, sections of which are already projected to be operating above capacity by 2040. These may warrant capacity expansion. Moreover, most traffic also uses local access roads in Chatham County to reach interstate highways or local distribution centers. Through the Federally-required transportation planning process, the Georgia Department of Transportation will continue to work with the Chatham County Metropolitan Planning Commission as it works on its current MPO Freight Plan to identify freight transportation needs servicing the port and distribution centers, including State Route 21 (Augusta Road) and State Route 307 (Dean Forest Road). This should include an analysis of likely future locations of distribution centers and other freight-generating facilities.

2. **Partner with other states in the Piedmont Atlantic Megaregion to address bottlenecks on primary port-related corridors outside the state.**
   All of largest truck corridor serving the Savannah Port involve Georgia's adjacent states. The Georgia Department should continue its membership in those freight-focused organizations consisting of neighboring state DOTs to ensure that port-related freight can reliably reach customers, reinforcing the port's competitive position.

3. **Leverage data and information technologies to optimize roadway operations.**
   The Georgia Department of Transportation collects significant amounts of data, which have allowed it to implement advanced intelligent transportation systems (ITS). ITS in Georgia has many components, including Transportation Management Centers and statewide Transportation Control Centers, ramp meters at some highway onramps, and the Georgia-NaviGAtor 511 portal to provide information to travelers (Georgia Department of Transportation, 2013a). These and similar technologies hold promise maintaining freight flow throughout the state and should be continually developed.

II. Strengthen Coordination between Port Operators and State Department of Transportation

1. **Maintain a close working relationship with the Georgia Ports Authority.**
   The Georgia Department of Transportation has a history of working closely with the Georgia Ports Authority to share information and understand how Georgia's road and sea infrastructure affect each other. It is important to continue the relationship since the Georgia Ports Authority is directly connected with the ocean carriers who call on the Port of Savannah. These carriers' operational decisions affect the timing and amount of cargo in the ports and on the roads. A working relationship between the Georgia Department of

Transportation and the Georgia Ports Authority should continue to convey shipping information relevant to inland travel, including total volumes, simultaneous discharge amounts, discharge frequency, and shipment configuration (e.g., bulk vs. containerized cargo).

2. **Build partnerships with other state departments of transportation and port operators in megaregions to explore how cooperation can maximize megaregion attractiveness to ocean carriers.**
   Freight crosses state lines regularly. Georgia can benefit from shipping in adjacent states and vice-versa. The state of Georgia can work with adjacent states to explore how Savannah and other ports can specialize in complementary areas of natural advantage. Specialization and coordination can make the megaregion's ports as attractive as possible to ocean carriers and avoid overinvestment which may result from pursuing the same market segments.

III. Leverage Designated Freight Corridors

1. **Align freight corridors with import truck traffic. The analysis has confirmed that most major port-related routes are already State Freight Network routes.**
   However, some routes such as US Route 25 between Savannah and Augusta are not currently State Freight Network routes. State Freight Network corridors should be re-examined in light of port traffic. Especially the routes between the Port of Savannah and the Augusta metro area, which is Georgia's second largest metropolitan area, are special interests. The routes are particularly important since there is no direct interstate highway connection between the two regions.

2. **Coordinate freight corridors with surrounding states in megaregion to ensure continuity across state lines.**
   Freight corridors normally cross multiple state boundaries. The Georgia Department of Transportation should work with other states to ensure that traffic continues to flow across state lines on state and local roads.

3. **Work with local governments to align zoning with designated freight corridors.**
   Georgia's freight corridors have the largest chance of effectively serving freight if locally controlled land uses align with freight functions. Local governments should regulate land use such that freight generators locate along freight routes and conflicting uses prefer other locations. The Georgia Department of Transportation can ensure that local land use departments are aware of the freight plan.

REFERENCES

Alabama Department of Transportation. (2010). *Alabama Statewide Freight Study and Action Plan* (Final Report). Retrieved from http://www.uahcmer.com/2010/06/01/alabama-statewide-freight-study-and-action-plan/statewide-freight-study-final-report/

American Transportation Research Institute. (2012). *National Corridors Analysis and Speed Tool*. Retrieved from http://atri-online.org/n-cast/

American Transportation Research Institute. (2013a). *An Analysis of the Operational Costs of Trucking: A 2013 Update*. Retrieved from http://atri-online.org/2013/09/04/an-analysis-of-the-operational-costs-of-trucking-a-2013-update-report-request/

American Transportation Research Institute. (2013b). *Critical Issues in the Trucking Industry: 2013*.

American Trucking Associations. (2013a). *American Trucking Trends 2013*. Retrieved from http://www.trucking.org/itemcontent.aspx?uid=d62a253d-b830-4fa3-b069-f7f8ff5d40df

American Trucking Associations. (2013b, May 29). New Report Underscores Trucking's Essential Role in U.S. Economy. Retrieved from http://www.truckline.com/article.aspx?uid=ef9eab57-99be-410b-999d-348b21fe5687

Ashar, A. (2006). Revolution #4. *Containerisation International*, 46–49.

Ashar, A. (2010). An expanding brief. *Containerisation International*, *43*. Retrieved from http://trid.trb.org/view.aspx?id=933903

Associated Press. (2012, December 2). Governors Meet on Savannah River Port. *Atlanta Journal Constitution*. Retrieved from http://www.ajc.com/news/governors-meet-on-savannah-1343781.html

Association of American Railroads. (2013). *Rail Intermodal Keeps America Moving*. Retrieved from https://www.aar.org/keyissues/Documents/Background-Papers/Rail-Intermodal.pdf

Baird, T., Bittner, J., Gollnik, R., & Gardner, S. (2011). *Understanding the Consequences of the Panama Canal Expansion on Midwest Grain and Agricultural Exports* (No. CFIRE 03-18). National Center for Freight & Infrastructure Research & Education. Retrieved from http://www.wistrans.org/cfire/documents/CFIRE_03-18_Final_Report.pdf

Bank of America Merrill Lynch. (2013). *Get Ready for the Big Ships*. Retrieved from http://corp.bankofamerica.com/documents/10157/67594/MISC-04-13-2648_Fortune_Custom_Content_Panama_Canal_FINAL_051613.pdf

Battelle. (2011a). *FAF3 FREIGHT TRAFFIC ANALYSIS - CHAPTER 3: DEVELOPMENT OF TRUCK PAYLOAD EQUIVALENCY FACTOR*. Oak Ridge National Laboratory. Retrieved from http://faf.ornl.gov/fafweb/Data/Freight_Traffic_Analysis/chap3.htm

Battelle. (2011b). *FAF3: Appendix A Truck Equivalency Factors*. Retrieved from http://faf.ornl.gov/fafweb/Data/Freight_Traffic_Analysis/appendixa.htm

Battelle. (2011c). *FAF3: Appendix B FAF3 Commodities*. Retrieved from http://faf.ornl.gov/fafweb/Data/Freight_Traffic_Analysis/appendixa.htm

Belenky, G., Wu, L., Zaslona, J., & Hodges, J. (2012). *Motorcoach Driver Fatigue Study, 2011* (Final Report No. FMCSA-RRR-12-042). Sleep and Performance Research Center. Retrieved from http://www.fmcsa.dot.gov/facts-research/research-technology/report/Motorcoach-Driver-Fatigue-Study-2011-508.pdf

References

Berman, J. (2013, June 26). ATA unveils U.S. Freight Forecast to 2024. *Logistics Management*. Retrieved from http://www.logisticsmgmt.com/article/ata_unveils_u.s._freight_forecast_to_2024

Blanco, M., Hanowski, R. J., Olson, R. L., Morgan, J. F., Soccolich, S. A., Wu, S.-C., & Guo, F. (2011). *The impact of driving, non-driving work, and rest breaks on driving performance in commercial motor vehicle operations*. Retrieved from http://trid.trb.org/view.aspx?id=1108816

Broward County Port Everglades Department. (n.d.). *Fort Lauderdale Port - Official Port Everglades Site - Fort Lauderdale, Florida*. Retrieved February 17, 2014, from http://www.porteverglades.net/

Bureau of Economic Analysis. (2014). *Regional Data - GDP and Personal Income*. U.S. Department of Commerce. Retrieved from http://www.bea.gov/itable/index.cfm

Bureau of Labor Statistics. (2005, March 30). *Location Quotient Calculator*. Retrieved November 20, 2013, from http://www.bls.gov/cew/cewlq.htm

Bureau of Labor Statistics. (2014, March 13). *Truck Transportation: NAICS 484*. *Industries at a Glance*. Retrieved March 13, 2014, from http://www.bls.gov/iag/tgs/iag484.htm

Bureau of Transportation Statistics. (2009). *Port of Philadelphia, Pennsylvania-Water Gateway*. Retrieved March 20, 2013, from http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/americas_freight_transportation_gateways/2009/highlights_of_top_25_freight_gateways_by_shipment_value/port_of_philadelphia/index.html

Bureau of Transportation Statistics. (n.d.). *Economic Impact on Transportation | Bureau of Transportation Statistics*. Retrieved March 13, 2014, from http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/subject_areas/freight_transportation/html/transportation.html

Burnson, P. (2012, October 1). Top 30 Ocean Carriers Special Report: Sailing into the black? Retrieved from http://www.logisticsmgmt.com/article/top_30_ocean_carriers_special_report_sailing_into_the_black

CanagaRetna, S. (2010). The Panama Canal Expansion and SLC State Ports. Southern Legislative Conference. Retrieved from https://www.slcatlanta.org/Publications/EconDev/ports_web.pdf

Carson, J. L., Pezoldt, V. J., Koncz, N., & Obeng-Boampong, K. (2011). *Benefits of Public Roadside Safety Rest Areas in Texas*. Retrieved from http://trid.trb.org/view.aspx?id=1114440

Center for Quality Growth and Regional Development. (2009). *Megaregions: Delineating Existing and Emerging Megaregions* (No. FHWA-BAA-HEPP-02-2007).

Chatterjee, A., & Wegmann, F. J. (2000). Overnight truck parking along Tennessee's Interstate highways and rest areas. *Transportation Research Record: Journal of the Transportation Research Board*, *1734*(1), 64–68.

ConnDOT. (2008). *CT Statewide Rest Area and Service Plaza Study* (Administrative Report No. 170-2533).

References

Copeland, L. (2011, February 10). U.S. Ports Racing to Get Ready for Bigger Ships. *USA Today*. Retrieved from http://www.usatoday.com/money/economy/story/2011-09-30/ports-bigger-ships/50637090/1

Costa, R., & Rosson, P. (2012). *The Impacts Of The Panama Canal Expansion On World Cotton Trade* (No. 145244). Texas A&M University. Retrieved from http://www.trforum.org/forum/downloads/2012_55_Panama_Canal_Expansion_Cotton.pdf

Dablanc, L., & Ross, C. (2012). Atlanta: a mega logistics center in the Piedmont Atlantic Megaregion (PAM). *Journal of Transport Geography*, *24*, 432–442.

Davis, R. E. (1997). Commercial driver rest and parking requirements: Making space for safety. *Transportation Research Record: Journal of the Transportation Research Board*, *1595*(1), 46–52.

De Monie, G., Rodrigue, J.-P., & Notteboom, T. E. (2009). Economic cycles in maritime shipping and ports: The path to the crisis of 2008. In *International Workshop on Integrating Maritime Transport in Value Chains, Montreal* (pp. 9–12). Retrieved from http://www.vliz.be/imisdocs/publications/248197.pdf

Diamond State Port Corporation. (n.d.). *Port of Wilmington - Our State*. Retrieved February 17, 2014, from http://www.portofwilmington.com/

Drewry. (2008). *US Transpacific Intermodal Today and Tomorrow* (White Paper).

FAF3. (2011). *Freight Analysis Framework Data Tabulation Tool*. Freight Analysis Framework 3. Retrieved from http://faf.ornl.gov/fafweb/Extraction3.aspx

Federal Highway Administration. (2012). *Freight Analysis Framework 3 User Guide*. U.S. Department of Transportation. Retrieved from http://www.ops.fhwa.dot.gov/freight/freight_analysis/faf/faf3/userguide/index.htm

Federal Highway Administration. (2013). *Freight Analysis Framework*. Retrieved from http://www.ops.fhwa.dot.gov/freight/freight_analysis/faf

Federal Highway Administration. (2014, January 31). *National Freight Network*. Retrieved June 11, 2014, from http://www.ops.fhwa.dot.gov/freight/infrastructure/nfn/

Federal Motor Carrier Safety Administration. (2006). *Report to Congress on the Large Truck Crash Causation Study* (No. MC-R/MC-RRA). Retrieved from http://www.fmcsa.dot.gov/facts-research/research-technology/report/ltccs-2006.htm

Federal Motor Carrier Safety Administration. (2013). *Motor Carrier Safety Progress Report (as of September 30, 2013)*. Retrieved from http://www.fmcsa.dot.gov/facts-research/art-safety-progress-report.htm

Federal Motor Carrier Safety Administration. (n.d.). *Interstate Truck Driver's Guide to Hours of Service*. Retrieved from http://www.fmcsa.dot.gov/rules-regulations/truck/driver/hos/fmcsa-guide-to-hos.pdf

Fleger, S. A., Haas, R. P., Trombly, J. W., Cross III, R. H., Noltenius, J. E., Pecheux, K. K., & Chen, K. J. (2002). *Study of Adequacy of Commercial Truck Parking Facilities-Technical Report*. Retrieved from http://trid.trb.org/view.aspx?id=719591

Fossey, J. (2010). A larger market share. Retrieved from http://www.nxtbook.com/nxteu/informa/ci_201005/index.php?startid=81

References

Garber, N. J., & Wang, H. (2004). *Estimation of the Demand for Commercial Truck Parking on Interstate Highways in Virginia*. Retrieved from http://trid.trb.org/view.aspx?id=697996

Georgia Department of Transportation. (2012). *Rest Areas & Welcome Centers*. Retrieved November 4, 2013, from http://www.dot.ga.gov/travelingingeorgia/pages/RestAreas.aspx

Georgia Department of Transportation. (2013a). *Fact Book*. Retrieved from http://www.dot.ga.gov/informationcenter/pressroom/Documents/publications/FactBook/GeorgiaDOT-FactBook.pdf

Georgia Department of Transportation. (2013b). *Georgia Freight*. Retrieved from http://www.dot.ga.gov/Projects/programs/georgiafreight/Pages/default.aspx

Georgia Department of Transportation. (2013c). *Georgia Statewide Freight and Logistics Plan, 2010-2050: Truck Modal Profile*. Retrieved from http://www.dot.ga.gov/Projects/programs/georgiafreight/logisticsplan/Documents/Plan/TruckModal-Task3.pdf

Gifford, J., Chen, Z., Li, J., Kelekar, U., Zebrowski, N., & Zhou, X. (2010). Mega-regions and Freight: Evidence from Commodity Flow Survey and Freight Analysis Framework. Retrieved from http://trid.trb.org/view.aspx?id=987388

Government Accountability Office. (2008). *Freight Transportation: National Policy and Strategies Can Help Improve Freight Mobility* (No. GAO-08-287). Retrieved from http://www.gao.gov/products/GAO-08-287

Hapag-Lloyd. (2014, April 28). *Services from Asia to North America*. Retrieved from http://www.hapag-lloyd.com/en/products_and_services/services_between_asia_and_north_america.html#NCE_east

Harrington, L. (2012, March). Nearshoring Latin America: a closer look. *Inbound Logistics*. Retrieved from http://www.inboundlogistics.com/cms/article/nearshoring-latin-america-a-closer-look

IHS Global Insights. (2009). *An Evaluation of Maritime Policy in Meeting the Commercial and Security Needs of the United States*. Retrieved from http://www.ihsglobalinsight.com/gcpath/MARADPolicyStudy.pdf

IMPLAN Group. (2013). *IMPLAN*. Retrieved from http://implan.com/

Institute for Water Resources. (2012). *U.S. Port and Inland Waterways Modernization Preparing for Post-Panamax Vessels*. U.S. Army Corps of Engineers. Retrieved from http://www.iwr.usace.army.mil/Portals/70/docs/portswaterways/rpt/June_20_U.S._Port_and_Inland_Waterways_Preparing_for_Post_Panamax_Vessels.pdf

Jacksonville Port Authority. (2013). *The Jacksonville Port Authority (JAXPORT)*. Retrieved February 17, 2014, from http://www.jaxport.com/

Jones Lang LaSalle. (2011). *The Panama Canal's Impact on U.S. Industrial Real Estate* (White Paper). Retrieved from http://www.us.jll.com/united-states/en-us/research/3592/the-panama-canal-s-impact-on-u-s-industrial-real-estate

Kendall, W., Shaw, J., & Kendall, L. (2012). *http://www.atlanticmarketingassociation.com/Resources/Kendall,%20Shaw,%20%26%20Kendall.pdf*. Retrieved from http://www.atlanticmarketingassociation.com/Resources/Kendall,%20Shaw,%20%26%20Kendall.pdf

References

Knight, K. (2008). *The Implications of Panama Canal Expansion to U.S. Ports and Coastal Navigation Economic Analysis* (White Paper). Institute for Water Resources, U.S. Army Corps of Engineers. Retrieved from http://www.iwr.usace.army.mil/Portals/70/docs/iwrreports/WhitePaperPanamaCanal.pdf

Knipling, R. R., Waller, P., Peck, R. C., Pfefer, R., Neuman, T. R., Slack, K. L., & Hardy, K. K. (2004). *GUIDANCE FOR IMPLEMENTATION OF THE AASHTO STRATEGIC HIGHWAY SAFETY PLAN. VOLUME 13: A GUIDE FOR REDUCING COLLISIONS INVOLVING HEAVY TRUCKS*. Retrieved from http://trid.trb.org/view.aspx?id=704165

Louisiana Department of Transportation and Development. (2003). *Louisiana Statewide Transportation Plan*. Retrieved from http://wwwsp.dotd.la.gov/Inside_LaDOTD/Divisions/Multimodal/Transportation_Plan/Pages/2003_Statewide_Plan.aspx

Maersk Lines. (2012, February 6). *Transpacific 3 (TP3) - Eastbound*. Retrieved June 17, 2014, from http://www.maerskline.com/en-us/shipping-services/routenet/maersk-line-network/transpacific/transpacific-3-eastbound

Maritime Administration. (2013). *Maritime Statistics*. Retrieved from http://www.marad.dot.gov/library_landing_page/data_and_statistics/Data_and_Statistics.htm

Martin, E. W., & Shaheen, S. A. (2013). Truck Parking and Traffic on I-5 in California: Analysis of a Clipboard Survey and Annual Average Daily Traffic Data. In *Transportation Research Board 92nd Annual Meeting*. Retrieved from http://trid.trb.org/view.aspx?id=1243103

Maryland Department of Transportation. (2009). *Maryland Statewide Freight Plan*. Retrieved from http://www.mdot.maryland.gov/Office_of_Planning_and_Capital_Programming/Freight_Planning/Documents/Freight_Plan_Final.pdf

Maryland Department of Transportation. (n.d.). *Maryland Department of Transportation; Port Administration*. Retrieved February 17, 2014, from http://www.mpa.maryland.gov/

Masson, R. (2013, August 9). *Port of N.O. could spend $450M to prepare for wider Panama Canal - FOX 8 WVUE New Orleans News, Weather, Sports*. Retrieved February 17, 2014, from http://www.fox8live.com/story/23033519/port-of-no-could-spend-450-million-to-prepare-for-panama-canal-widening

Miami-Dade County. (2012). *PortMiami - - Miami-Dade County*. Retrieved February 17, 2014, from http://www.miamidade.gov/portmiami/

Miami-Dade County. (2013). *Port of Miami - Deep Dredge*. Retrieved from http://www.miamidade.gov/portmiami/deep-dredge.asp

Mitchell, C. (2011). *Impact of the expansion of the Panama Canal: an engineering analysis*. Retrieved from http://fitsnews.com/wp-content/uploads/2013/04/Mitchell-Impact-of-the-Expansion-of-the-Panama-Canal-FINAL-with-Chapters.pdf

Moore, M. (2013, July 30). Chinese entrepreneur reveals route for Nicaraguan canal - Telegraph. *The Telegraph*. Retrieved from http://www.telegraph.co.uk/news/worldnews/asia/china/10212169/Chinese-entrepreneur-reveals-route-for-Nicaraguan-canal.html

Moving Ahead for Progress in the 21st Century Act, U.S.C. § 134-135 (2012). Retrieved from http://www.gpo.gov/fdsys/pkg/BILLS-112hr4348enr/pdf/BILLS-112hr4348enr.pdf

References

National Association of Truck Stop Owners. (2013a, March 1). Trends And Priorities Affecting The Truckstop And Travel Plaza Industry. Retrieved from http://www.natso.com/articles/articles/view/trends-and-priorities-affecting-the-truckstop-and-travel-plaza-industry-2

National Association of Truck Stop Owners. (2013b, August 5). FHWA Should Strategically Tackle Truck Parking Needs. Retrieved from http://www.natso.com/articles/articles/view/fhwa-should-strategically-target-truck-parking-needs

North Carolina Department of Transportation. (2008). *Governor's Logistics Task Force* (Final Report). Retrieved from http://www.ncdot.gov/download/business/committees/logistics/GovernorsReport_Jun2012.pdf

North Carolina State Ports Authority. (2012). *Port of Wilmington — NC Ports*. Retrieved February 17, 2014, from http://www.ncports.com/port-of-wilmington/

On the Conference Report to Accompany H.R. 3080, Water Resources Development Act of 2013: Roll Vote No. 163. (2014, May 22). Congressional Record Daily Digest. Retrieved from http://beta.congress.gov/congressional-record/2014/5/22/daily-digest

Panama Canal Authority. (2006). *Proposal for the Expansion of the Panama Canal: Third Set of Locks Project*. Retrieved from http://www.pancanal.com/eng/plan/documentos/propuesta/acp-expansion-proposal.pdf

Panama Canal Authority. (2012). *Press Releases: 2012*. Retrieved from http://www.pancanal.com/eng/pr/press-releases/2012/index.html

Panama Canal Authority. (2013a). *Commodity Movement through the Panama Canal by Country of Origin and Destination -- Principal Trade Routes, Pacific to Atlantic (Long Tons)*. Statistics and Models Administration Unit (MEEM). Retrieved from http://www.pancanal.com/eng/op/transit-stats/

Panama Canal Authority. (2013b). *Transit Statistics*. Retrieved from http://www.pancanal.com/eng/op/transit-stats/

Panama Canal Authority. (2014). *Press Releases: 2014*. Retrieved from http://www.pancanal.com/eng/pr/press-releases/2014/index.html

Payer, H. (2005). *Adequacy of Selected Lock Size Parameters for Expanded Panama Canal*. Retrieved from http://www.pancanal.com/esp/plan/estudios/0286.pdf

Philadelphia Regional Port Authority. (2013). *Philadelphia Regional Port Authority*. Retrieved February 17, 2014, from http://www.philaport.com/

Port Authority of New York and New Jersey. (2013). *Port of New York and New Jersey - The Port Authority of NY & NJ*. Retrieved February 17, 2014, from http://www.panynj.gov/port/

Port of Houston Authority. (2013). *The Port of Houston Authority*. Retrieved February 17, 2014, from http://www.portofhouston.com/

Port of New Orleans. (n.d.). *Port of New Orleans - Home*. Retrieved February 17, 2014, from http://www.portno.com/

Puentes, R. (2008). *A Bridge to Somewhere: Rethinking American Transportation for the 21st Century*. Brookings Institution. Retrieved from http://trid.trb.org/view.aspx?id=863713

References

Regional Plan Association. (2014a). *Piedmont Atlantic*. *America 2050*. Retrieved January 31, 2014, from http://www.america2050.org/piedmont_atlantic.html

Regional Plan Association. (2014b). *Texas Triangle*. *America 2050*. Retrieved January 31, 2014, from http://www.america2050.org/texas_triangle.html

Rodigue, J. P., & Ashar, A. (2012). *Evolution of Containerships*. Retrieved June 19, 2014, from https://people.hofstra.edu/geotrans/eng/ch3en/conc3en/containerships.html

Rodrigue, J.-P. (2010). *Factors impacting North American freight distribution in view of the Panama Canal expansion*. Van Horne Institute. Retrieved from http://people.hofstra.edu/jean-paul_rodrigue/downloads/Panama%20Canal%20Study%202011%20Final.pdf

Rodrigue, J.-P., & Notteboom, T. (2010). Comparative North American and European gateway logistics: the regionalism of freight distribution. *Journal of Transport Geography*, *18*(4), 497–507.

Ross, C., Barringer, J., Yang, J., Woo, M., Doyle, J., West, H., … Meyer, M. (2008). *Megaregions: Literature review of the implications for US infrastructure investment and transportation planning*. US Department of Transportation, Federal Highway Administration. Retrieved from http://fhwicsint01.fhwa.dot.gov/planning/publications/megaregions_report/index.cfm/megaregions.pdf

Ross, C., Woo, M., West, H., Meyer, M., & Amekudzi, A. (2011). *Megaregions: Literature Review of Organizational Structures and Finance of Multi-jurisdictional Initiatives and the Implications for Megaregion Transportation Planning in the U.S. (Deliverable 1)* (No. DTFH61-11-C-00003). Center For Quality Growth and Regional Development. Retrieved from http://www.fhwa.dot.gov/planning/megaregions/reports/megaregions_report_2011/

Salin, D. L. (2010). *Impact of Panama Canal Expansion on the US Intermodal System*. United States Department of Agriculture, Agricultural Marketing Service, Transportation and Marketing Program. Retrieved from http://ideas.repec.org/p/ags/uamstr/147032.html

Seedah, D., & Harrison, R. (2011). *Megaregion Freight Movements: A Case Study of the Texas Triangle*. Southwest Region University Transportation Center, Center for Transportation Research, University of Texas at Austin. Retrieved from http://ntl.bts.gov/lib/45000/45400/45420/476660-00075-1.pdf

Smith, L. C., & Stephenson, S. R. (2013). New Trans-Arctic shipping routes navigable by midcentury. *Proceedings of the National Academy of Sciences*, *110*(13), E1191–E1195.

South Carolina Department of Transportation. (2013). *Multimodal Transportation Plan*. Retrieved April 14, 2014, from http://www.scdot.org/Multimodal/

South Carolina Ports Authority. (n.d.). *South Carolina Ports Authority*. Retrieved February 17, 2014, from http://www.port-of-charleston.com/

Tennessee Department of Transportation. (2014). *Long Range Planning Division - Freight Planning*. Retrieved April 14, 2014, from http://www.tdot.state.tn.us/longrange/freightplanning.htm

Texas Department of Transportation. (2014). *Texas Freight Mobility Plan*. Retrieved from http://www.dot.state.tx.us/move-texas-freight/freight_plan.htm

The Economist. (2013, January 19). *Reshoring manufacturing: Coming home | The Economist*. Retrieved February 17, 2014, from http://www.economist.com/news/special-report/21569570-growing-number-american-companies-are-moving-their-manufacturing-back-united

The Port of Virginia. (2013). *VPA 2040 Master Plan: Executive Summary*. Retrieved from http://www.portofvirginia.com/media/11163/vpamasterplan052113.pdf

The White House. (2012, July 19). We Can't Wait: Obama Administration Announces 5 Major Port Projects to Be Expedited. Retrieved from http://www.whitehouse.gov/the-press-office/2012/07/19/we-can-t-wait-obama-administration-announces-5-major-port-projects-be-ex

Trombly, J. W. (2003). *Dealing with truck parking demands* (Vol. 317). Transportation Research Board. Retrieved from http://books.google.com/books?hl=en&lr=&id=2bbqswwUTk0C&oi=fnd&pg=PA1&dq=Dealing+with+truck+parking+demands+&ots=SibUw8dARx&sig=6rX7soIhBjSsjhmUdG7-OAN3o9w

TruckStopGuide.com. (2013). *Truck Stop Guide*. Retrieved November 3, 2013, from http://www.truckstopguide.com/Default.aspx

U.S. Army Corps of Engineers Navigation Data Center. (2014). Retrieved March 14, 2014, from http://www.navigationdatacenter.us/

U.S. Census Bureau. (2012). *2012 NAICS Definition*. *North American Industry Classification System*. Retrieved March 10, 2014, from https://www.census.gov/cgi-bin/sssd/naics/naicsrch?code=493&search=2012%20NAICS%20Search

U.S. Department of Commerce. (2012). *The Logistics and Transportation Industry in the United States*. Retrieved from http://selectusa.commerce.gov/industry-snapshots/logistics-and-transportation-industry-united-states

U.S. Maritime Administration. (n.d.). *MARAD*. Retrieved from www.marad.dot.gov/documents/US_Port_Calls_by_Vessel_Type.xls

Van Dongen, H., Jackson, M., & Belenky, G. (2010). *Duration of Restart Period Needed to Recycle with Optimal Performance: Phase II* (No. FMCSA-MC-RRR-10-062). Sleep and Performance Research Center.

Virginia Department of Transportation. (2013). *Virginia Multimodal Freight Plan* (Draft). Retrieved from http://www.vtrans.org/resources/Virginia_Multimodal_Freight_Plan_11.01.13_Draft_Final_with_appendices.pdf

Virginia Port Authority. (2013). *The Port of Virginia - Home*. Retrieved February 17, 2014, from http://www.portofvirginia.com/

Water Resources Development Act of 1999, § Aug. 17, 1999.

Water Resources Reform & Development Act of 2013. Retrieved from http://www.gpo.gov/fdsys/pkg/BILLS-113hr3080eas/pdf/BILLS-113hr3080eas.pdf

APPENDICES

APPENDIX 1: Industrial Clustering Methodology

Two-digit North American Industry Classification System (NAICS) codes

Provided by the U.S. Census Bureau (2012)

- **NAICS 11: Agriculture, Forestry, Fishing and Hunting.** The Agriculture, Forestry, Fishing and Hunting sector comprises establishments primarily engaged in growing crops, raising animals, harvesting timber, and harvesting fish and other animals from a farm, ranch, or their natural habitats.
- **NAICS 21: Mining, Quarrying, and Oil and Gas Extraction.** The Mining, Quarrying, and Oil and Gas Extraction sector comprises establishments that extract naturally occurring mineral solids, such as coal and ores; liquid minerals, such as crude petroleum; and gases, such as natural gas.
- **NAICS 22: Utilities.** The Utilities sector comprises establishments engaged in the provision of the following utility services: electric power, natural gas, steam supply, water supply, and sewage removal.
- **NAICS 23: Construction.** The Construction sector comprises establishments primarily engaged in the construction of buildings or engineering projects (e.g., highways and utility systems).
- **NAICS 31-33: Manufacturing.** The Manufacturing sector comprises establishments engaged in the mechanical, physical, or chemical transformation of materials, substances, or components into new products.
- **NAICS 42: Wholesale Trade.** The Wholesale Trade sector comprises establishments engaged in wholesaling merchandise, generally without transformation, and rendering services incidental to the sale of merchandise.
- **NAICS 44-45: Retail Trade.** The Retail Trade sector comprises establishments engaged in retailing merchandise, generally without transformation, and rendering services incidental to the sale of merchandise.
- **NAICS 48-49: Transportation and Warehousing.** The Transportation and Warehousing sector includes industries providing transportation of passengers and cargo, warehousing and storage for goods, scenic and sightseeing transportation, and support activities related to modes of transportation.
- **NAICS 51: Information.** The Information sector comprises establishments engaged in the following processes: (a) producing and distributing information and cultural products, (b) providing the means to transmit or distribute these products as well as data or communications, and (c) processing data.
- **NAICS 52: Finance and Insurance.** The Finance and Insurance sector comprises establishments primarily engaged in financial transactions (transactions involving the creation, liquidation, or change in ownership of financial assets) and/or in facilitating financial transactions.
- **NAICS 53: Real Estate and Rental and Leasing.** The Real Estate and Rental and Leasing sector comprises establishments primarily engaged in renting, leasing, or

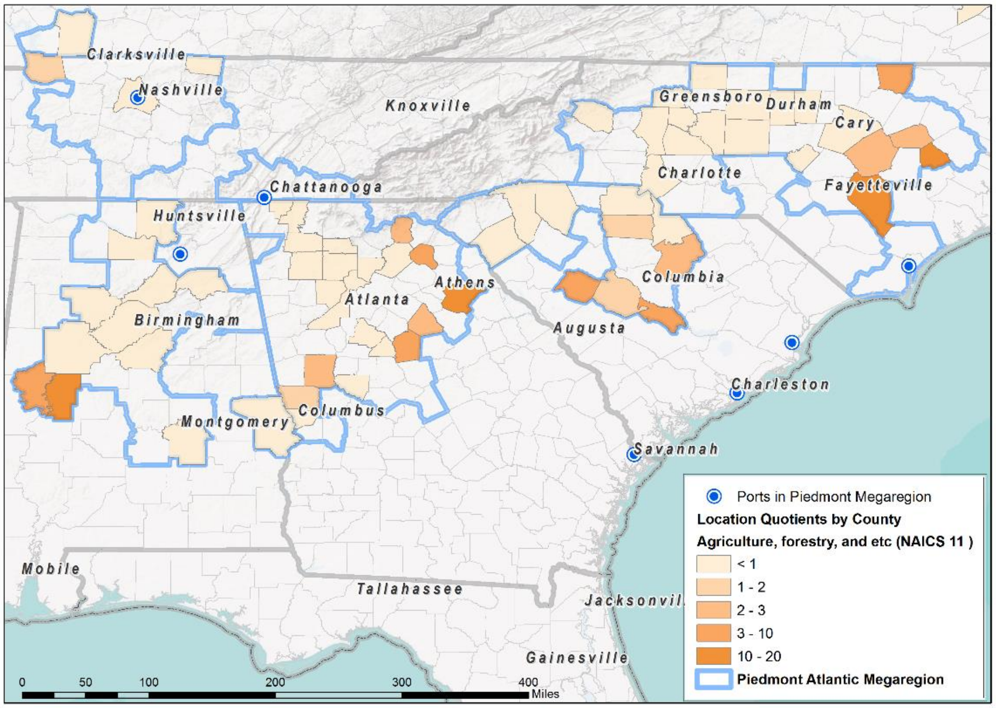
otherwise allowing the use of tangible or intangible assets, and establishments providing related services.

- **NAICS 54: Professional, Scientific, and Technical Services.** The Professional, Scientific, and Technical Services sector comprises establishments that specialize in performing professional, scientific, and technical activities for others." "Activities performed include: legal advice and representation; accounting, bookkeeping, and payroll services; architectural, engineering, and specialized design services; computer services; consulting services; research services; advertising services; photographic services; translation and interpretation services; veterinary services; and other professional, scientific, and technical services.
- **NAICS 55: Management of Companies and Enterprises.** The Management of Companies and Enterprises sector comprises (1) establishments that hold the securities of (or other equity interests in) companies and enterprises for the purpose of owning a controlling interest or influencing management decisions or (2) establishments (except government establishments) that administer, oversee, and manage establishments of the company or enterprise and that normally undertake the strategic or organizational planning and decision making role of the company or enterprise.
- **NAICS 56: Administrative and Support and Waste Management and Remediation Services.** The Administrative and Support and Waste Management and Remediation Services sector comprises establishments performing routine support activities for the day-to-day operations of other organizations." "Activities performed include: office administration, hiring and placing of personnel, document preparation and similar clerical services, solicitation, collection, security and surveillance services, cleaning, and waste disposal services.
- **NAICS 61: Educational Services.** The Educational Services sector comprises establishments that provide instruction and training in a wide variety of subjects. This instruction and training is provided by specialized establishments, such as schools, colleges, universities, and training centers.
- **NAICS 62: Health Care and Social Assistance.** The Health Care and Social Assistance sector comprises establishments providing health care and social assistance for individuals.
- **NAICS 71: Arts, Entertainment, and Recreation.** The Arts, Entertainment, and Recreation sector includes a wide range of establishments that operate facilities or provide services to meet varied cultural, entertainment, and recreational interests of their patrons.
- **NAICS 72: Accommodation and Food Services**. The Accommodation and Food Services sector comprises establishments providing customers with lodging and/or preparing meals, snacks, and beverages for immediate consumption.
- **NAICS 81: Other Services (except Public Administration).** The Other Services (except Public Administration) sector comprises establishments engaged in providing services not specifically provided for elsewhere in the classification system. Establishments in this sector are primarily engaged in activities such as equipment and machinery repairing, promoting or administering religious activities, grant making, advocacy, and providing dry cleaning and laundry services, personal care services,

death care services, pet care services, photofinishing services, temporary parking services, and dating services.

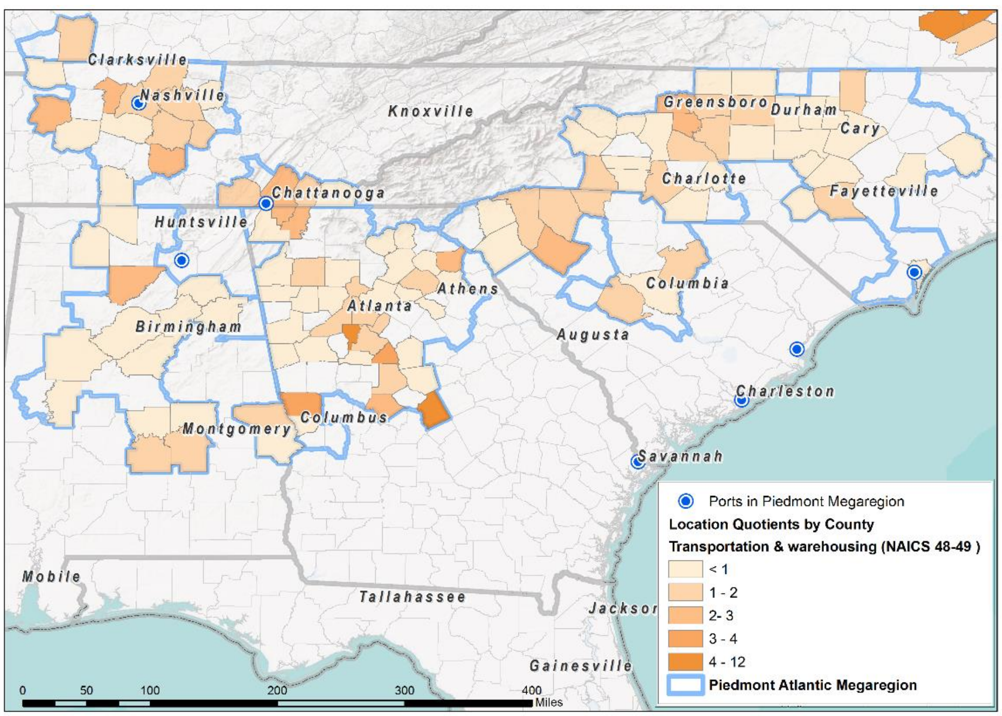
- **NAICS 92: Public Administration.** The Public Administration sector consists of establishments of federal, state, and local government agencies that administer, oversee, and manage public programs and have executive, legislative, or judicial authority over other institutions within a given area.

Industry Clustering in Piedmont Atlantic Megaregion



Data Source: American Census Bureau 2012

Figure 94: Location Quotient for NAICS 11 / Agriculture, Forestry, Fishing, and Hunting



Data Source: American Census Bureau 2012

Figure 95: Location Quotient for NAICS 48-49 / Transportation and Warehousing

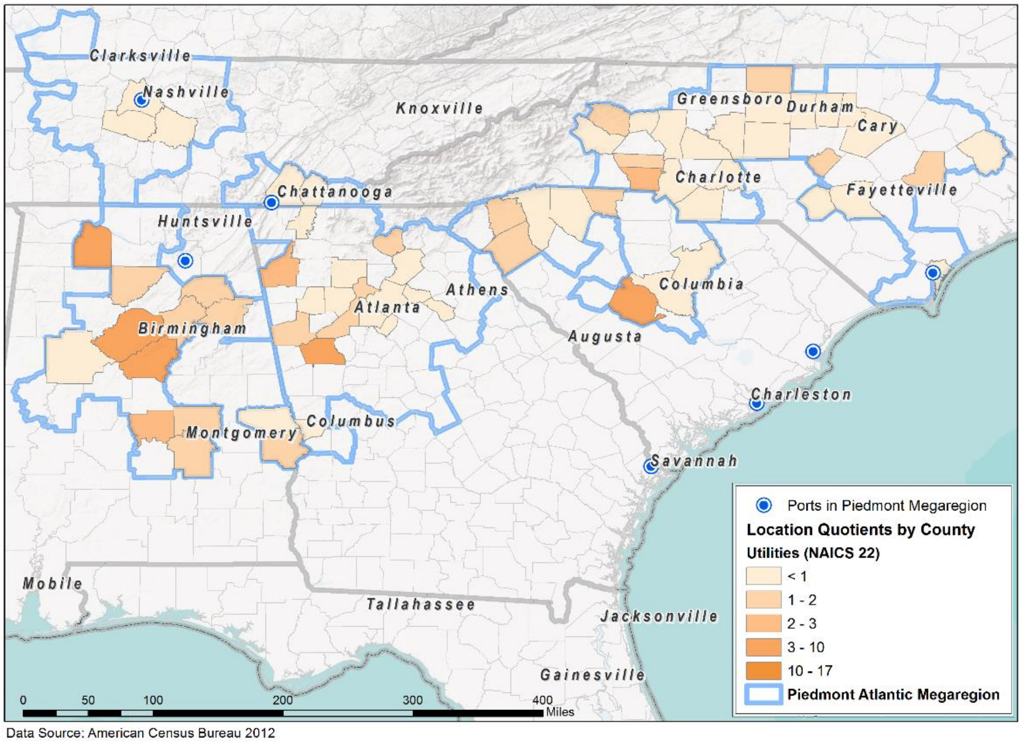


Figure 96: Location Quotient for NAICS 22 / Utilities

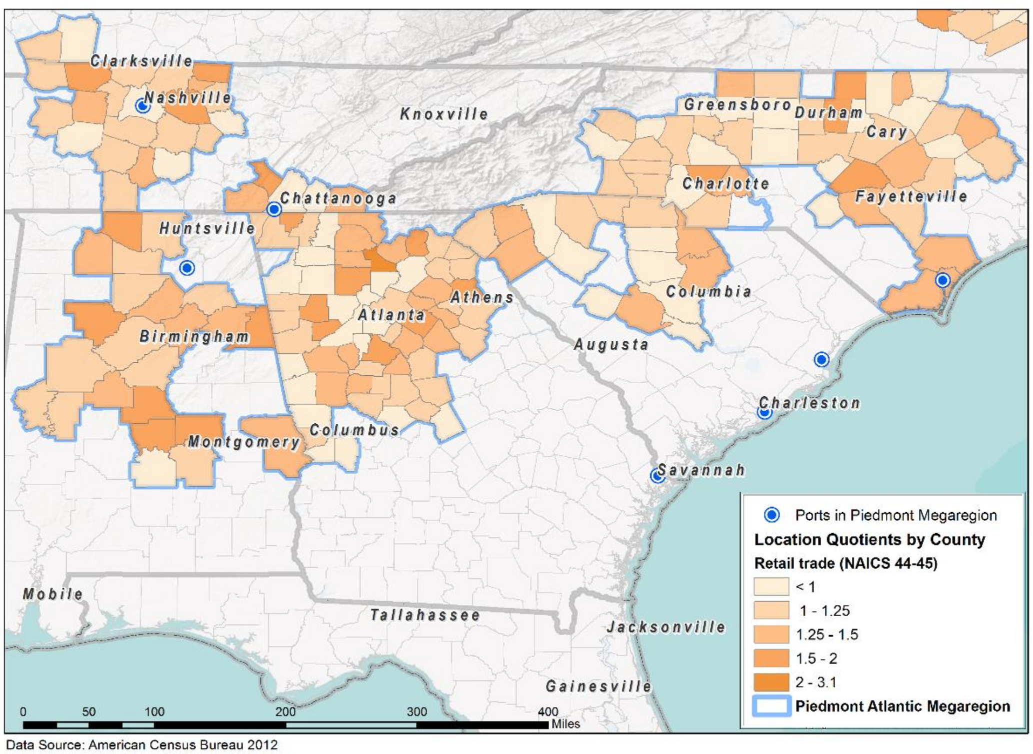
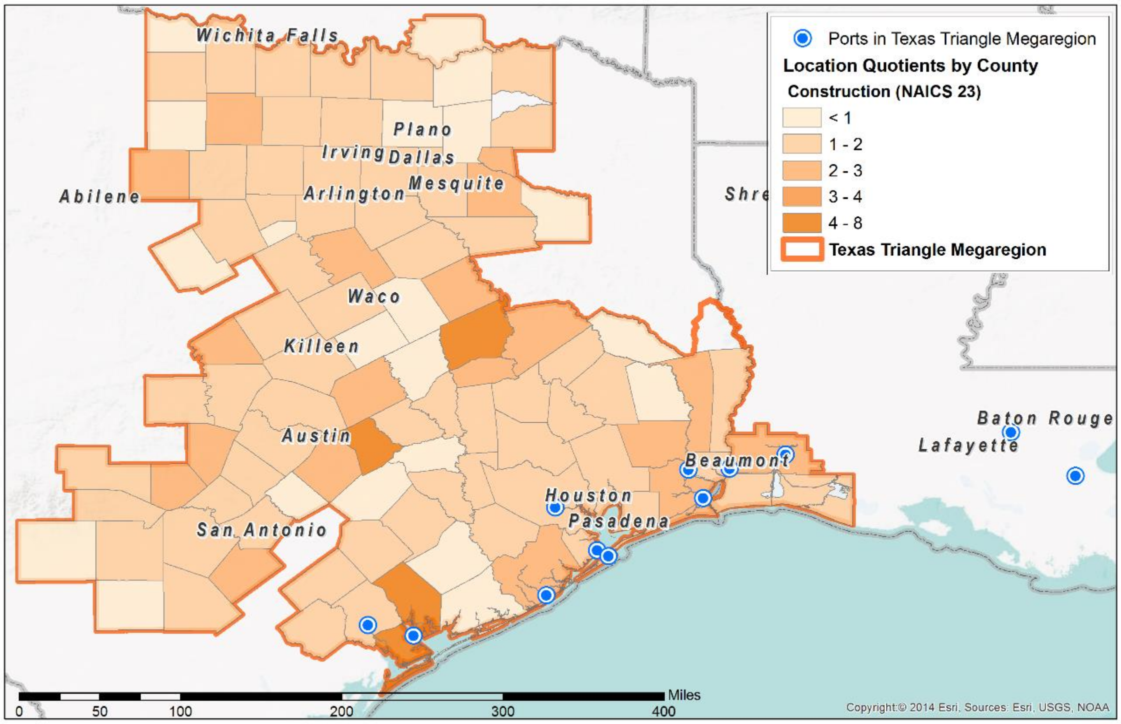


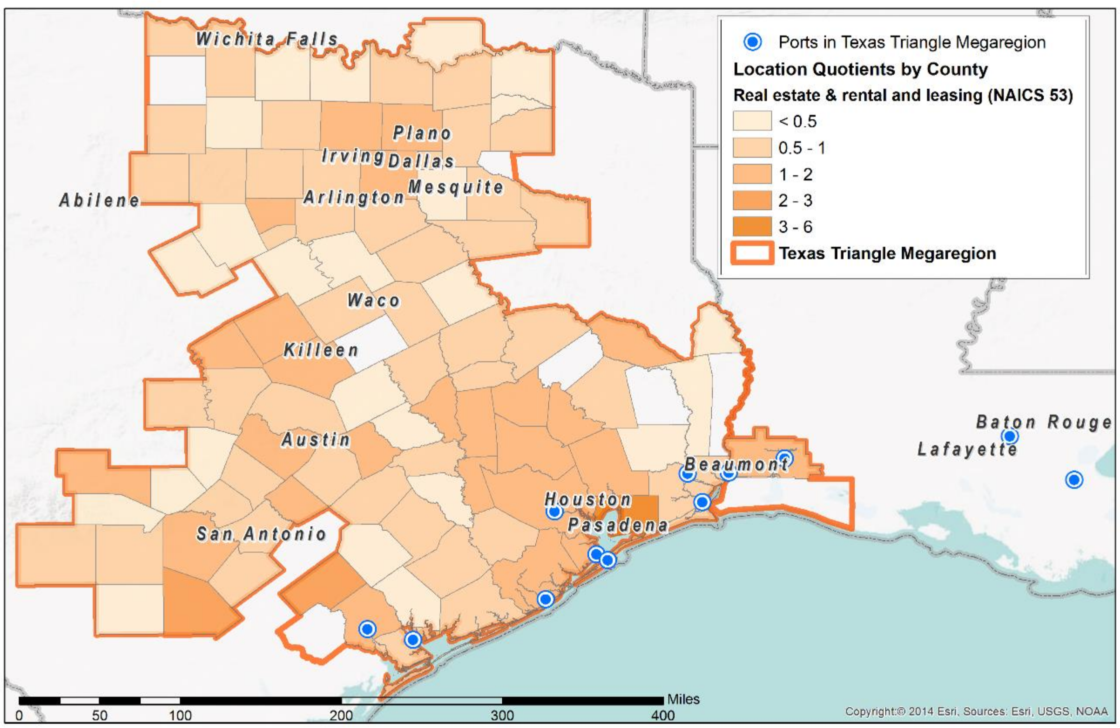
Figure 97: Location Quotient for NAICS 44-45 / Retail Trade

Industry Clustering in Texas Triangle Megaregion



Data Source: American Census Bureau 2012

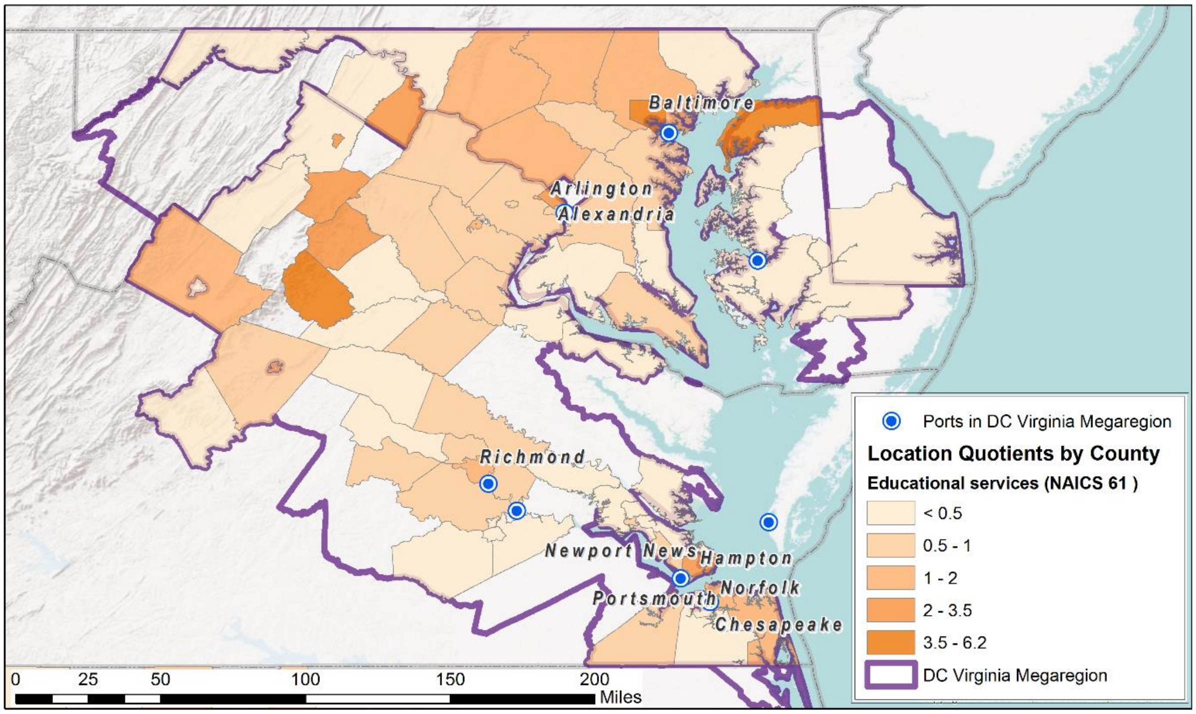
Figure 98: Location Quotient for NAICS 23 Activity in the Texas Triangle



Data Source: American Census Bureau 2012

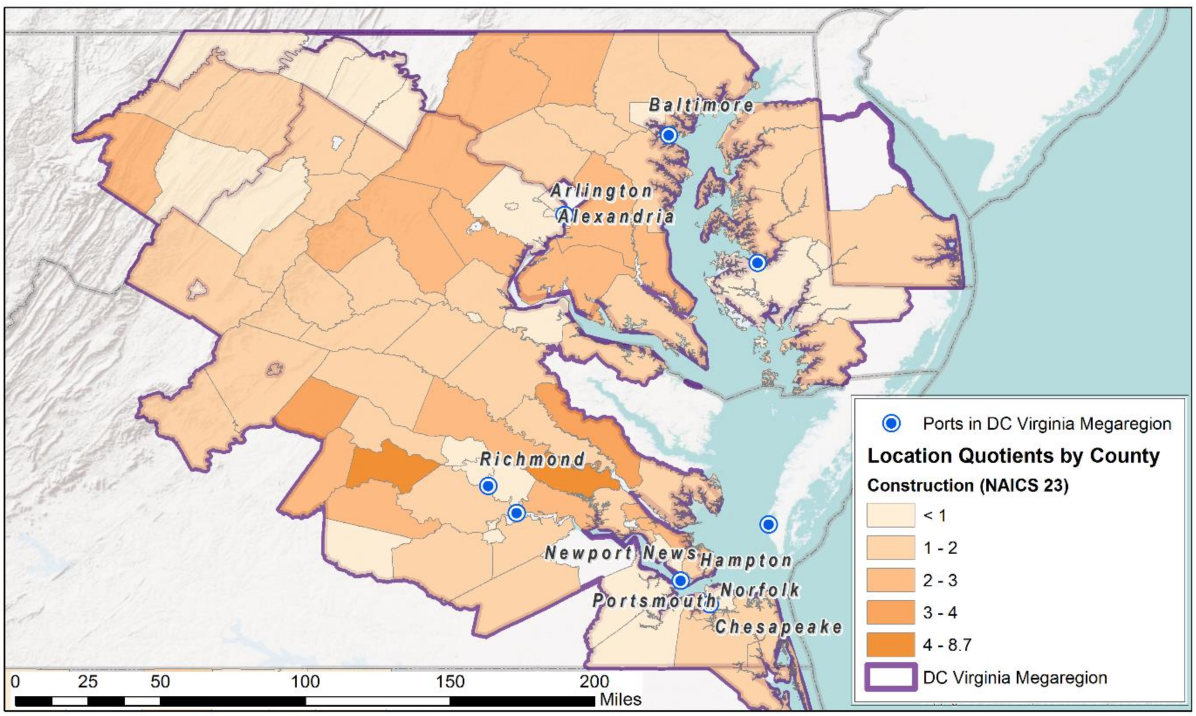
Figure 99: Location Quotient for NAICS 53 Activity in the Texas Triangle

Industry Clustering in DC-VA Megaregion



Data Source: American Census Bureau 2012

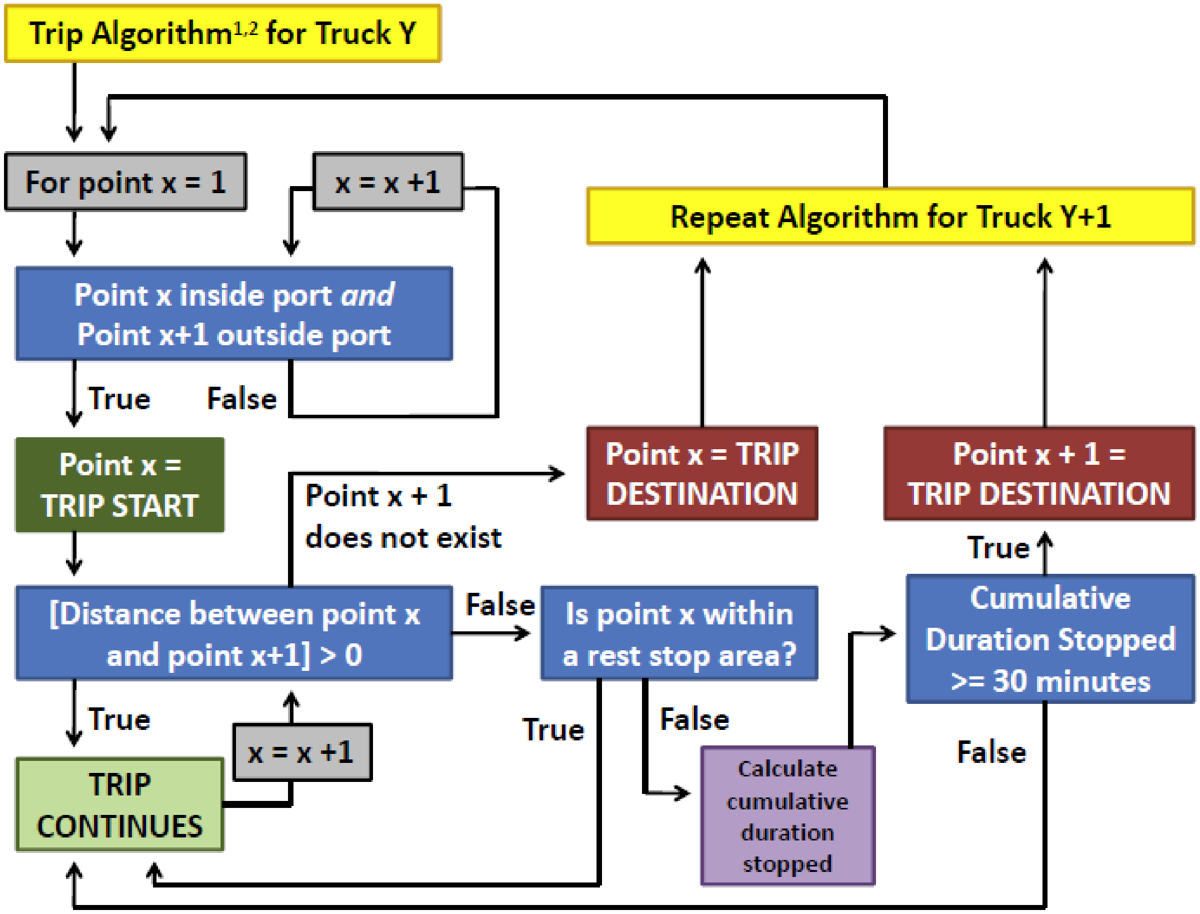
Figure 100: Location Quotient for NAICS 61 / Educational Services



Data Source: American Census Bureau 2012

Figure 101: Location Quotient for NAICS 23 / Construction

APPENDIX 2: Trip Algorithm



[1] All points are first sorted by Truck ID (ascending) and then point date/time (oldest to newest) prior to running algorithm.
[2] Trips less than 0.5 miles in length were discarded to reduce impacts of GPS margin of error.

APPENDIX 3: Distribution Centers

Table 65: Distribution Centers in Piedmont Atlantic

Piedmont Atlantic			
City	**25 Miles**	**50 Miles**	**100 Miles**
Atlanta	329	398	561
Charlotte	141	185	459
Nashville	111	146	205
Spartanburg	94	177	404
Raleigh	82	131	299
Chattanooga	72	104	588
Birmingham	67	86	184
Columbia	34	64	389

Source: Center for Quality Growth and Regional Development, U.S. Census Bureau, County Business Patterns, 2011

Table 66: Distribution Center Density in Piedmont Atlantic

Piedmont Atlantic (Distribution Centers per 100 Square Miles)		
25 Miles	**50 Miles**	**100 Miles**
16.76	5.07	1.79
7.18	2.36	1.46
5.65	1.86	0.65
4.79	2.25	1.29
4.18	1.67	0.95
3.67	1.32	1.87
3.41	1.09	0.59
1.73	0.81	1.24

Source: Center for Quality Growth and Regional Development, U.S. Census Bureau, County Business Patterns, 2011

Table 67: Distribution Centers in Texas Triangle

Texas Triangle			
City	**25 Miles**	**50 Miles**	**100 Miles**
Dallas	340	356	410
Houston	245	259	296
San Antonio	66	71	200
Austin	48	74	160

Source: Center for Quality Growth and Regional Development, U.S. Census Bureau, County Business Patterns, 2011

Appendix 3: Distribution Centers

Table 68: Distribution Center Density in Texas Triangle

Texas Triangle (Distribution Centers per 100 Square Miles)		
25 Miles	**50 Miles**	**100 Miles**
17.32	4.53	1.31
12.48	3.30	0.94
3.36	0.90	0.64
2.44	0.94	0.51

Source: Center for Quality Growth and Regional Development, U.S. Census Bureau, County Business Patterns, 2011

Table 69: Distribution Centers in DC-Virginia

DC-Virginia			
City	25 Miles	50 Miles	100 Miles
Baltimore	188	374	849
Washington	152	286	635
Norfolk	85	96	224
Richmond	79	97	403
Martinsburg	73	194	500

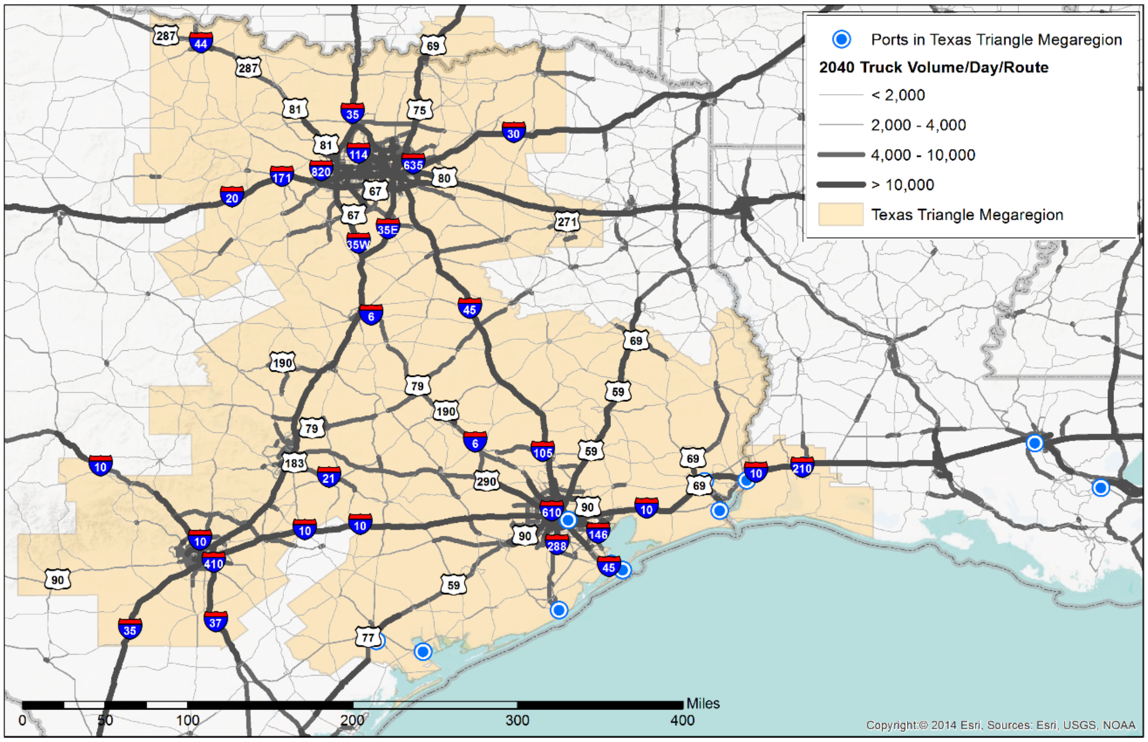
Source: Center for Quality Growth and Regional Development, U.S. Census Bureau, County Business Patterns, 2011

Table 70: Distribution Center Density in DC-Virginia

DC-Virginia (Distribution Centers per 100 Square Miles)		
25 Miles	**50 Miles**	**100 Miles**
9.57	4.76	2.70
7.74	3.64	2.02
4.33	1.22	0.71
4.02	1.24	1.28
3.72	2.47	1.59

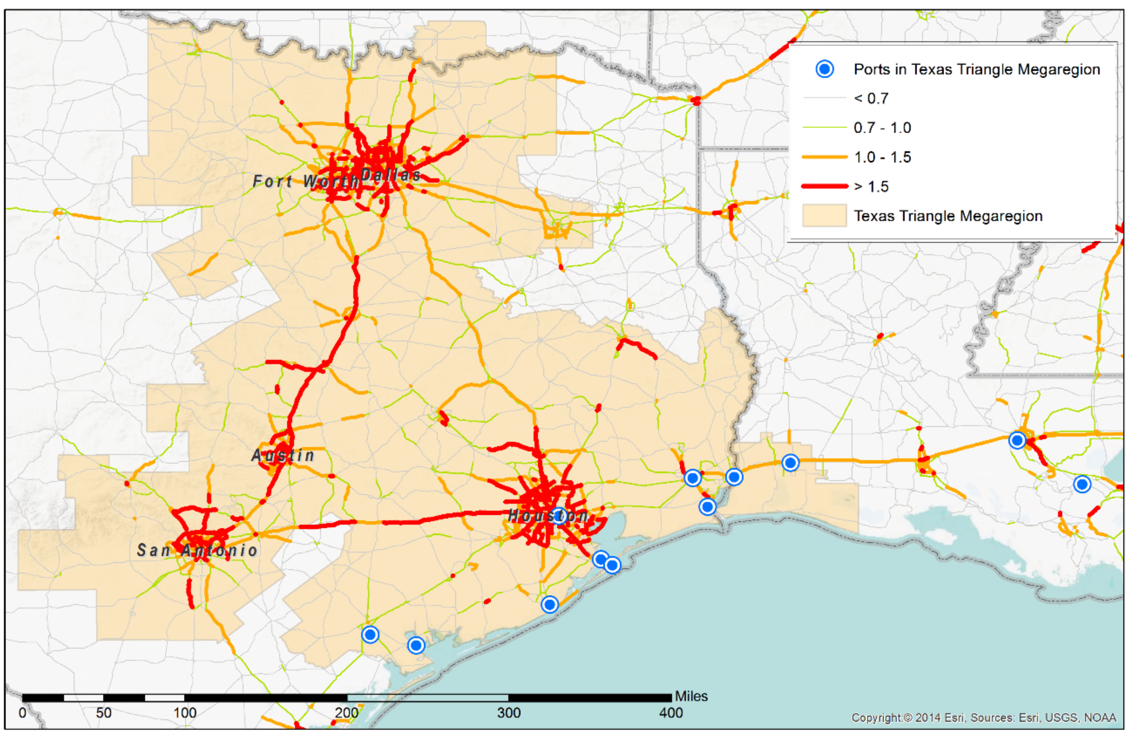
Source: Center for Quality Growth and Regional Development, U.S. Census Bureau, County Business Patterns, 2011

APPENDIX 4: Major Truck Corridors



Data Source: FAF3 Network Database

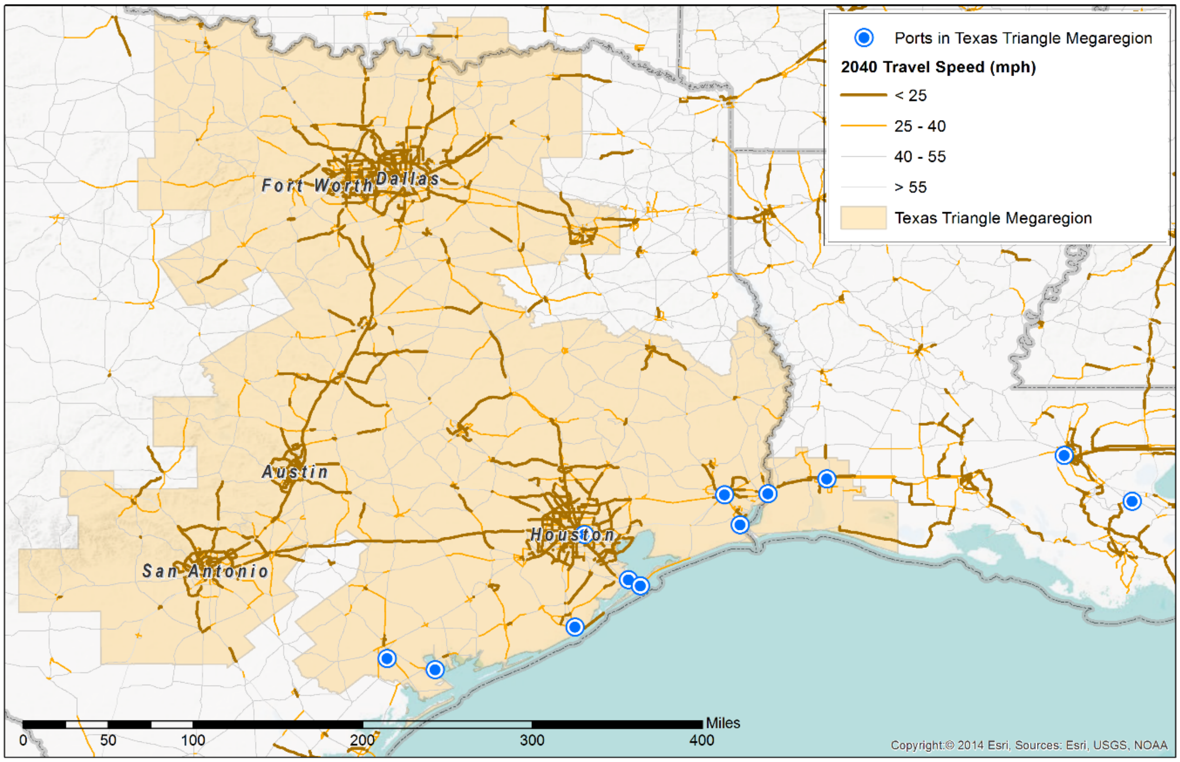
Figure 102: 2040 Truck Volume per Day per Route in the Texas Triangle



Data Source: FAF3 Network Database

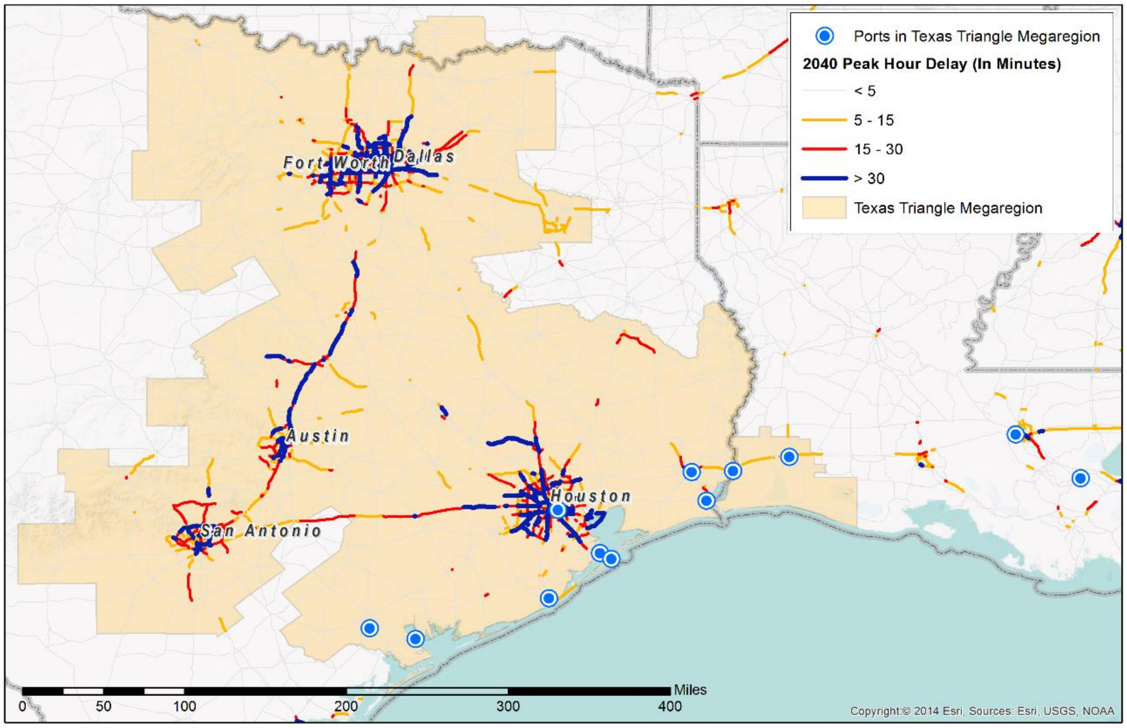
Figure 103: 2040 Volume to Capacity Ratio Along Routes in the Texas Triangle

Appendix 4: Major Truck Corridors



Data Source: FAF3 Network Database

Figure 104: Average Travel Speed Along the Routes in Texas Triangle in 2040



Data Source: FAF3 Network Database

Figure 105: Peak Hour Delay in Minutes along the Routes in the Texas Triangle in 2040

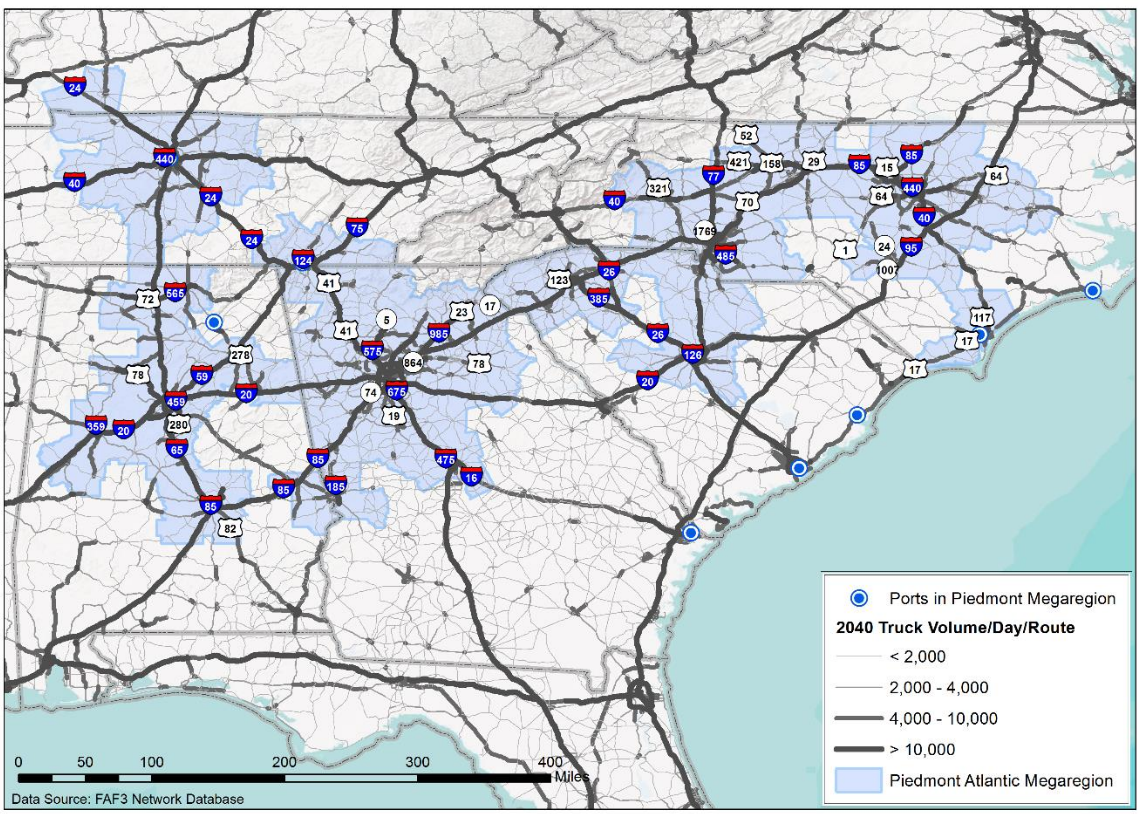
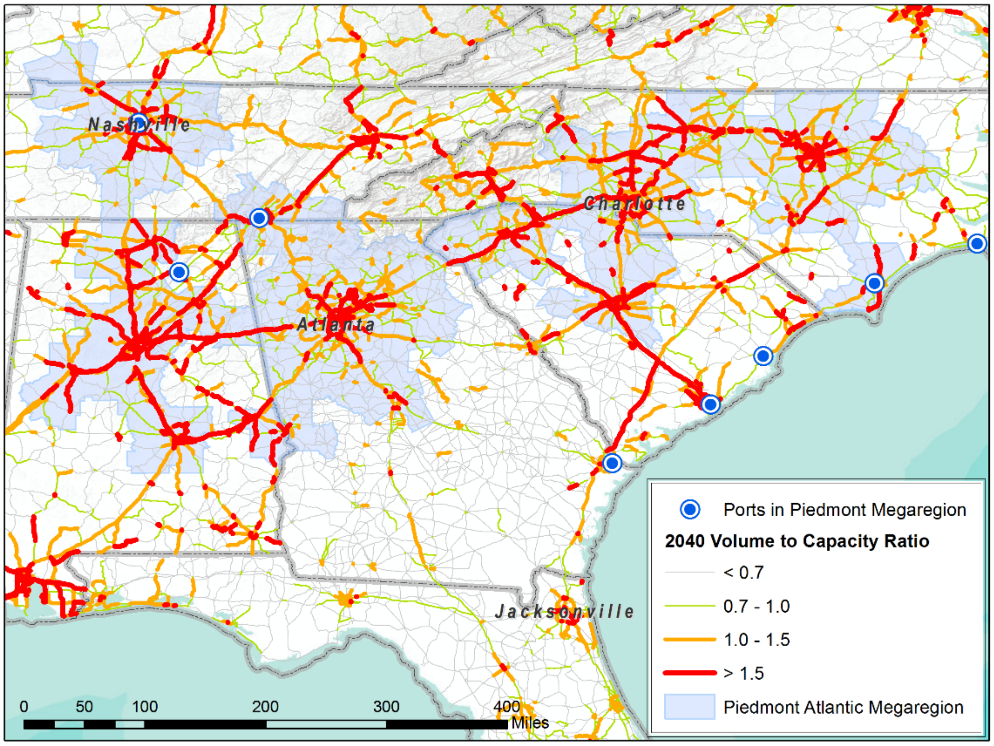
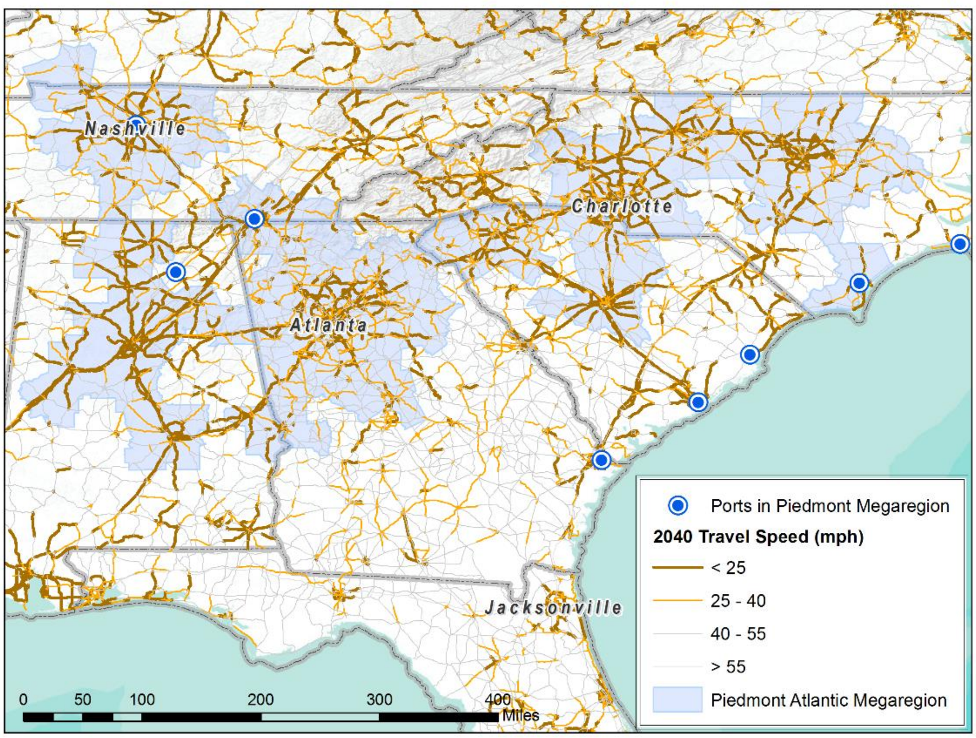


Figure 106: Major Corridors and Truck Volumes in Piedmont Atlantic Megaregion in 2040



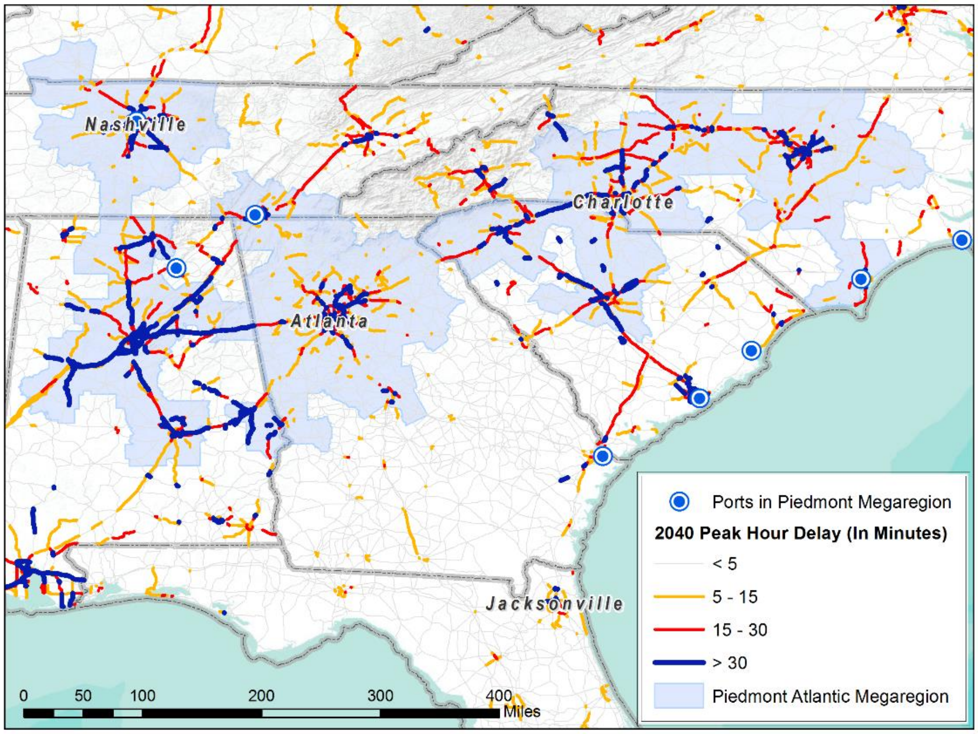
Data Source: FAF3 Network Database

Figure 107: Volume to Capacity Ratio Along routes in Piedmont Atlantic Megaregion



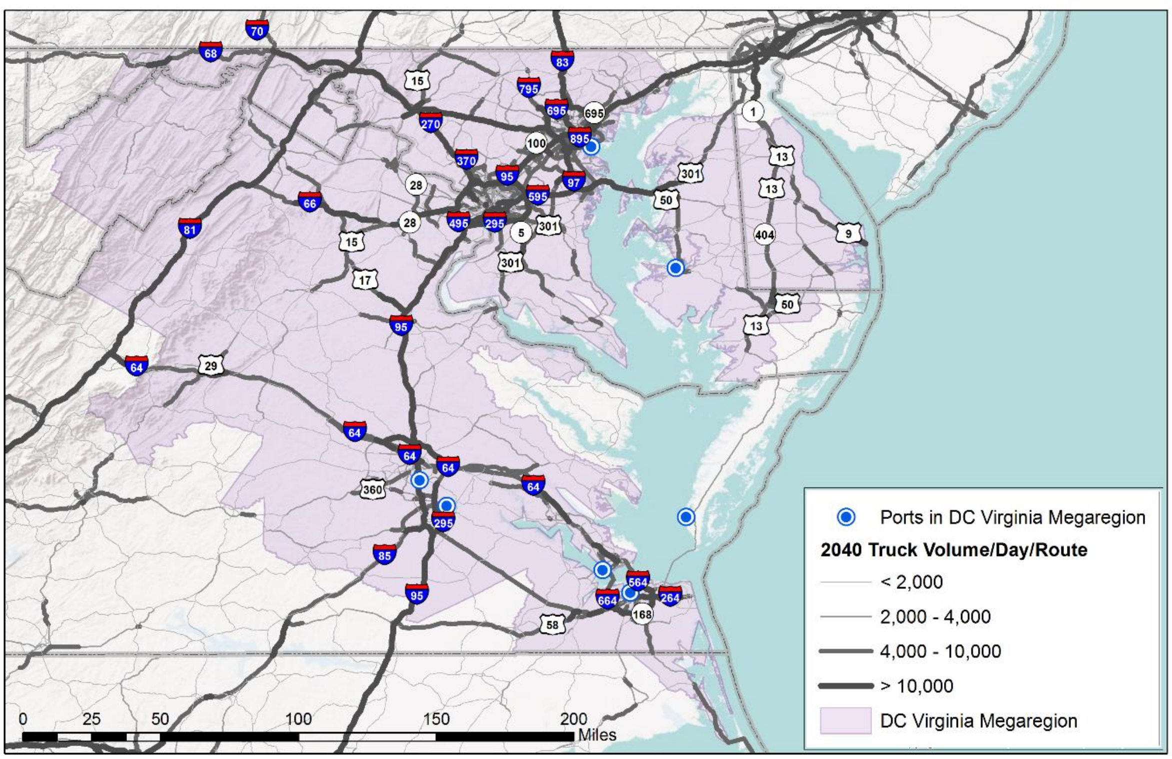
Data Source: FAF3 Network Database

Figure 108: Average Travel Speed Along the Routes in Piedmont Atlantic Megaregion in 2040



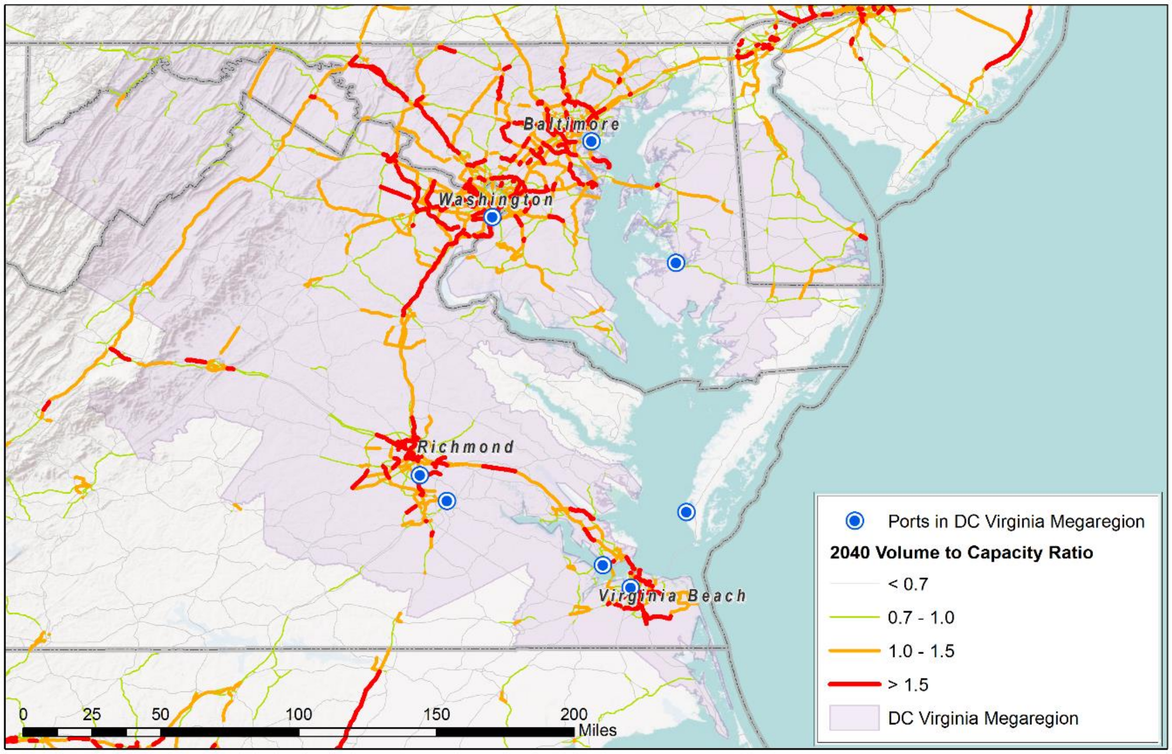
Data Source: FAF3 Network Database

Figure 109: Peak Hour Delay on the Routes in Piedmont Atlantic Megaregion in 2040



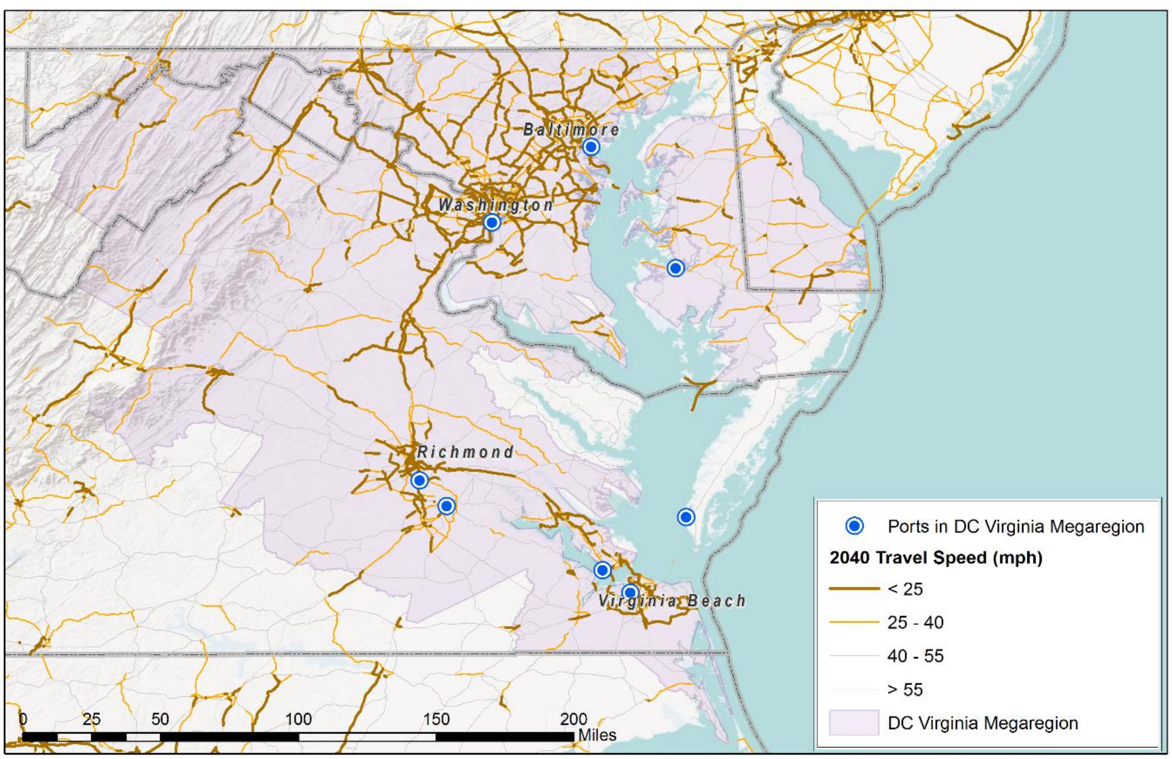
Data Source: FAF3 Network Database

Figure 110: Forecasted Major Corridors and Truck Volumes in DC-Virginia 2040



Data Source: FAF3 Network Database

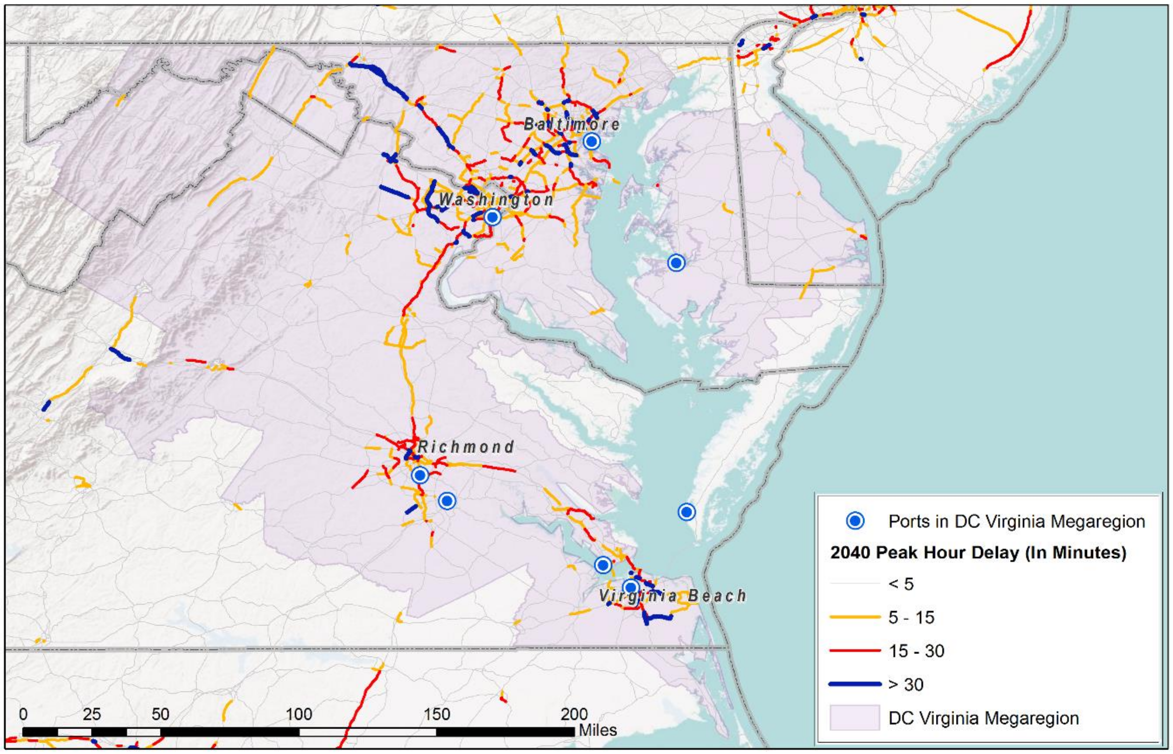
Figure 111: Volume to Capacity Ratio of the Routes in DC-Virginia Megaregion



Data Source: FAF3 Network Database

Figure 112: Forecasted Average Travel Speed along the Routes in DC-Virginia Megaregion

Appendix 4: Major Truck Corridors



Data Source: FAF3 Network Database

Figure 113: Forecasted Peak Hour Delay in DC-Virginia Megaregion

APPENDIX 5: Truck Volumes in Destination Counties

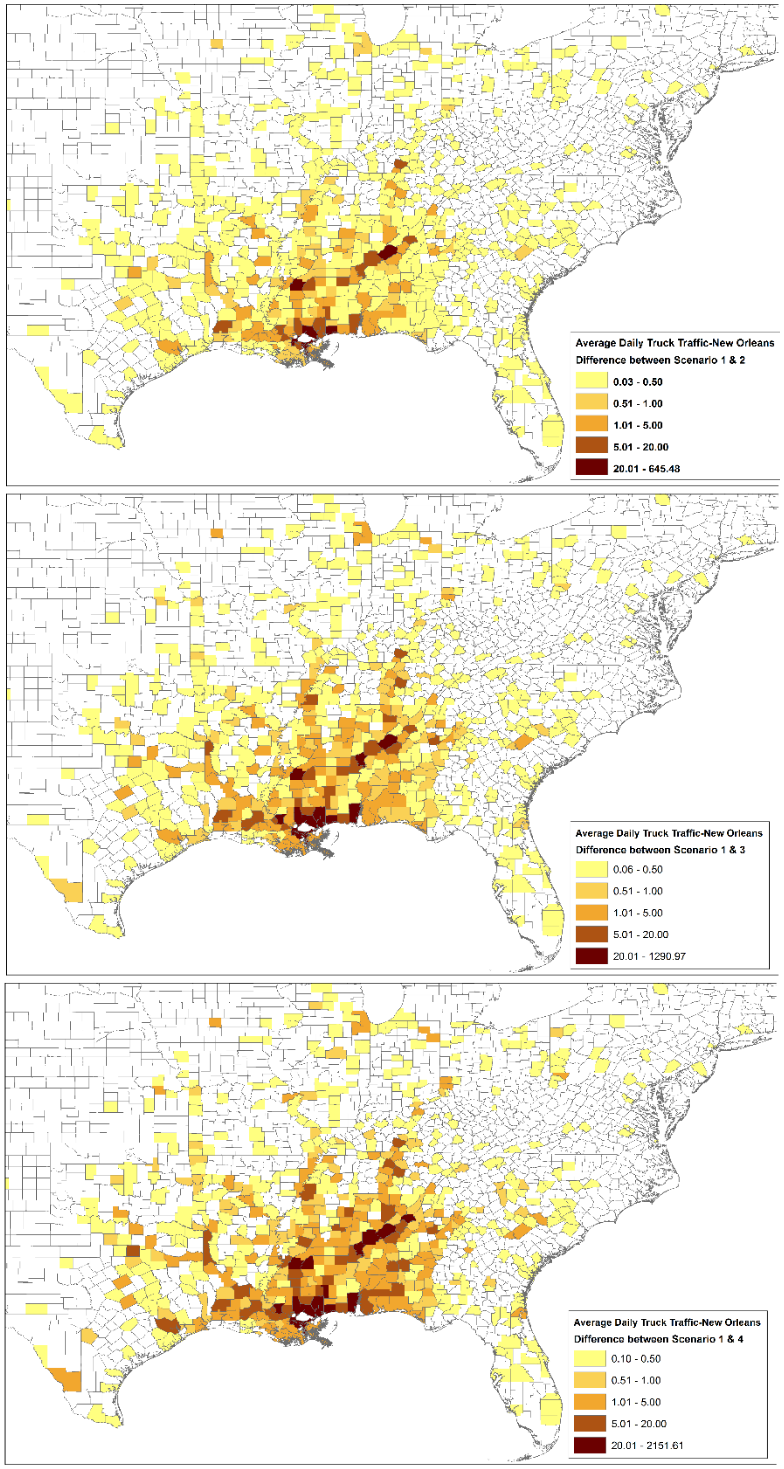


Figure 114: Differences in 2040 Truck Volume per Day between Scenarios for New Orleans

Appendix 5: Truck Volumes in Destination Counties

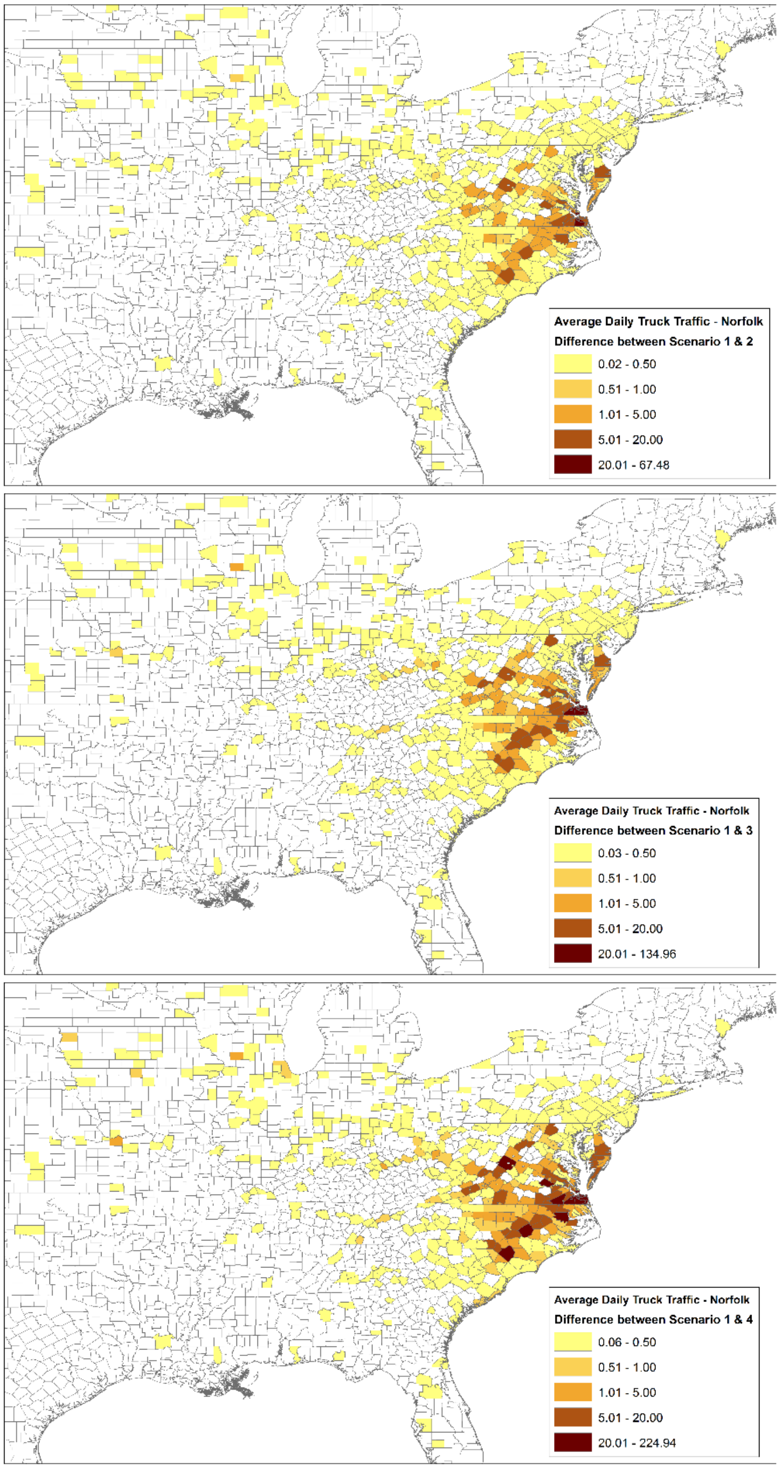


Figure 115: Differences in 2040 Truck Volume per Day between Scenarios for Norfolk

APPENDIX 6: Truck Volumes on Major Corridors

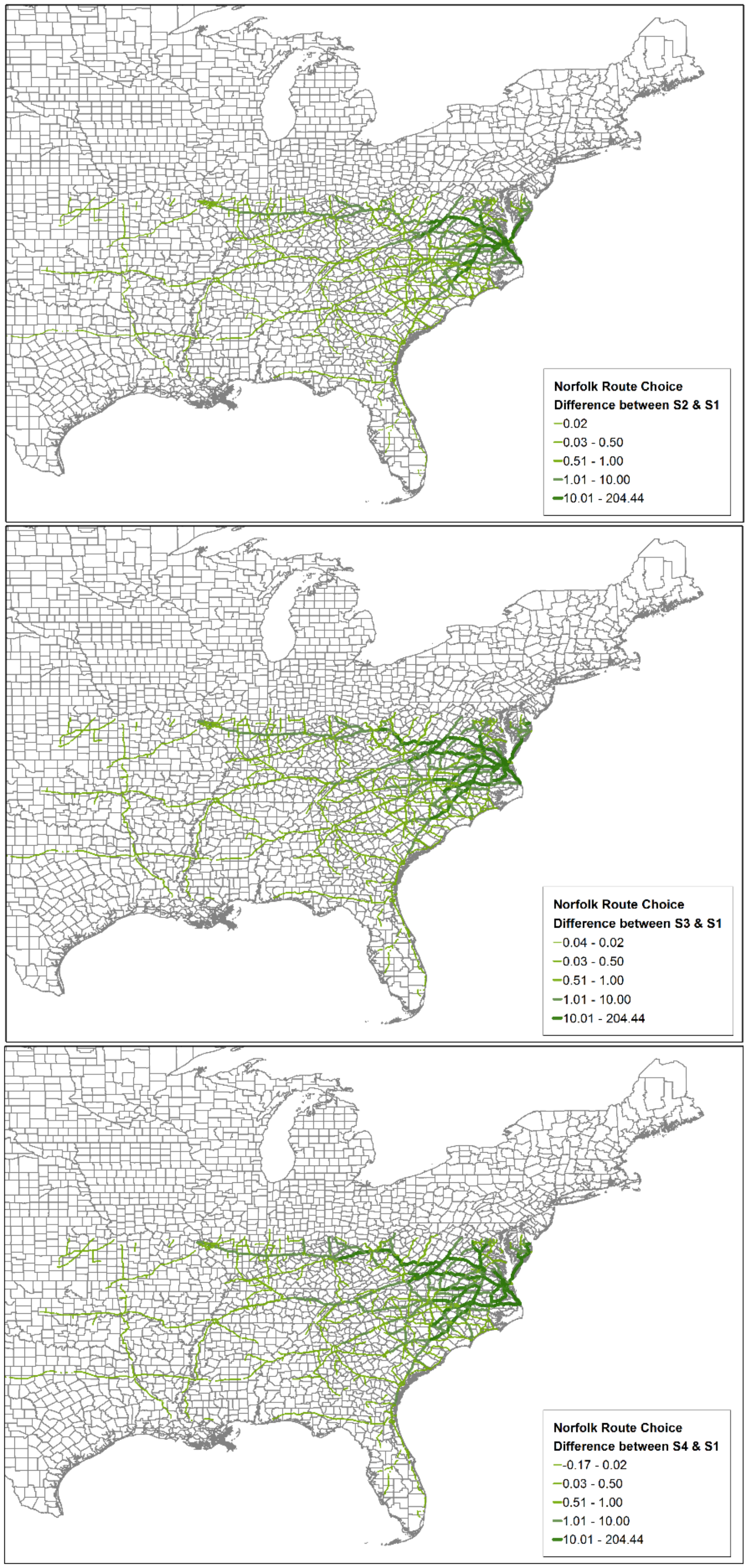


Figure 116: Differences in 2040 Corridor Level Truck Volume per Day between Scenarios for Norfolk

Difference between Scenarios 1 and 2 (top), 1 and 3 (middle) and 1 and 4 (bottom)

Appendix 5: Truck Volumes in Destination Counties

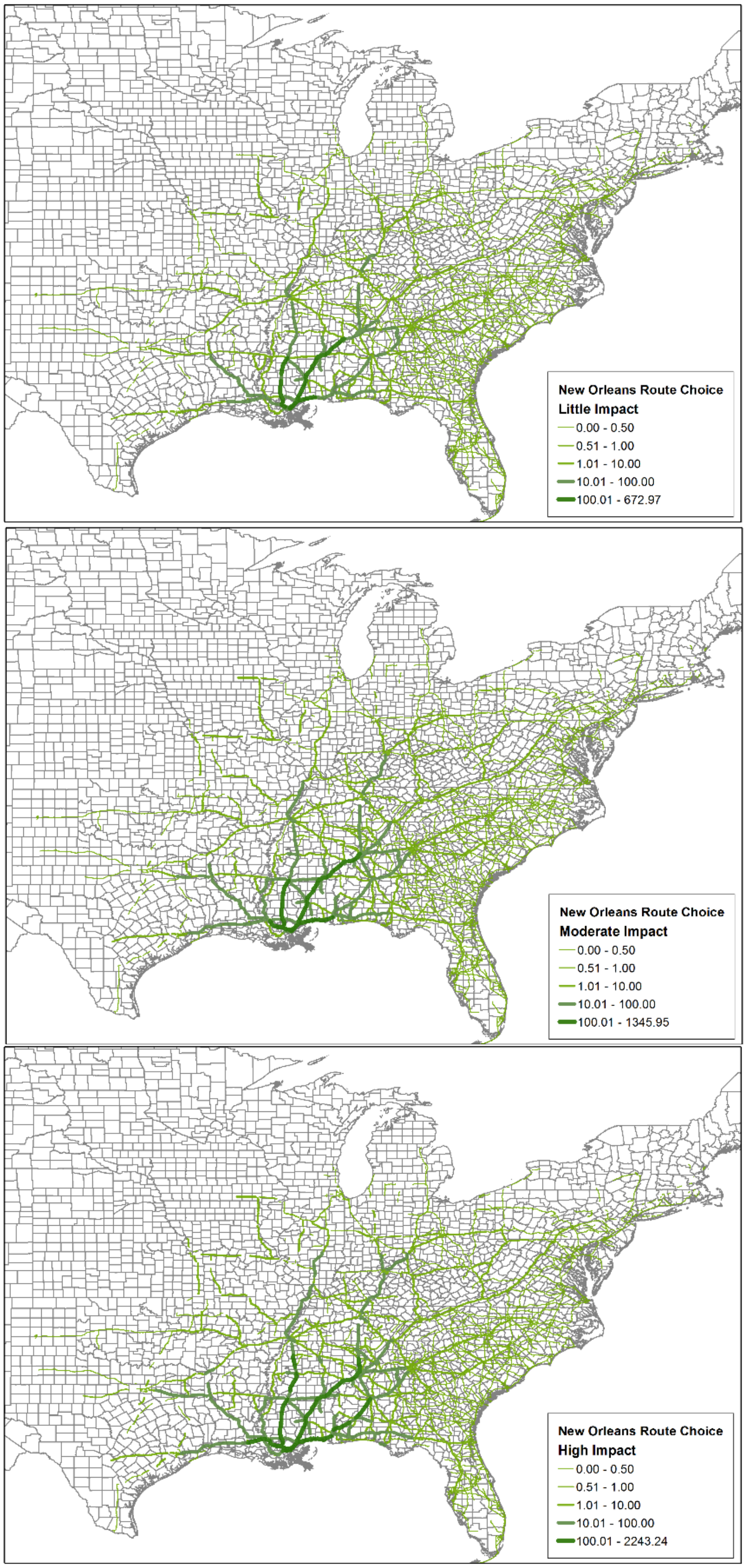
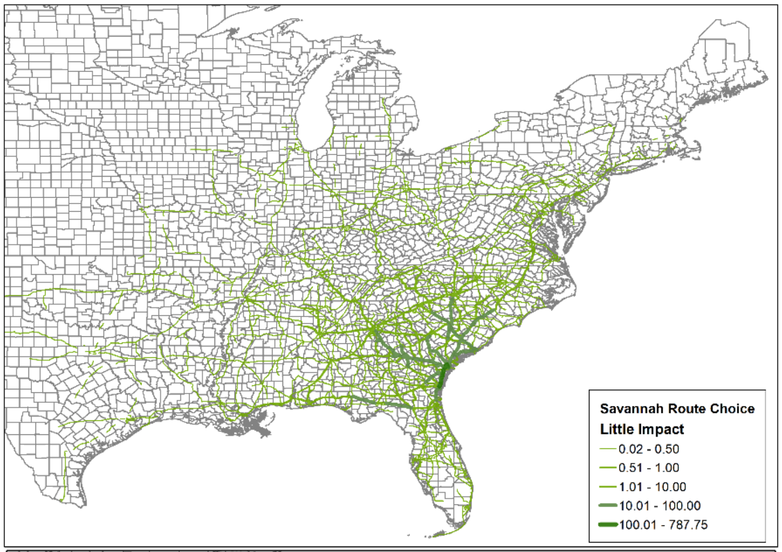
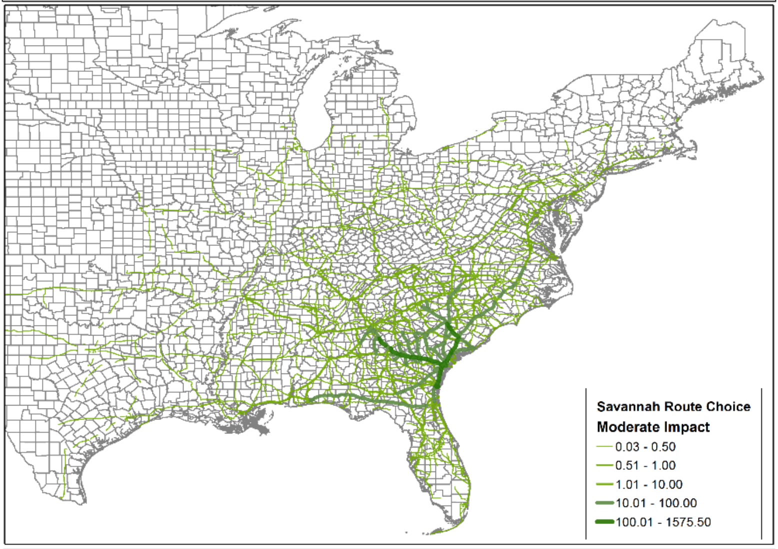


Figure 117: Differences in 2040 Corridor Level Truck Volume per Day Between Scenarios for New Orleans

Difference between Scenarios 1 and 2 (top), 1 and 3 (middle) and 1 and 4 (bottom)





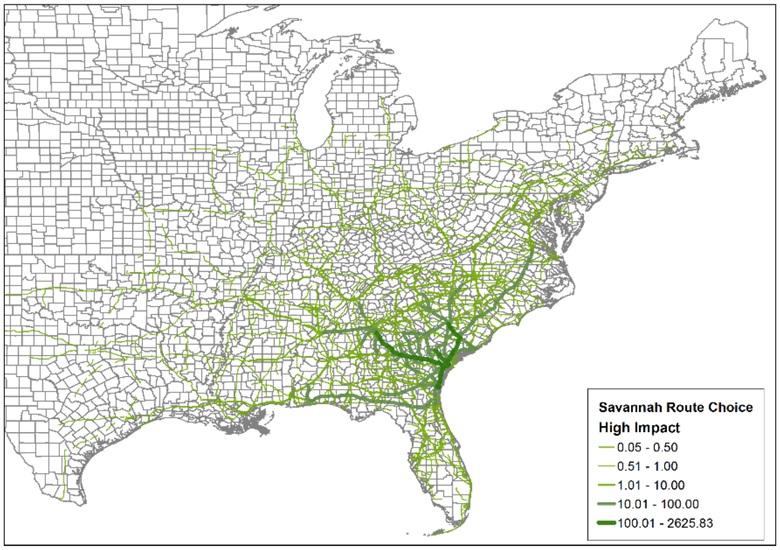


Figure 118: Differences in 2040 Corridor Level Truck Volume per Day Between Scenarios for Savannah

Difference between Scenarios 1 and 2 (top), 1 and 3 (middle) and 1 and 4 (bottom)