North Carolina Statewide Multimodal Freight Plan

Commodity Flow Analysis

prepared for

North Carolina
Department of Transportation

prepared by

Cambridge Systematics, Inc.

with

AECOM

Volkert Inc.

IEM

Baseline Mobility Group

February 2, 2017

report

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List of Acronyms

AAR	Association of American Railroads
BTS	Bureau of Transportation Statistics
CAGR	Compound Annual Growth Rate
CFS	Commodity Flow Survey
CMA	Census Metropolitan Area
CS	Cambridge Systematics
CSA	Combined Statistical Area
CSV	Comma Separated Values
DOT	Department of Transportation
FAF	Freight Analysis Framework
FHWA	Federal Highway Administration
FIPS	Federal Information Processing Standard
GB	Gigabyte
Mfg.	Manufactured
Min.	Mineral
Misc.	Miscellaneous
MS Access	Microsoft Access
MSA	Metropolitan Statistical Area
N/A	Not available or not applicable
NAICS	North American Industry Classification System
n.e.c.	Not elsewhere classified
OD	Origin-Destination
Prods.	Products
SCTG	Standard Classification of Transported Goods
SE	Southeast
STB	Surface Transportation Board
STCC	Standard Transportation Commodity Code
SW	Southwest
TDF	Travel Demand Forecasting
US	United States

USACE   United States Army Corps of Engineers

WACF   World Air Cargo Forecast

1.0   Introduction

The future needs of North Carolina's freight system are substantially driven by what future freight demand might look like. This report presents existing and potential future demand for freight in the State for the plan year of 2045. It also provides insight into modal dependence, route choice, and equipment and service needs of the State's businesses. Findings from this analysis will be used throughout the North Carolina Statewide Multimodal Freight Plan efforts and may be updated during the process as new data become available.

1.1   Data and Methodology

Several data sources were used in the commodity flow analysis, detailed as follows:

1. **Freight Analysis Framework version 4 (FAF4) Database**. The Freight Analysis Framework (FAF), produced through a partnership between Bureau of Transportation Statistics (BTS) and Federal FHWA, integrates data from a variety of sources to create a comprehensive picture of freight movement among states and major metropolitan areas by all modes of transportation. Starting with data from the 2012 Commodity Flow Survey (CFS) and international trade data from the Census Bureau, FAF incorporates data from agriculture, extraction, utility, construction, service, and other sectors. FAF version 4 (FAF4) provides estimates for tonnage and value by regions (multi-county or state FAF zones) of origin and destination, a 2-digit Standard Classification of Transported Goods (SCTG) commodity type, and mode. Data are available for the base year of 2012, the recent years of 2013 - 2015, and forecasts from 2020 through 2045 in 5-year intervals. Freight Analysis Framework version 4.1 (FAF4.1) 2012-2045 data was disaggregated to obtain truck, water, air, pipeline, and other flows at the county level for the State of North Carolina. Additionally, growth factors estimated from FAF4.1 for rail only (carload equivalent) mode and multiple modes and mail mode (which includes rail intermodal) were applied to 2012 and 2014 Carload Waybill Sample data to forecast the future year (2045) freight rail traffic.

2. **2012-2014 Carload Waybill Sample for North Carolina**. The Association of American Railroads (AAR) collects a stratified sample of carload waybills annually for the Surface Transportation Board (STB) from railroads that terminated at least 4,500 carloads each year for each of the previous three years, or which move five percent or more of any state's total rail traffic. NCDOT obtained and provided to the consultant the confidential version of the Waybill Sample, which includes detailed shipment data including origin county, destination county, 7-digit level Standard Transportation Commodity Code (STCC) commodity type, equipment type, and tonnage. This data formed the basis for the base year freight rail traffic. Cambridge Systematics had developed a proprietary lookup table between a 7-digit STCC commodity type and a 2-digit Standard Classification of Transported Goods (SCTG) commodity types. In this analysis, the rail traffic flows in the 2012 and 2014 Carload Waybill Sample data were converted to a 2-digit SCTG-equivalent commodity flows database using this lookup table.

3. **Bureau of Transportation Statistics (BTS) TranStats Database** T-100 Market data provides annual air cargo statistics for all North Carolina airports with reported activity. The data contains domestic and international market data reported by US and foreign air carriers, and contains market data by carrier and origin/destination for enplaned freight and mail. BTS air cargo data for North

Carolina airports were used to disaggregate FAF4 air cargo data from FAF zones to county-level commodity flow data.

4. **2015 Boeing World Air Cargo Forecast (WACF)** is a biennial report that provides an overview of the air cargo industry at the National level. The report summarizes major air trade markets, trends and forecasts for domestic and international markets. These growth rates were applied to the FAF4 disaggregated air cargo data to develop a "high growth scenario" forecast for North Carolina's air cargo markets.

Appendix A and Appendix B describe the FAF4 disaggregation methodology and the rail forecasting methodology in detail. This forecast provides a "baseline" against which future demand for goods movement can be considered, and thus is not only a reflection of current macro-economic trends, but also the current trends in logistics, distribution, and sourcing within the freight dependent economic sectors. However, there can and will be significant changes in the economic composition, logistics, public policy and other factors that can and will affect the general demand for goods movement.

1.2   Report Organization

This profile consists of four chapters. Chapter 1, this introduction, is followed by three additional chapters:

- **Statewide Freight Demand** (Chapter 2) provides an overview of actual and projected demand for freight transportation in North Carolina, including modal split, directional analysis, and top commodities moving in the State;

- **North Carolina's Trading Partners** (Chapter 3) identifies the State's top domestic and international trading partners for freight imports and exports; and

- **County Level Freight Demand** (Chapter 4) examines North Carolina's actual and projected freight activity at the county level, including top counties generating freight tonnage and value.

2.0 Statewide Freight Demand

In 2012, 594 million tons of freight valued at $1 trillion moved over North Carolina's transportation system. By 2045, North Carolina's transportation system is projected to carry more than 890 million tons of freight valued at $2 trillion annually, an increase of 50 percent by tonnage and 93 percent by value.

2.1 Modal Split

Trucks were the dominant mode utilized for these movements, carrying 79 percent of the total weight and just over 82 percent of the total value of goods. Rail accounted for the second highest modal share measured by weight, carrying 15 percent of the total weight with 13 percent in full carloads and 2 percent by intermodal cars. Pipelines carried nearly 30 million tons (5 percent of the total freight flow weight) valued at $7 billion, a 1 percent share of the total freight flow value. When measured by value, the second highest modal share belongs to intermodal rail, which carried more than $128 billion in goods, while an additional $27 billion traveled by rail carload service. Air transport accounted for $20.5 billion or approximately 2 percent of the total freight flow value in the State. This modal split by both weight and value for 2012 is shown in Figure 2.1   .

Figure 2.1 North Carolina Tonnage and Value by Mode, 2012
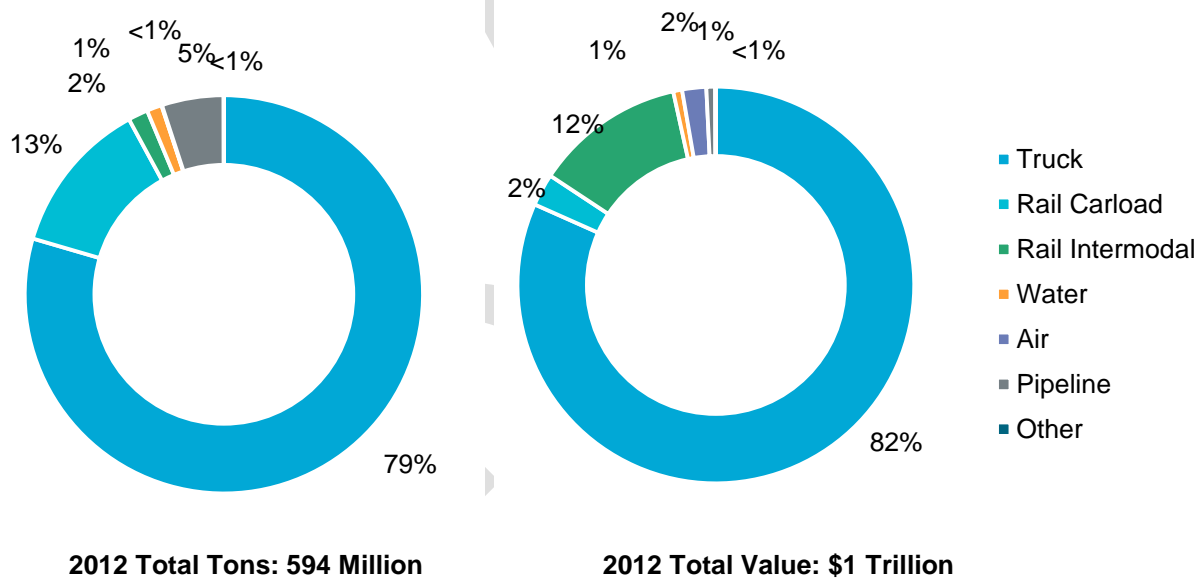
2012 Total Tons: 594 Million   **2012 Total Value: $1 Trillion**

Source: Cambridge Systematics disaggregation of FAF4.1 2012-2045 data, 2012 STB Waybill rail data, and 2045 STB Waybill rail data forecasted by Cambridge Systematics.

The divergence in modal choice when measured by weight and value follows the goods movement spectrum shown in Figure 2.2. Air cargo offers fast transit times and higher supply chain visibility and security for higher value goods. Rail, pipeline and water are used to move goods that are less time-sensitive or bulk commodities at a lower cost, with water transport being the slowest but least costly. Trucks, which serve as the mode of choice for first- and last-mile needs, offer a balance between cost and travel time when serving as the primary mode of transportation.

Figure 2.2   Goods Movement Spectrum
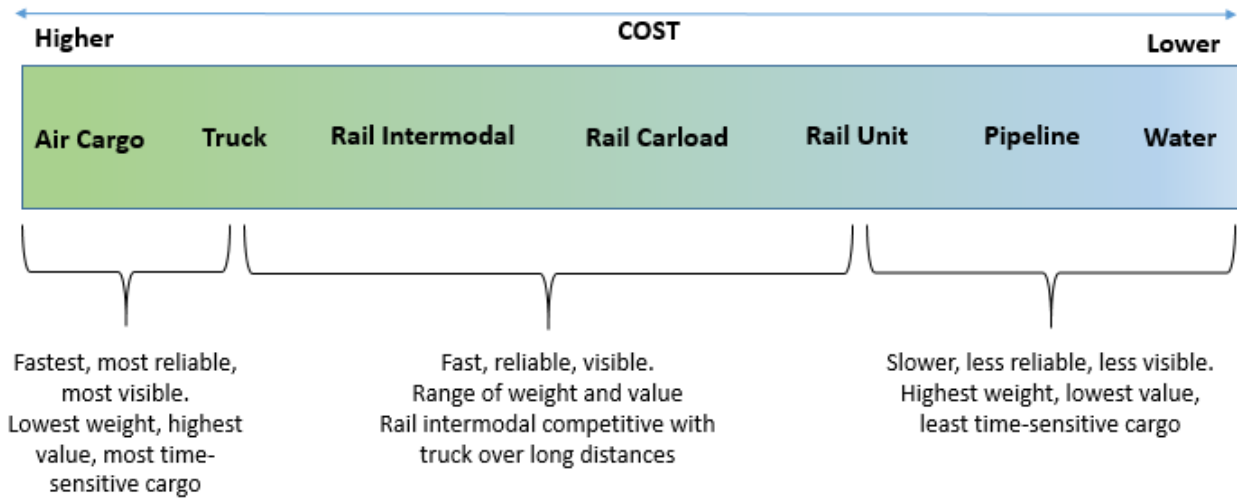
Source: Cambridge Systematics, Inc.

Modal projections for 2045 tell a similar story about tonnage trends. The total amount of goods shipped to, from, within, and through North Carolina is expected to grow by 50 percent to 890 million tons by 2045. Although the total tonnage carried by each mode is projected to increase, modal share is expected to shift based on the forecast trends for the commodities carried by each mode. Trucks are expected to carry similar percent of shipments (approximately 80 percent). The rail carload share is expected to decrease from 13 percent to 11 percent, mostly due to a projected decline in coal shipments.

A different story emerges when examining projected goods movement measured by value. All modes will see an overall increase in the value of transported goods, with the total value of goods projected to reach slightly more than $2 trillion by 2045. Truck modal share is projected to account for 81 percent of the total value of goods moving in North Carolina. Rail intermodal's share is expected to comprise 10 percent of the moves in 2045. Water shipments are projected to slightly gain modal share, from 0.7 percent in 2012 to approximately 1.4 percent in 2045. Air cargo value, which also includes truck-air shipments,[1] is projected to increase more than 300 percent to $84 billion. This increase is mostly driven by international air cargo growth, which is projected to increase to 4 percent of all shipments in 2045 from just 2 percent in 2012. A summary of goods moved by each mode in 2045 by weight and value is shown in Figure 2.3.

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[1]   Includes shipments typically weighing more than 100 pounds that move by air or a combination of truck and air in commercial or private aircraft. Includes air freight and air express.

Figure 2.3   North Carolina Tonnage and Value by Mode, 2045

2045 Total Tons: 890 Million   **2045 Total Value: $2 Trillion**

Legend:
- Truck
- Rail Carload
- Rail Intermodal
- Water
- Air
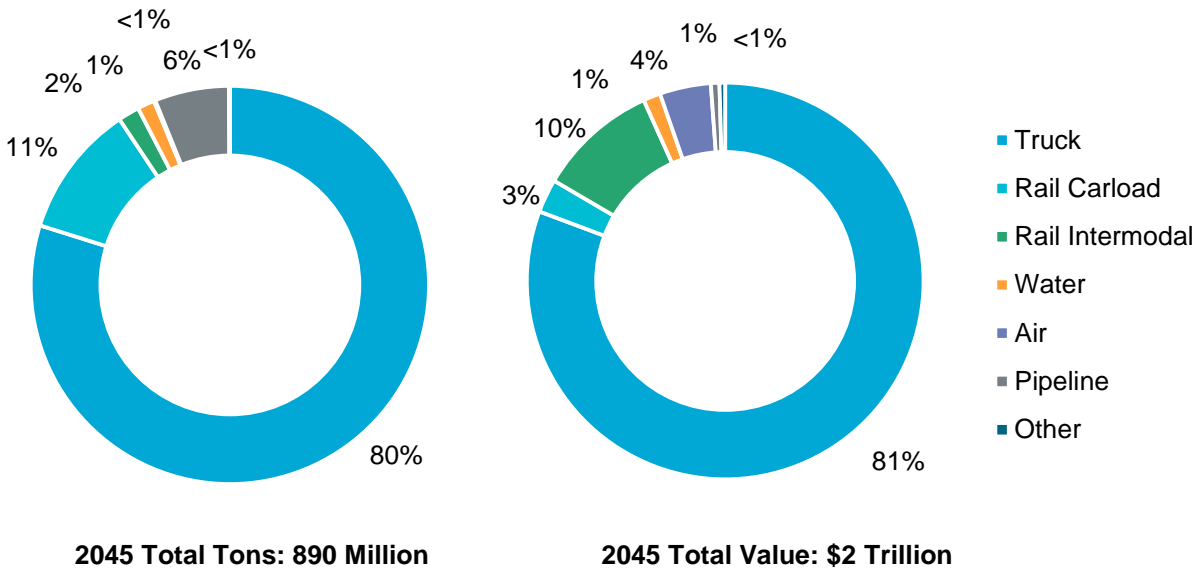- Pipeline
- Other

Source: Cambridge Systematics disaggregation of FAF4.1 2012-2045 data, 2012 STB Waybill rail data, and 2045 STB Waybill rail data forecasted by Cambridge Systematics.

2.2   Directional Split

Freight moves to, from, within and through the State of North Carolina on a daily basis.   When measured by weight, iIntra-state shipments accounted for 34 percent of the 594 million tons moved in 2012, the largest percent of any direction. Through shipments, which pass through the State without stopping, comprised 28 percent of tonnage, followed by inbound shipments (22 percent) and outbound shipments (16 percent). Moreover, the highest total value of goods moved through the State (39 percent), followed by outbound shipments (26 percent), inbound shipments (20 percent), and intrastate shipments (15 percent). Figure 2.4 summarizes the directional split by weight and value for goods movement in North Carolina in 2012.

Figure 2.4   North Carolina Direction of Goods Movement Tonnage and Value, 2012
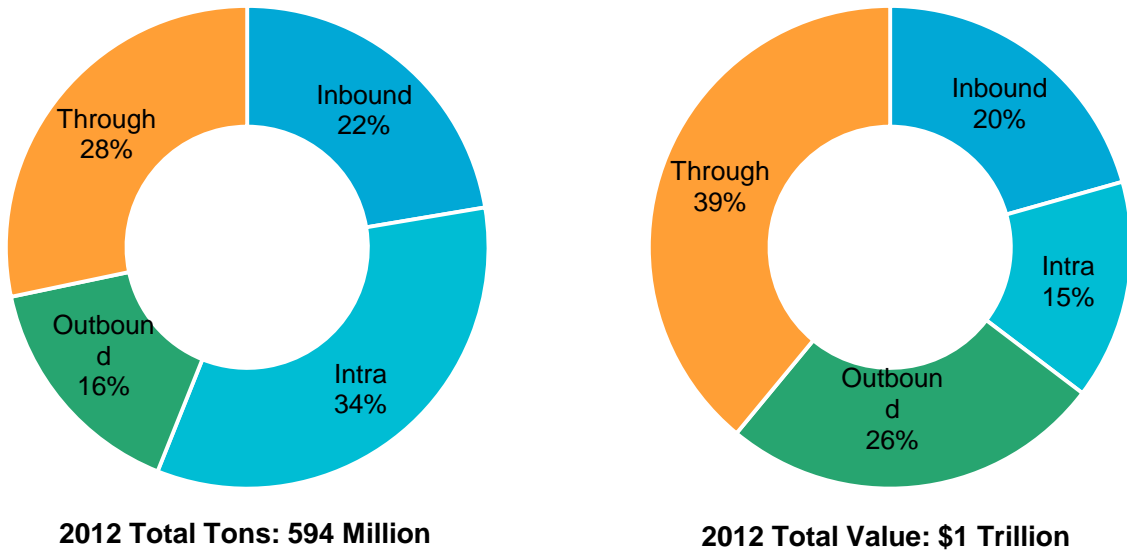
2012 Total Tons: 594 Million

2012 Total Value: $1 Trillion

By 2045, the directional split is expected to remain mostly consistent. Total tonnage of intra-state shipments is expected to drop to 30 percent, while the shares of outbound shipments and through shipments are expected to increase moderately. The shares of outbound and inbound freight value are projected to increase slightly, while the shares of through and intra-state freight value are expected to decrease. Figure 2.5 shows the projected directional split by weight and value for 2045.

Figure 2.5   North Carolina Direction of Goods Movement Tonnage and Value, 2045
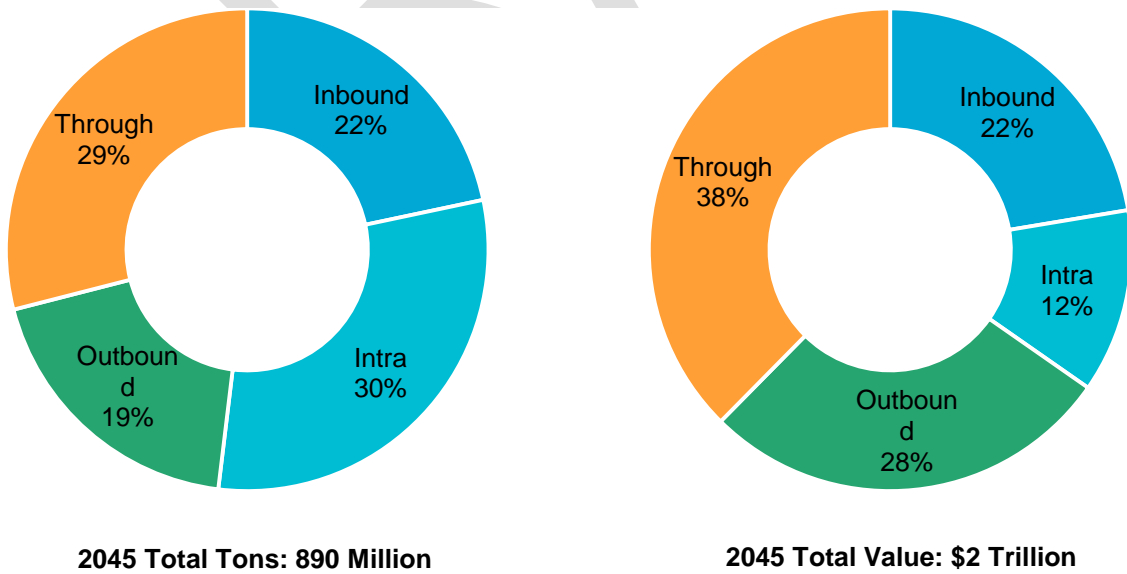
2045 Total Tons: 890 Million

2045 Total Value: $2 Trillion

2.3   Top Commodities

In 2012, the top commodity moved by weight throughout North Carolina was coal[2], accounting for 10 percent of the total weight of all goods. The next top four products were also bulk commodities, and included gravel and crushed stone, other coal and petroleum products, non-metallic mineral products, and wood products. These five commodities accounted for more than 224 million tons of freight annually, which is approximately 38 percent of total tonnage.

By 2045, these top five commodities are expected to remain somewhat consistent. The top two commodities moved by weight are projected to be other coal and petroleum products, and non-metallic mineral products. The tonnage of coal shipments is projected to decrease slightly, while gravel and crushed stone is projected to remain steady. These two commodity groups are expected to become the third- and fourth-highest commodity groups by tonnage. Including wood products, the fifth-most transported good by weight, the top five commodities combined are expected to comprise 34 percent of all shipments (299 million tons). Plastics and rubber are projected to double in tonnage from 2012 to 2045 (from 22 million tons to 45 million tons, the largest percentage growth among the top commodities. Figure 2.6 shows the top 10 commodities moved in North Carolina by weight for 2012 and their project growth by 2045.

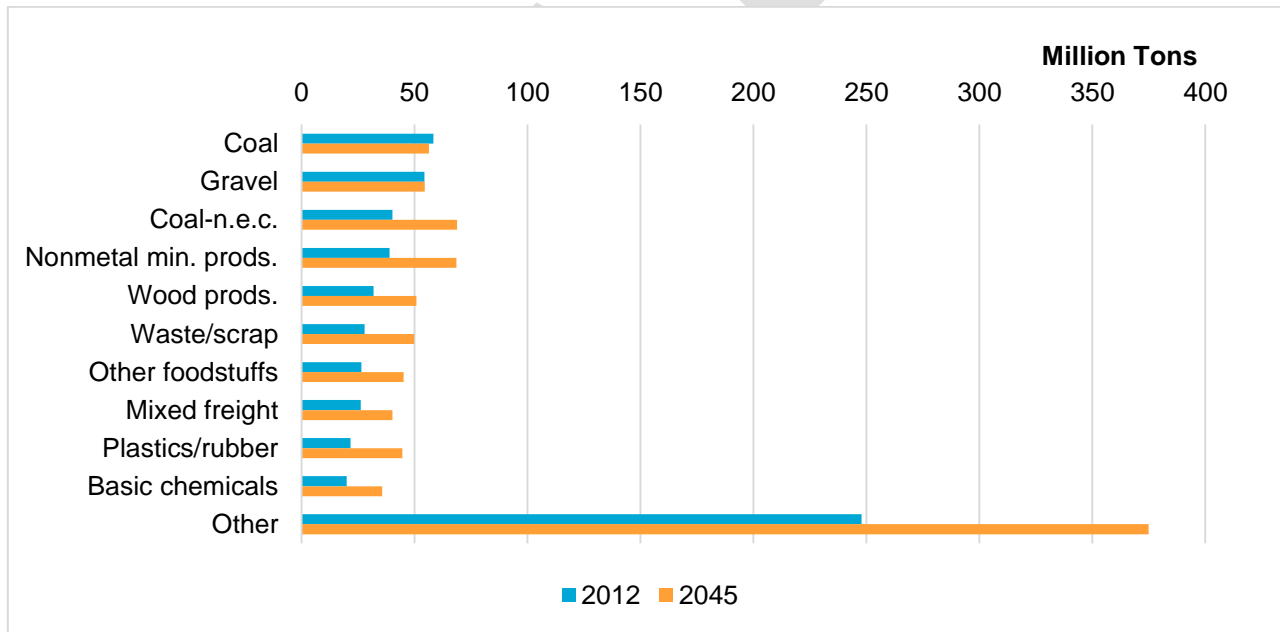**Figure 2.6   North Carolina Commodities by Tonnage, 2012 and 2045**

Source: Cambridge Systematics disaggregation of FAF4.1 2012-2045 data, 2012 STB Waybill rail data, and 2045 STB Waybill rail data forecasted by Cambridge Systematics.

The top commodity moved by value in 2012 was mixed freight, followed by pharmaceutical products, machinery, electronic and electrical equipment and components, and textiles and leather products. These five commodities accounted for $486 billion, which was 47 percent of the total value.

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[2] For a complete list of goods included in each category, refer to the Standard Classification of Transported Goods (SCTG) codes produced by the US Census at: https://www.census.gov/econ/cfs/2012/2012_manual.pdf

The top commodities by value are projected to remain in similar rankings through 2045. Mixed freight is expected to continue to dominate, comprising 14 percent of the total value, followed by electronic and electrical equipment and components, machinery, pharmaceutical products, and plastics and rubber. The top five commodities combined are expected to account for 50 percent or $1 trillion of the total value of all goods moved in the State in 2045. Figure 2.7 shows the top 10 commodities moved by value in 2012 and their project growth by 2045.

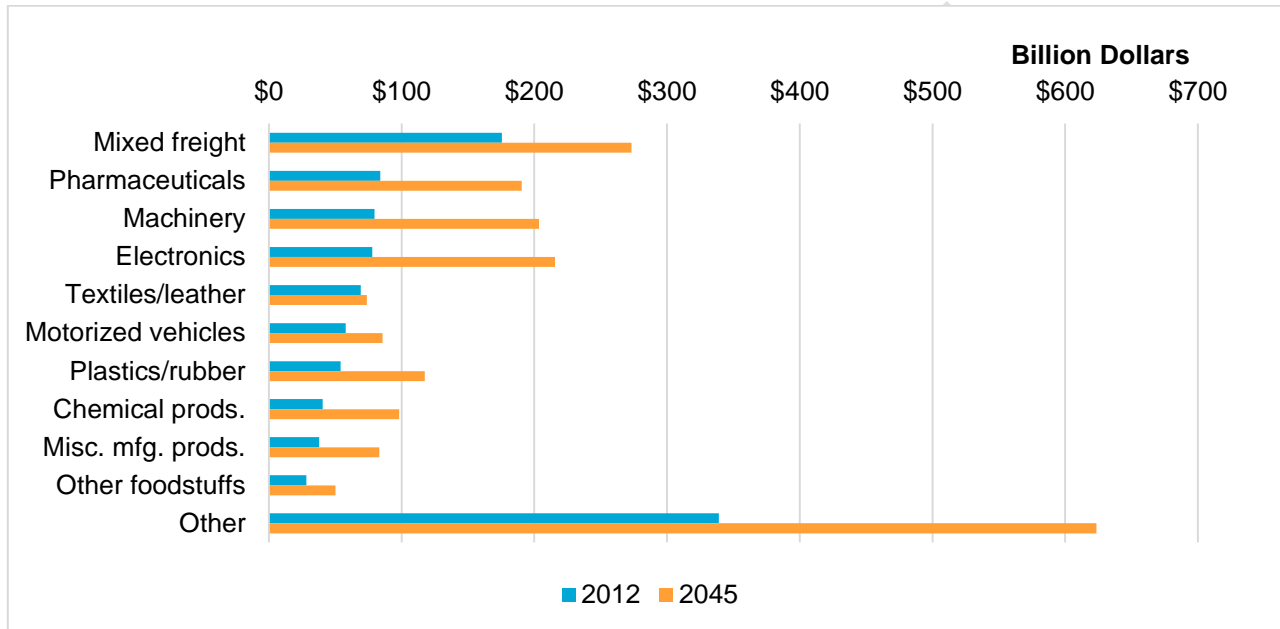**Figure 2.7   North Carolina Commodities by Value, 2012 and 2045**

Source: Cambridge Systematics disaggregation of FAF4.1 2012-2045 data, 2012 STB Waybill rail data, and 2045 STB Waybill rail data forecasted by Cambridge Systematics.

3.0   North Carolina's Trading Partners

Exports create wealth in a state's economy, and the level of exports is a key determinant of an economy's growth and vitality. North Carolina exported more than $28.8 million in 2012, which increased to $31.4 million in 2014 before declining to $30 million in 2015. The State's share of total US exports increased slightly, from 1.9 percent in 2012 to 2.0 percent in 2015[3]. Over this same period, the State's imports grew from $49.6 million to $51.3 million, comprising 2.2 percent and 2.3 percent of the US total imports, respectively[4].

3.1   Domestic Trade Partners

Outbound Goods

Goods shipped from North Carolina travel to a wide range of US destinations. In 2012, over 93 million tons of goods left North Carolina to destinations throughout the US. The top domestic destinations included the Rest of South Carolina[5] (13 percent of the outbound tonnage), the Rest of Virginia (11 percent), and Virginia Beach-Norfolk VA (6 percent). All of the top destinations by weight in 2012 are to states in the Southeast and Mid-Atlantic regions. By 2045, the top three destinations are projected to remain consistent. Figure 3.1 shows the top domestic destinations for goods by weight in 2012 and 2045.

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[3] https://www.census.gov/foreign-trade/statistics/state/data/nc.html

[4] https://www.census.gov/foreign-trade/statistics/state/data/imports/nc.html

[5] Note: Trade partners are categorized into FAF Zones. FAF Zones were created using the census metropolitan area (CMA) boundaries, such as the Combined Statistical Area (CSA) and Metropolitan Statistical Area (MSA). Many CMA boundaries cross more than one state. Major subareas of a CMA are defined as separate FAF regions, one for each state. Small subareas of a CMA are included with the State or Rest of State regions. A complete description and definition of FAF Zones is available in the FAF4 Users Guide: http://faf.ornl.gov/fafweb/data/FAF4%20User%20Guide.pdf

Figure 3.1   North Carolina Top Domestic Destinations by Tonnage, 2012 and 2045
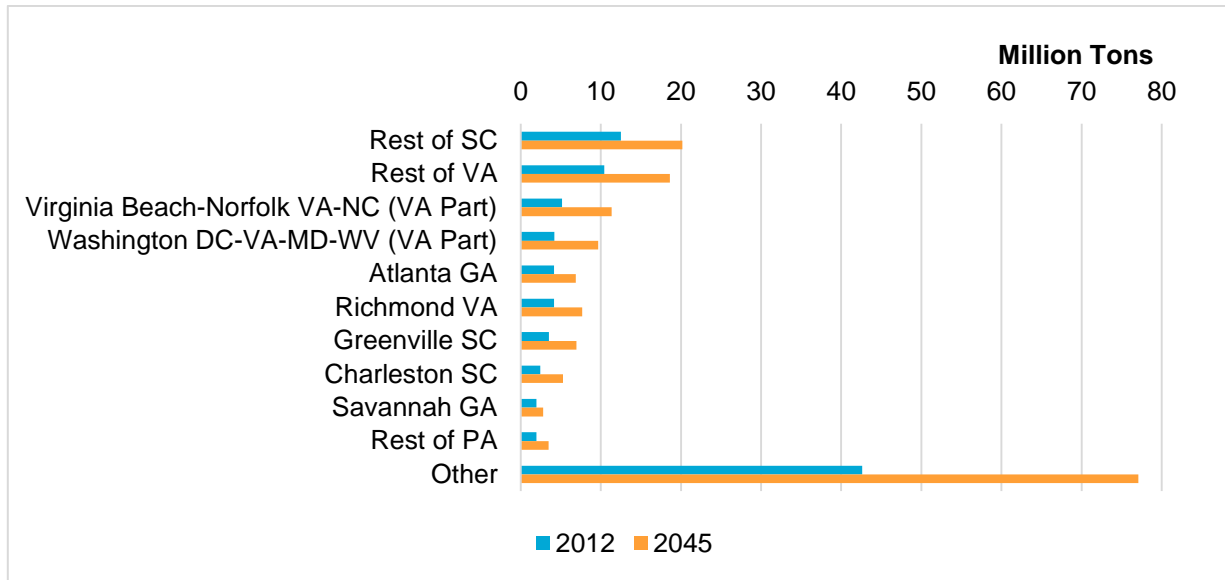
The top 10 destinations by value in 2012 were more dispersed across the country than when measured by weight. North Carolina's top destinations by value, shown in Figure 3.2, comprised $105 billion (39 percent) of the total outbound value in 2012. The top three destinations were Atlanta, GA (9 percent), Rest of South Carolina (5 percent), and Miami, FL (4 percent).

By 2045, the Atlanta region is projected to remain the top destination by value, followed by Virginia Beach-Norfolk, VA-NC, Rest of South Carolina, the Chicago, IL area, and Miami, FL. These five destinations are projected to receive more than $144 billion worth of goods (26 percent of the total outbound value) from North Carolina in 2045.

Figure 3.2   North Carolina Top Domestic Destinations by Value, 2012 and 2045
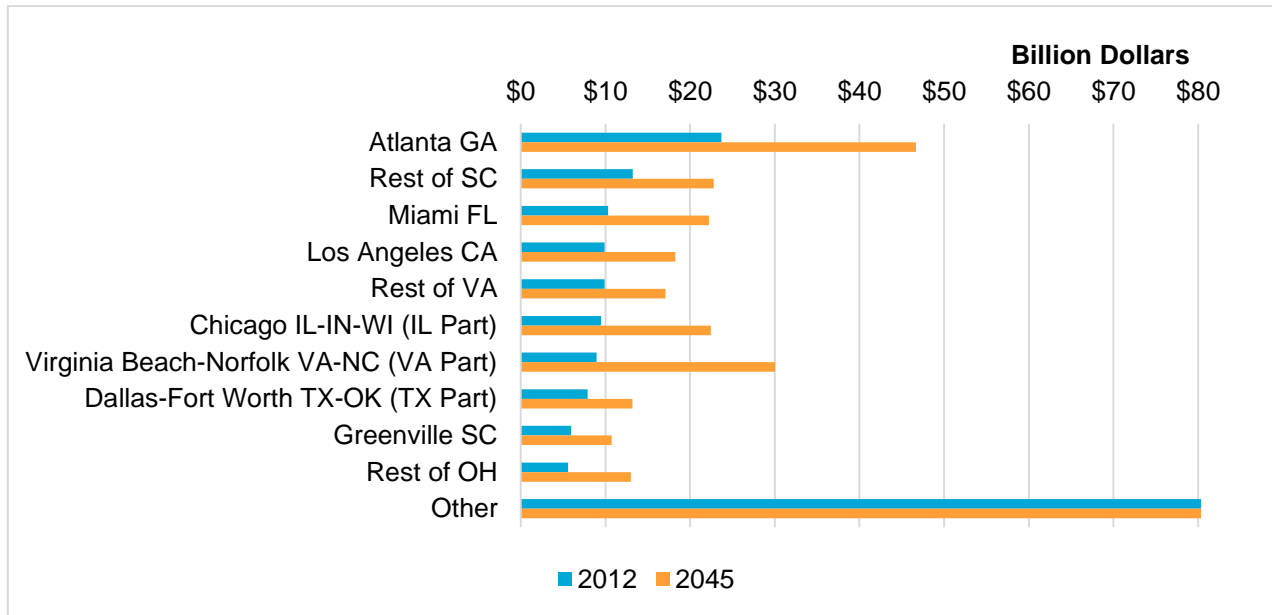

Source: Cambridge Systematics disaggregation of FAF4.1 2012-2045 data, 2012 STB Waybill rail data, and 2045 STB Waybill rail data forecasted by Cambridge Systematics.

Inbound Goods

North Carolina receives goods from trading partners across the country. The top 10 origins shown in Figure 3.3 accounted for 63 percent of the total inbound tonnage in 2012. North Carolina received the most tonnage from West Virginia, followed by Greenville, SC, Rest of South Carolina, Rest of Virginia, and Rest of Kentucky. These five regions accounted for 61 million (46 percent) of the total inbound tonnage to North Carolina.

By 2045, the top five origins are projected to shift. Greenville, SC and Rest of South Carolina are projected to become the top origins, followed by Charleston, SC, Rest of Virginia, and the Chicago, IL area. Together, these regions are expected to account for 76 million tons (39 percent) of inbound trade in 2045. Shipments from Rest of West Virginia, the top origin in 2012, are projected to decrease by 49 percent in 2045, led by the expected decline of coal traffic. Figure 3.3 show the top 10 domestic origins of goods by weight in 2012 and 2045.

Figure 3.3   North Carolina Top Domestic Origins by Tonnage, 2012 and 2045

In 2012, the top domestic origin by value was Atlanta, GA followed by Rest of South Carolina, Chicago, IL, Los Angeles, CA, and Miami, FL. These five origin regions accounted for 23 percent ($50 billion) of the total value of goods shipped to North Carolina. The remaining top origin regions in 2012 are shown in Figure 3.4.

By 2045, Greenville, SC and Rest of Virginia are projected to drop out of the top 10 and be replaced by Laredo, TX (9th) and New Orleans, LA (10th). Charleston, SC is projected to become the top inbound trading partner for North Carolina, followed by Atlanta, GA, Chicago, IL, Savannah, GA, and Los Angeles, CA. Together the projected top five origin regions are expected to comprise 25 percent of the $451 billion of inbound goods shipped to North Carolina. Figure 3.4 shows the projected value of North Carolina's top domestic inbound trading partners by value.

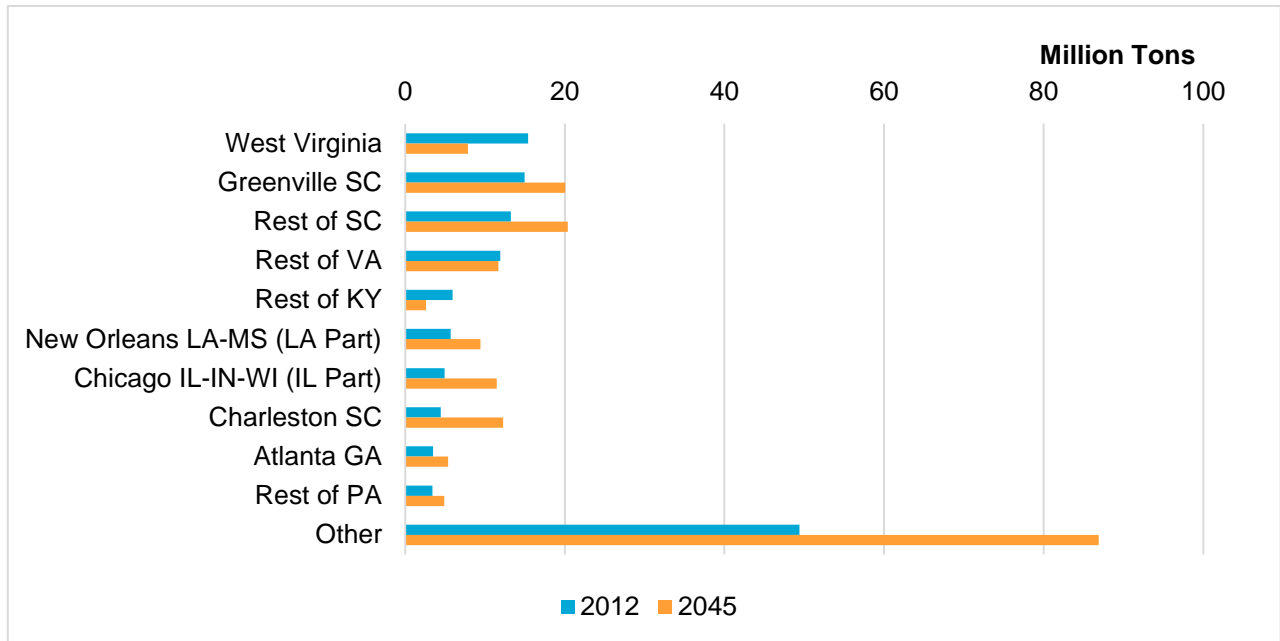**Figure 3.4   North Carolina Top Domestic Origins by Value, 2012 and 2045**
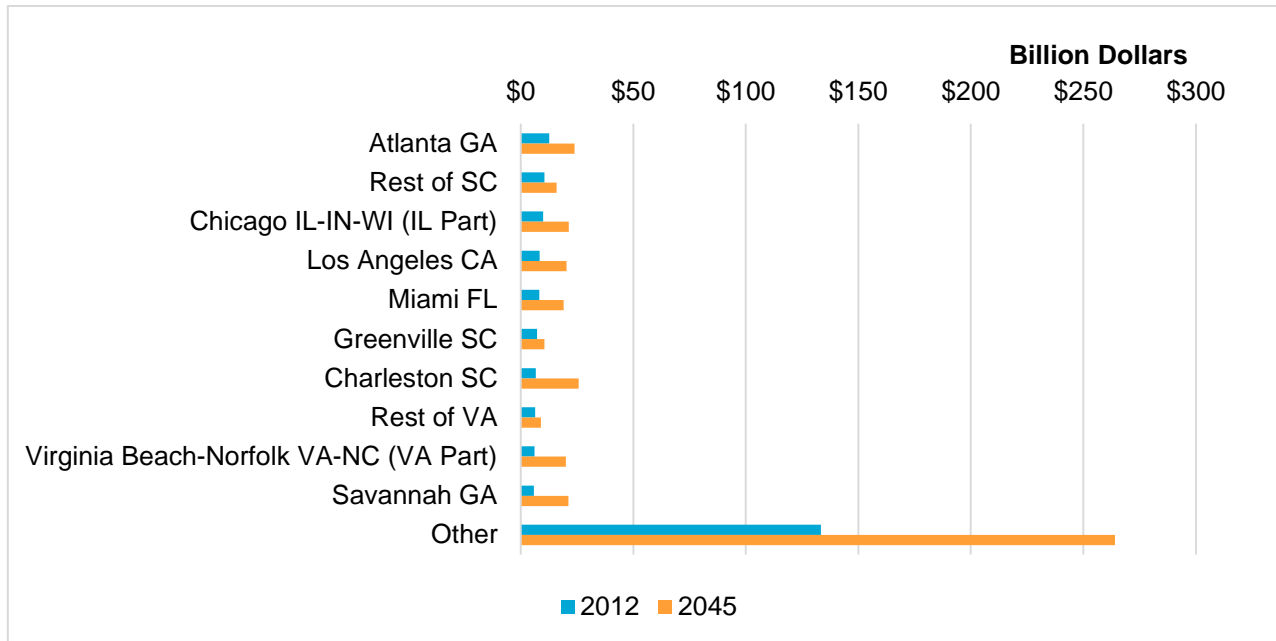

Source: Cambridge Systematics disaggregation of FAF4.1 2012-2045 data, 2012 STB Waybill rail data, and 2045 STB Waybill rail data forecasted by Cambridge Systematics.

It is important to note that many of the top origins and destinations by tonnage and value are important transload hubs. Cities and regions including Atlanta, Los Angeles-Long Beach, Chicago, Virginia Beach-Norfolk, Charleston, and Savannah may be the domestic origin or destination, but the final origin or destination of many of the goods that flow through these regions are likely overseas. International trade partners are examined in further detail in the next section.

3.2   International Trade Partners

In 2012, international trade comprised approximately 20 million tons worth over $76 billion of goods shipped to, from and through North Carolina. Fifty-eight percent of these foreign shipments were US imports, while the rest were US exports. These international shipments include imports and exports through North Carolina ports, as well as ports outside of the State. By 2045, foreign shipments in the State are projected to rise to 55 million tons of goods worth more than $333 billion.

North Carolina's international trading partners can be divided into eight regions:

1. Canada

2. Mexico

3. Rest of Americas (South and Central America, including the Caribbean)

4. Europe

5. Africa

6. Southwest and Central Asia

7. Eastern Asia

8. Southeast Asia and Oceania

Outbound Goods / Exports

The top three export destinations in 2012 measured by both weight and value were Eastern Asia, Canada, and Europe. These three destinations accounted for 61 percent of the 8 million tons of exported goods by weight, and 66 percent of the $21 billion exported by value. By 2045, total exports by weight are projected to triple to 25 million tons worth $141 billion, with the top three destinations remaining the same (Eastern Asia, Canada, Europe).

Foreign trade partners for North Carolina exports via any US port in 2012 and 2045 are shown in Figure 3.5 and Figure 3.6 for total weight and value, respectively.

Figure 3.5   North Carolina International Destinations by Tonnage, 2012 and 2045
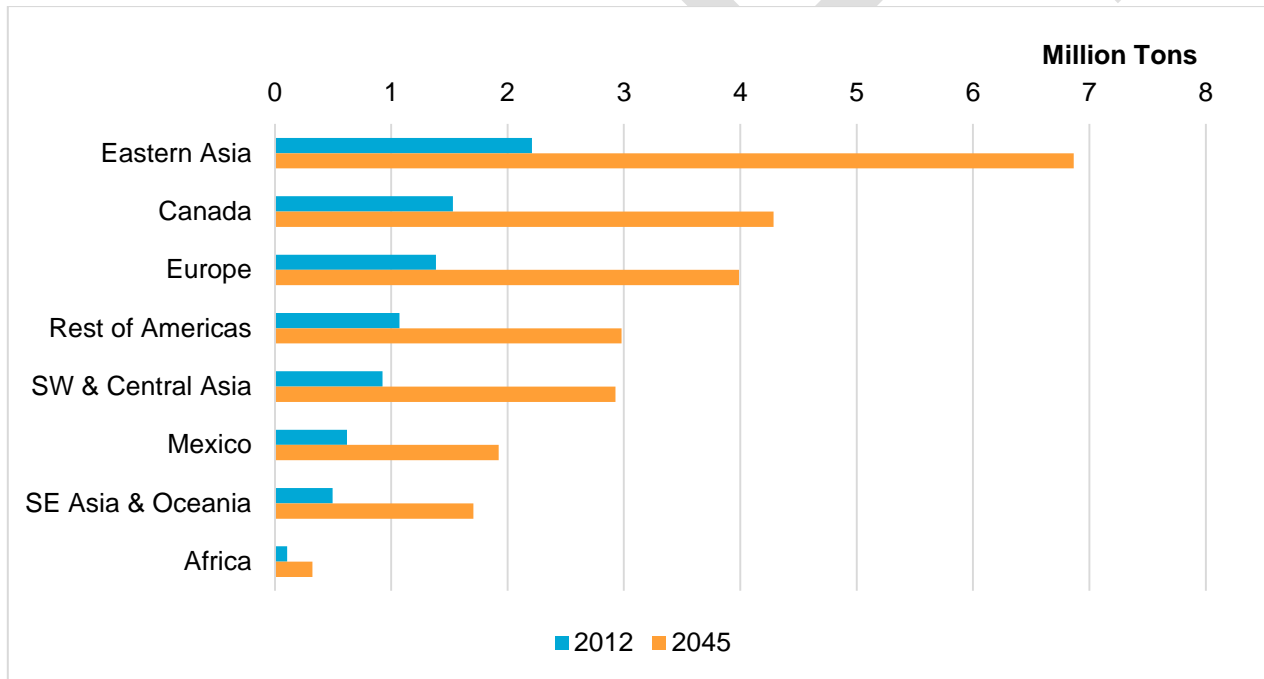
Source: Cambridge Systematics disaggregation of FAF4.1 2012-2045 data, 2012 STB Waybill rail data, and 2045 STB Waybill rail data forecasted by Cambridge Systematics.

Figure 3.6   North Carolina International Destinations by Value, 2012 and 2045
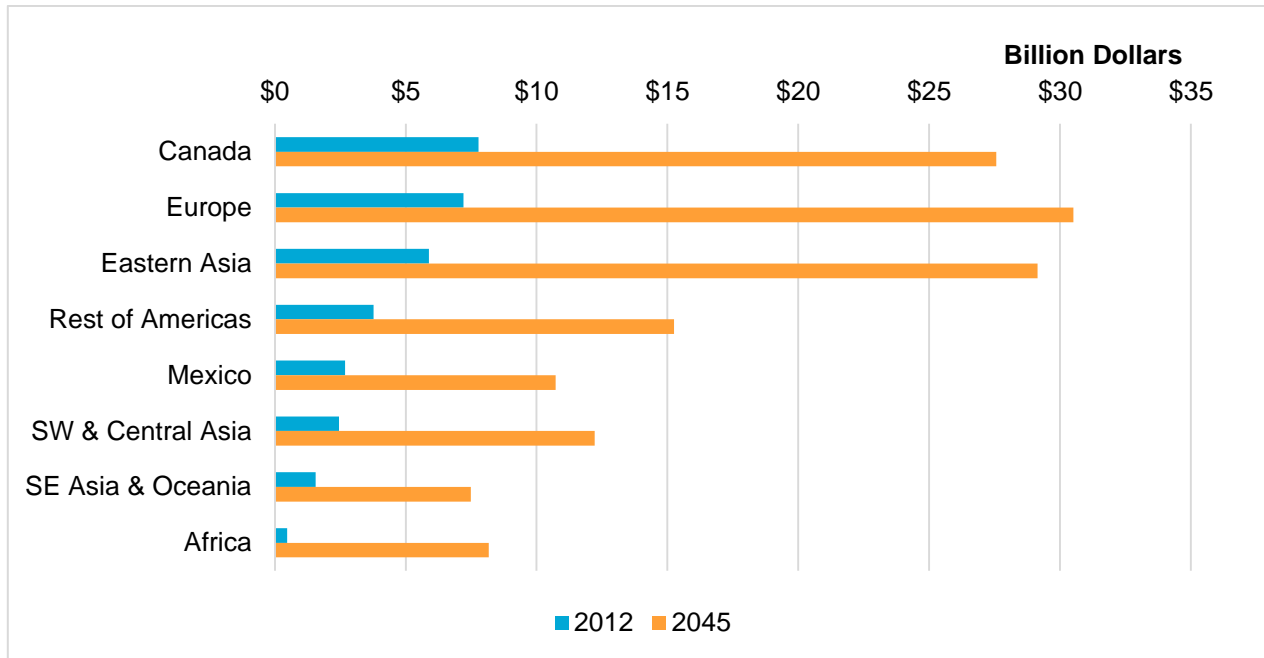
Inbound Goods / Imports

In 2012, North Carolina imports through State ports and out-of-State ports totaled 11 million tons. The top international trading partners for these imports were Canada, Europe, and Rest of Americas (does not include Mexico). Canada was the leading source for international tonnage in 2012. Combined with Europe and East Asia, these three foreign origins accounted for approximately 62 percent (7 million tons) of the imported tonnage. Total imported weight in 2045 is projected to grow to 30 million tons. Eastern Asia is projected to become the largest import trading partner at 26 percent of total imported tons. Figure 3.7 shows the import trading partners by weight in 2012 and 2045.

North Carolina imports through State ports and out-of-State ports totaled $44 billion in 2012. The top three imports trading partners by value were Europe, Eastern Asia, and Mexico, which together comprised 71 percent ($31 billion) of the imports. By 2045, the total value of North Carolina imports is projected to increase by over 300 percent to $192 billion. Eastern Asia will account for more than one-third of that increase. Figure 3.8 shows the import trading partners by value in 2012 and 2045.

Figure 3.7 North Carolina International Origins by Tonnage, 2012 and 2045

Source: Cambridge Systematics disaggregation of FAF4.1 2012-2045 data, 2012 STB Waybill rail data, and 2045 STB Waybill rail data forecasted by Cambridge Systematics.

Figure 3.8 North Carolina International Origins by Value, 2012 and 2045
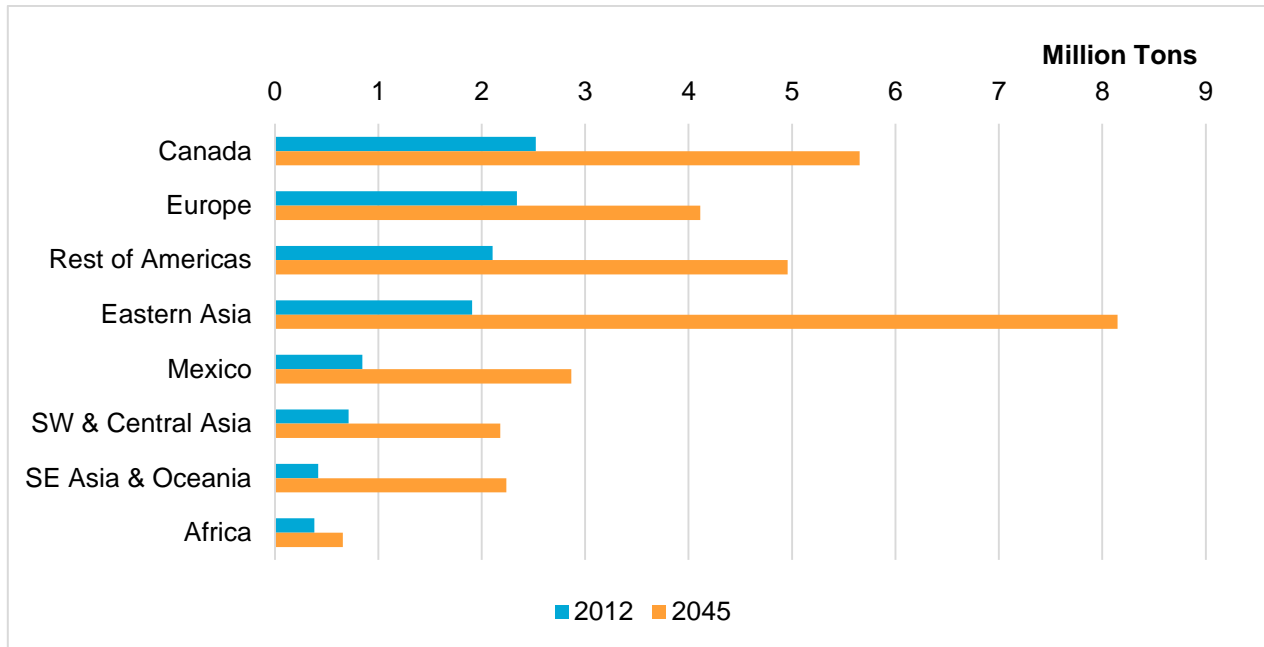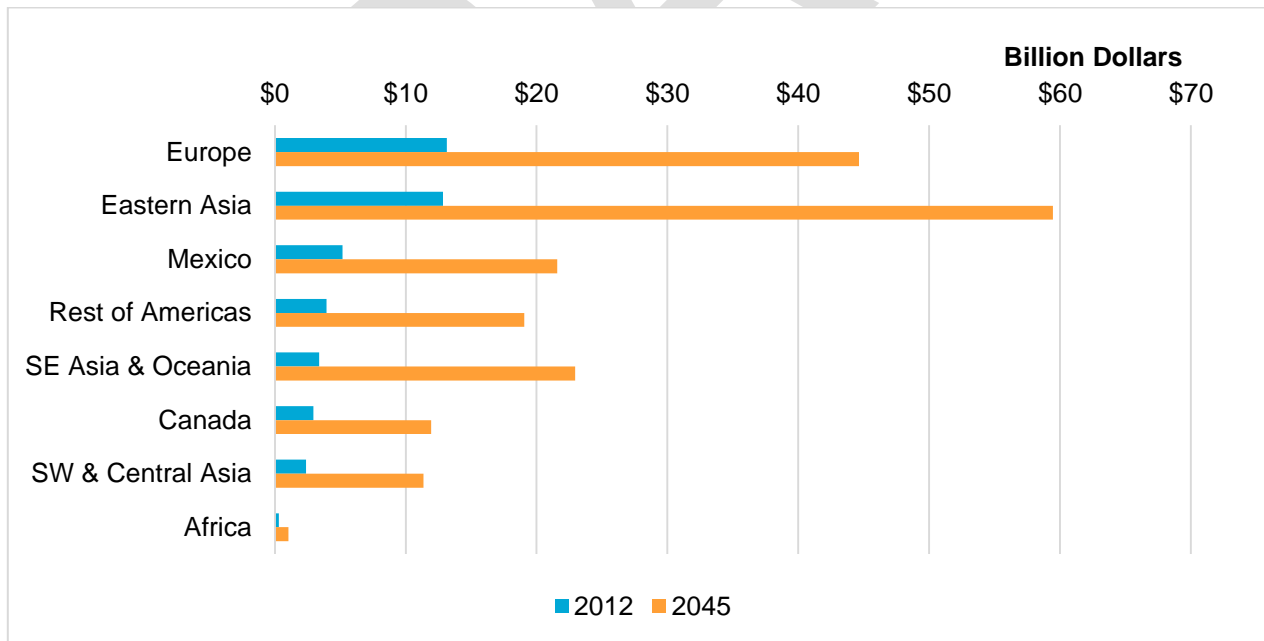

Source: Cambridge Systematics disaggregation of FAF4.1 2012-2045 data, 2012 STB Waybill rail data, and 2045 STB Waybill rail data forecasted by Cambridge Systematics.

4.0   County Level Freight Demand

Mecklenburg County was the dominant county for goods movement in North Carolina in 2012. A total of 16 million tons were shipped from the County, 26 million tons of goods were shipped to the County, and 4 million tons of goods moved within the County. This activity accounted for 11 percent of the 426 million tons shipped to, from, and within North Carolina in 2012. The remaining top counties for freight activity measured by weight were Wake, Guilford, Davidson, Forsyth and Randolph. Collectively, the tons generated by these five counties accounted for 28 percent of the cargo tons shipped to, from and within the State.

By 2045, Mecklenburg is projected to remain the top county for freight activity, and is projected to generate 72 million (11 percent) of the tons shipped to, from, and within North Carolina. The top 10 counties with freight activity (inbound, outbound and intra-county combined) are projected to remain the same over the next 30 years, albeit with different rankings. Among the top 10, the largest percentage growth by 2045 is forecasted for Guilford County (69 percent growth), followed by Davidson County (60 percent growth).

Figure 4.1 shows the top 10 counties by weight in 2012 and 2045. These figures include shipments that moved in into, out of, and within each county. Figure 4.2 and Figure 4.3 present maps of the total tonnage of goods that moved within, to, or from each North Carolina County in 2012 and 2045, respectively.

Figure 4.1   Top North Carolina Counties by Combined Inbound, Outbound, and Intra-County Tonnage, 2012 and 2045
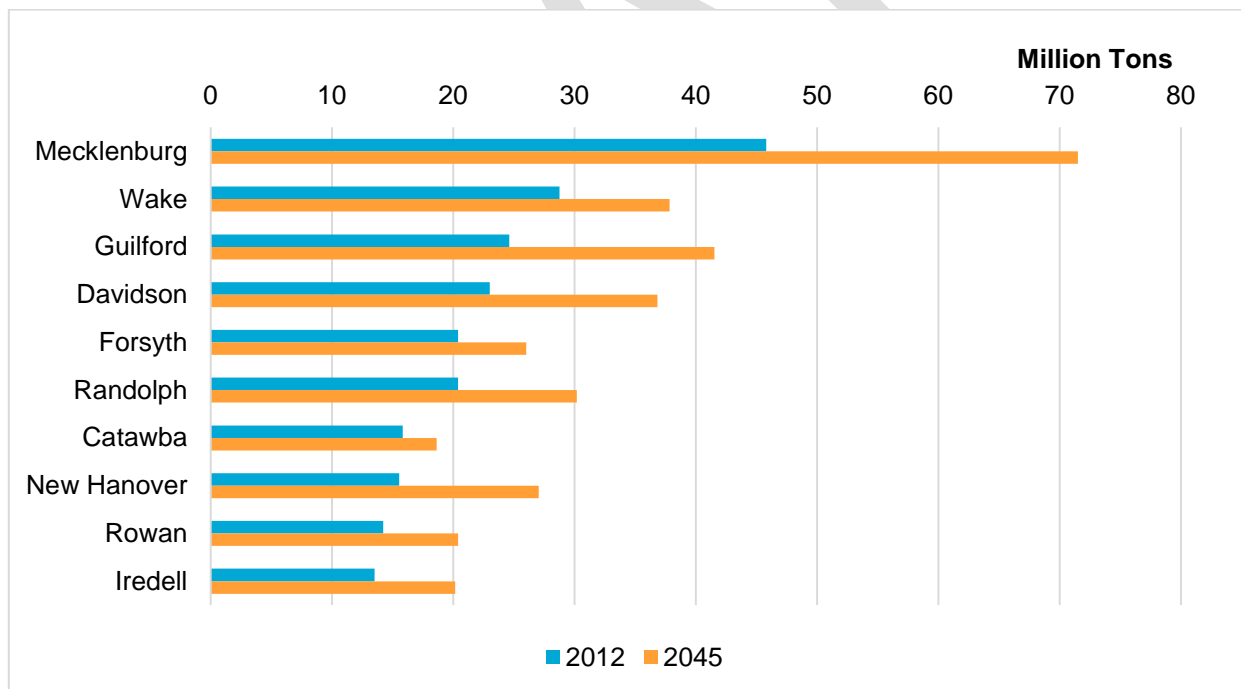
Source: Cambridge Systematics disaggregation of FAF4.1 2012-2045 data, 2012 STB Waybill rail data, and 2045 STB Waybill rail data forecasted by Cambridge Systematics.

Figure 4.2   Freight Tonnage by County for Inbound, Outbound, Intra-County Flows, 2012
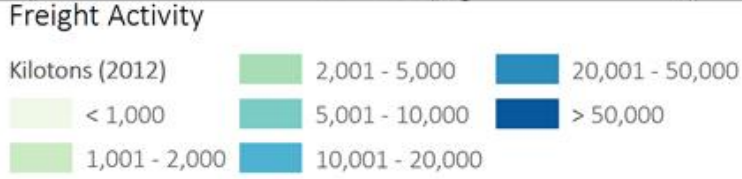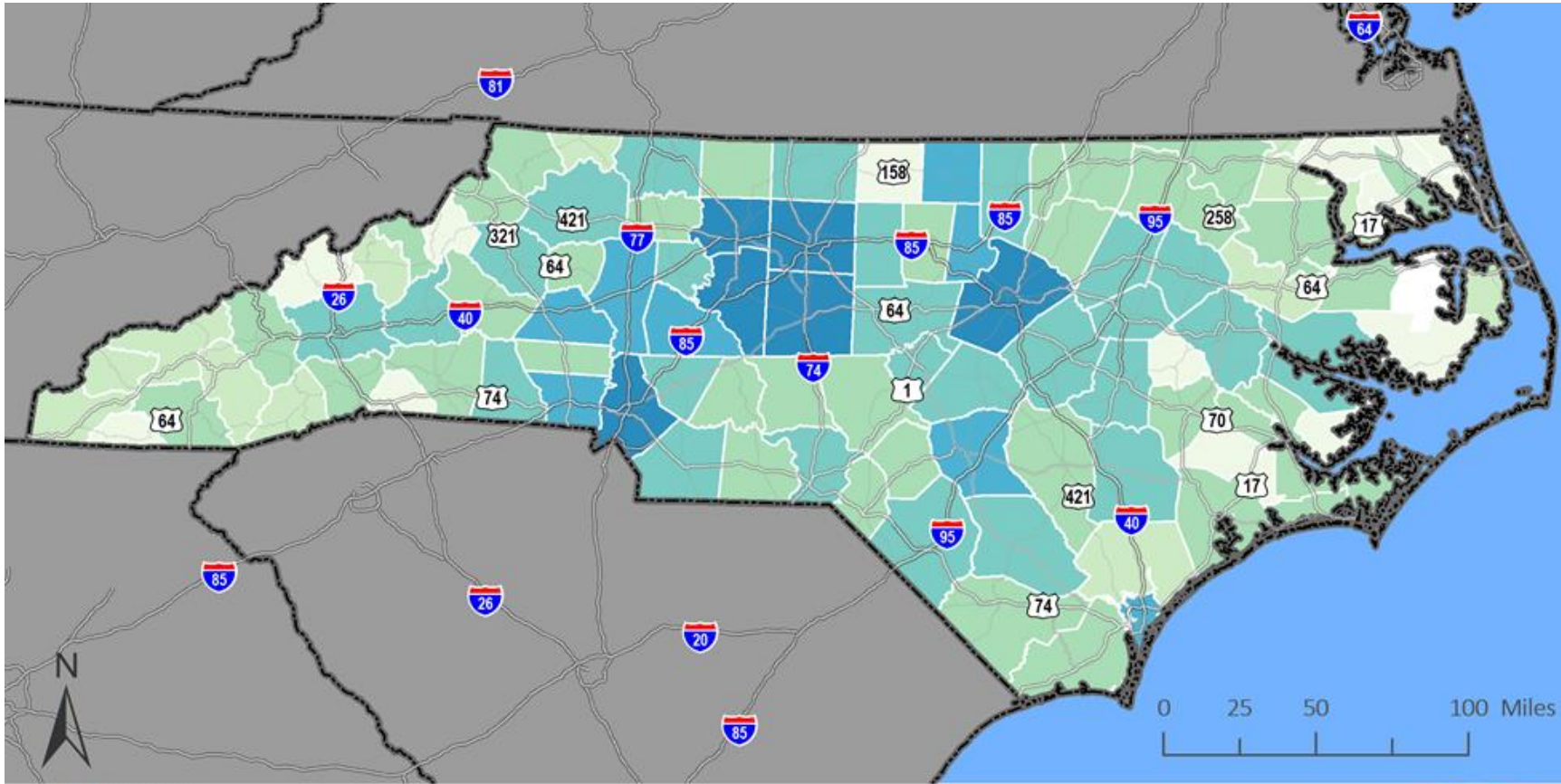
Freight Activity

Kilotons (2012)

< 1,000	2,001 - 5,000	20,001 - 50,000
1,001 - 2,000	5,001 - 10,000	> 50,000
	10,001 - 20,000	

Figure 4.3   Freight Tonnage by County for Inbound, Outbound, Intra-County Flows, 2045

Freight Activity

Kilotons (2045)		
< 1,000	2,001 - 5,000	20,001 - 50,000
1,001 - 2,000	5,001 - 10,000	> 50,000
	10,001 - 20,000	

Source: Cambridge Systematics disaggregation of FAF4.1 2012-2045 data, 2012 STB Waybill rail data, and 2045 STB Waybill rail data forecasted by Cambridge Systematics.

Mecklenburg County shipped the highest value of goods in 2012, which accounted for 17 percent of the $636 billion in goods shipped to, from and within North Carolina. Outbound flows from Mecklenburg County totaled $53.1 billion, inbound flows totaled $53.6 billion, and intra-county shipments totaled $3.5 billion. The remaining top five counties by value in 2012 were Guilford, Wake, Forsyth, and Randolph. The freight value generated by these four counties accounted for 24 percent of the cargo value shipped to, from and within the State.

By 2045, Mecklenburg is expected to remain the leading county for freight value. The County's total share of value is expected to increase to 19 percent ($236 billion) of the projected $1.3 trillion shipped to, from and within the State. The remaining top counties by value are projected to be Guilford, Wake, New Hanover, and Forsyth. By 2045, these four counties are projected to generate $328 billion of freight moving to, from and within the counties.

Figure 4.4 shows the top 10 counties by value in 2012 and 2045 for total inbound, outbound, and intra-county movements. Figure 4.5 and Figure 4.6 present maps showing the total value of goods that moved within, to, or from each North Carolina County in 2012 and 2045 respectively.

Figure 4.4   Top North Carolina Counties by Combined Inbound, Outbound, Intra-County Value, 2012 and 2045

Source: Cambridge Systematics disaggregation of FAF4.1 2012-2045 data, 2012 STB Waybill rail data, and 2045 STB Waybill rail data forecasted by Cambridge Systematics.

Figure 4.5   Freight Value by County for Inbound, Outbound, and Intra-County Flows, 2012
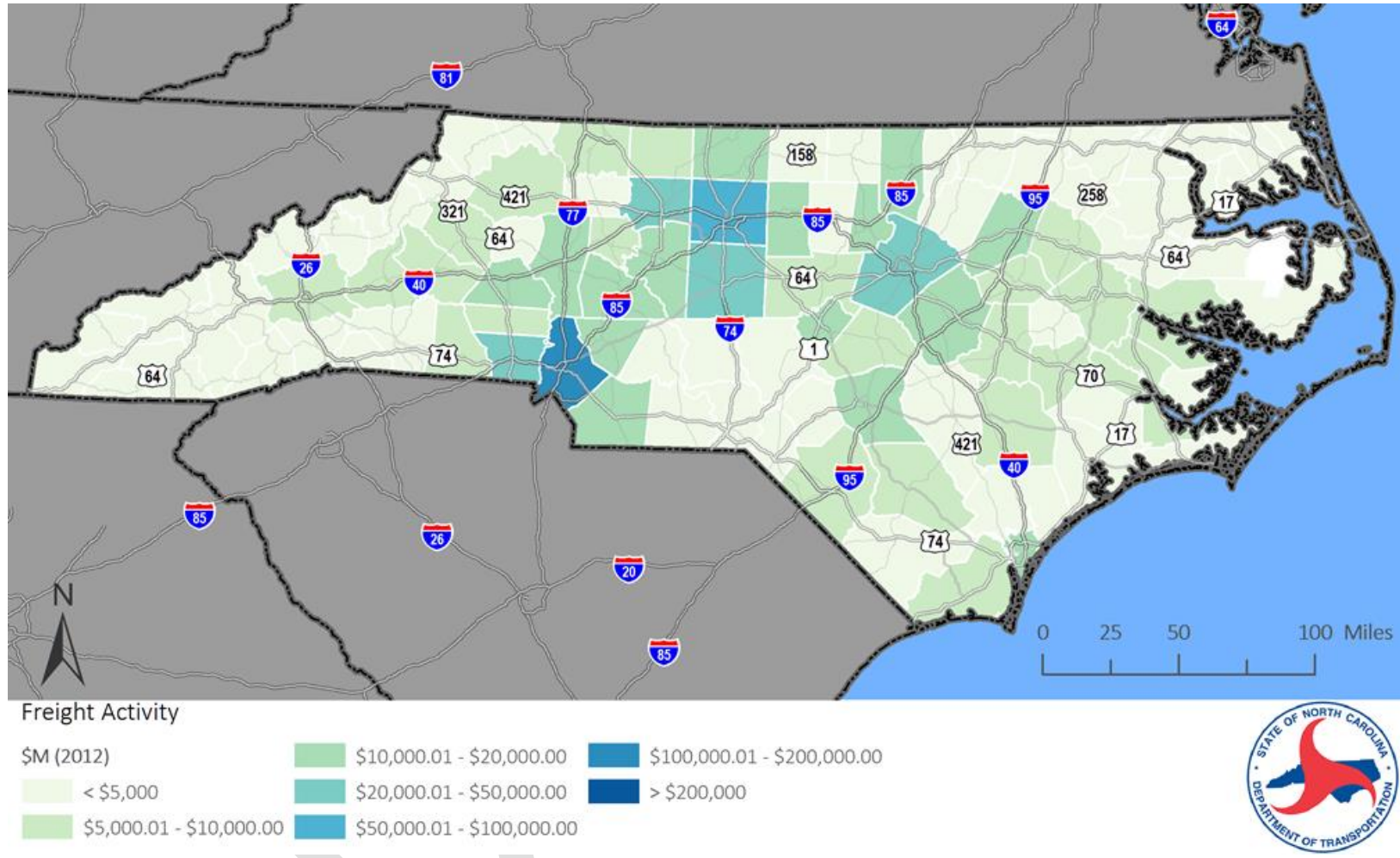
Freight Activity

$M (2012)

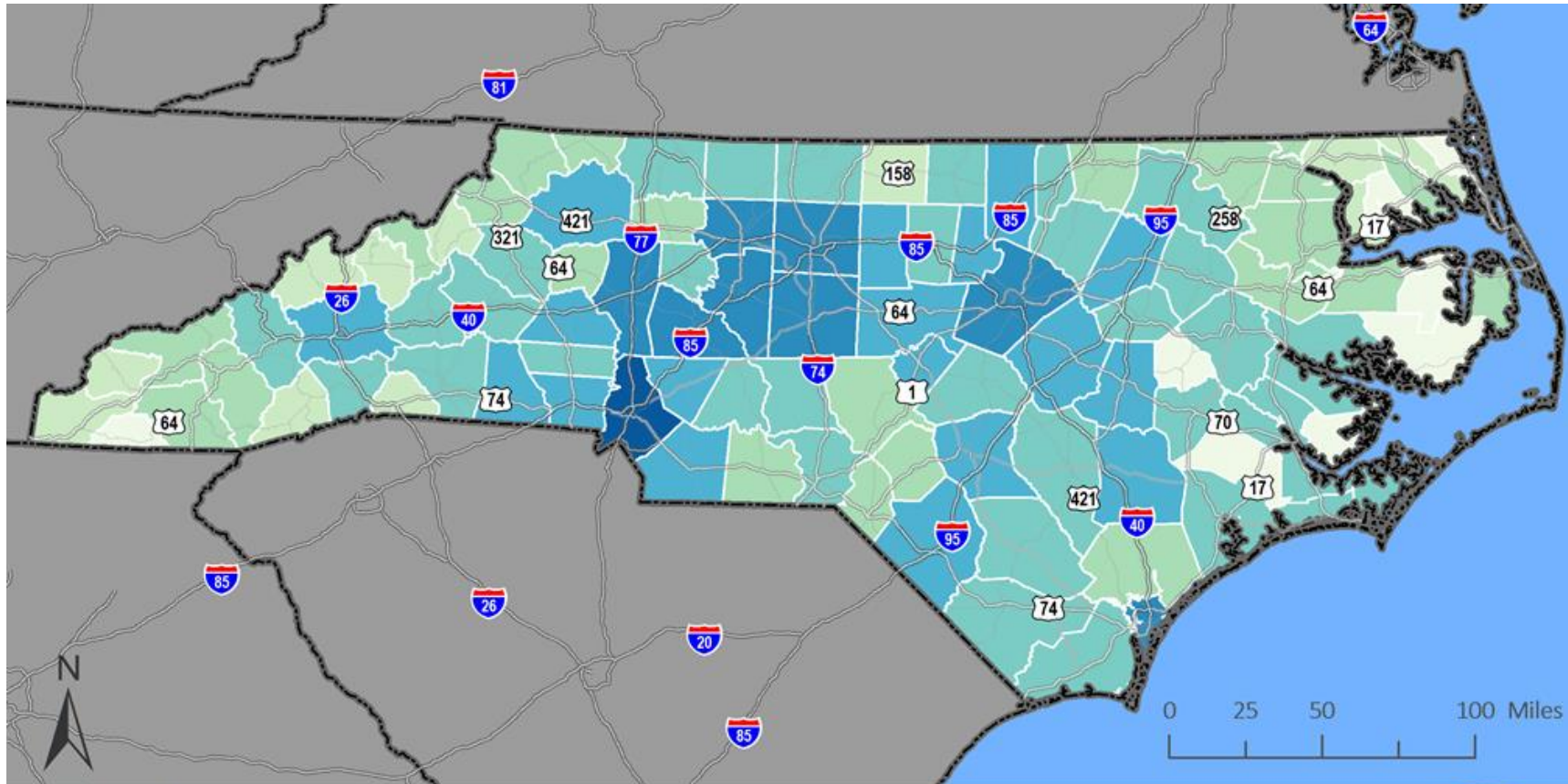|		
< $5,000	$10,000.01 – $20,000.00	$100,000.01 – $200,000.00
$5,000.01 – $10,000.00	$20,000.01 – $50,000.00	> $200,000
	$50,000.01 – $100,000.00	

Source: Cambridge Systematics disaggregation of FAF4.1 2012-2045 data, 2012 STB Waybill rail data, and 2045 STB Waybill rail data forecasted by Cambridge Systematics.

Figure 4.6   Freight Value by County for Inbound, Outbound, and Intra-County Flows, 2045
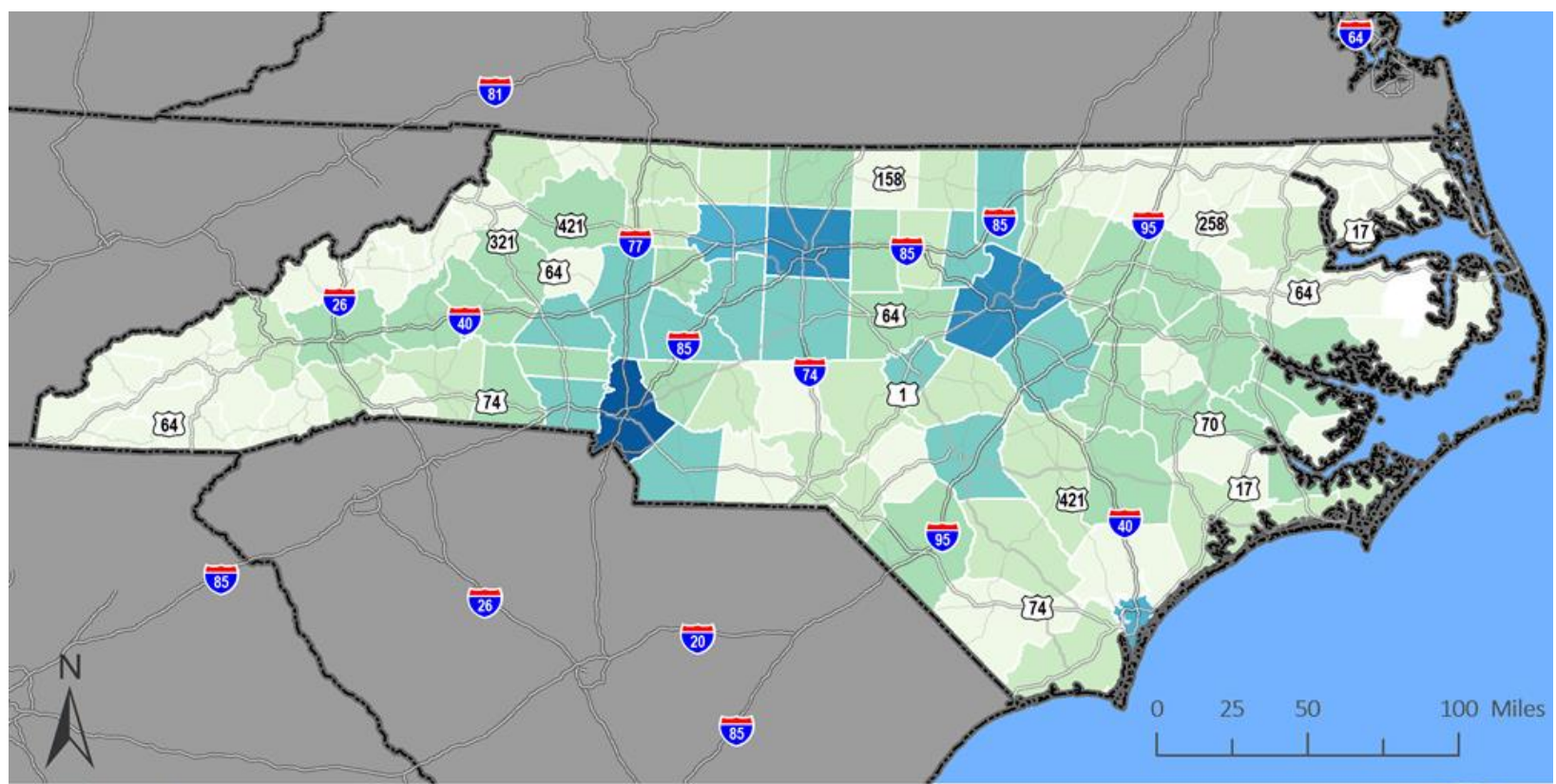
Freight Activity

$M (2045)

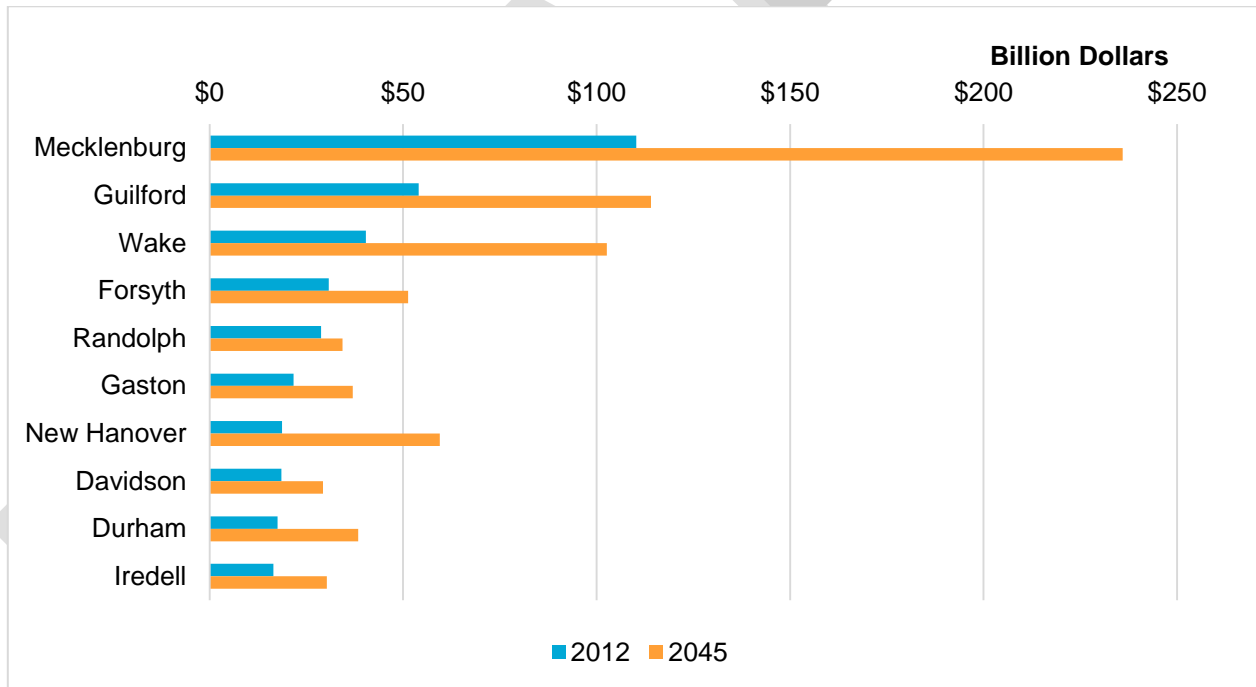|	
< $5,000	$10,000.01 - $20,000.00
$5,000.01 - $10,000.00	$20,000.01 - $50,000.00
	$50,000.01 - $100,000.00
	$100,000.01 - $200,000.00
	> $200,000

Source: Cambridge Systematics disaggregation of FAF4.1 2012-2045 data, 2012 STB Waybill rail data, and 2045 STB Waybill rail data forecasted by Cambridge Systematics.

Appendix A.   Disaggregation of the FAF4 Database for North Carolina

This Appendix discusses the disaggregation process of the FHWA's Freight Analysis Framework version 4.1 (FAF4.1) database for use in North Carolina Statewide Multimodal Freight Plan. As part of this effort, a tool was developed in MS Access, consistent with the format of the FAF4.1. FAF4.1 is an MS Access database that is available for download from the FHWA. While the FAF Study regions included in the FAF disaggregation database are unique to the North Carolina study, the disaggregation factors themselves can be applied to any set of FAF regions. The North Carolina FAF regions (see Figure A.1) that were disaggregated include:

- 371-Charlotte, NC-SC [NC Part];

- 372-Greensboro--Winston-Salem--High Point, NC;

- 373-Raleigh-Durham, NC; and

- 379-Rest of NC

The FAF regional flows which are domestic, i.e. not imports and exports through a US Port of Entry/Exit, are disaggregated to FIPS counties. Flows that are imports and exports through a water port are distributed to the water ports in that FAF region based on the share of the 2-digit Standard Classification of Transported Goods (SCTG2) tons served by that port in the USACE's Navigational Data Center Waterborne Commerce database[6]. Flows that are imports or exports by rail or truck at border crossings with Canada or Mexico are distributed to rail or highway border crossings in that FAF region, with the same factor for each SCTG2 commodity, based on the reported trucks (for the FAF truck mode) or trains (for the FAF rail mode) at that border crossing as reported by BTS's Border Crossing/Entry data. For imports or exports through FAF regions that are not border crossings or water ports, the original FAF region as a Port of entry is retained. There is information which could be used to disaggregate flows imported or exported by air, however there are only 6 FAF regions that contain multiple airports and for those only total tonnages, not tonnages by import, exports and domestic are known. If disaggregations are needed of air imports and exports in these FAF regions with multiple airports, it is recommended that this should be done off model.

The disaggregation database includes a table "FIPS & Ports/Borders to FAF4 Regions all" that is a cross walk of the FAF regions in which all FIPS counties, water ports and border crossings are located for the entire country. For the case of North Carolina, only the information germane to North Carolina is output from the tool. For example, even though factors are available to allocate from a FAF region to land border crossings with Canada and Mexico exists, there are no such border crossings on the North Carolina border, and thus no import or export flows would be disaggregated to those nonexistent border crossings. By contrast, in the FAF region 379-Rest of NC there are two ports, the Port of Wilmington and the Port of Morehead City and the factors for these ports are utilized.

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[6] Prior to 2014, only total tonnages for commodities were reported electronically by the USACE and only a single factor for all commodities was used for each port. Beginning with 2014, flows were reported by commodity by waterway, including ports, and those are now used to develop disaggregation factors.

Figure A.1   FAF4 Zones in North Carolina
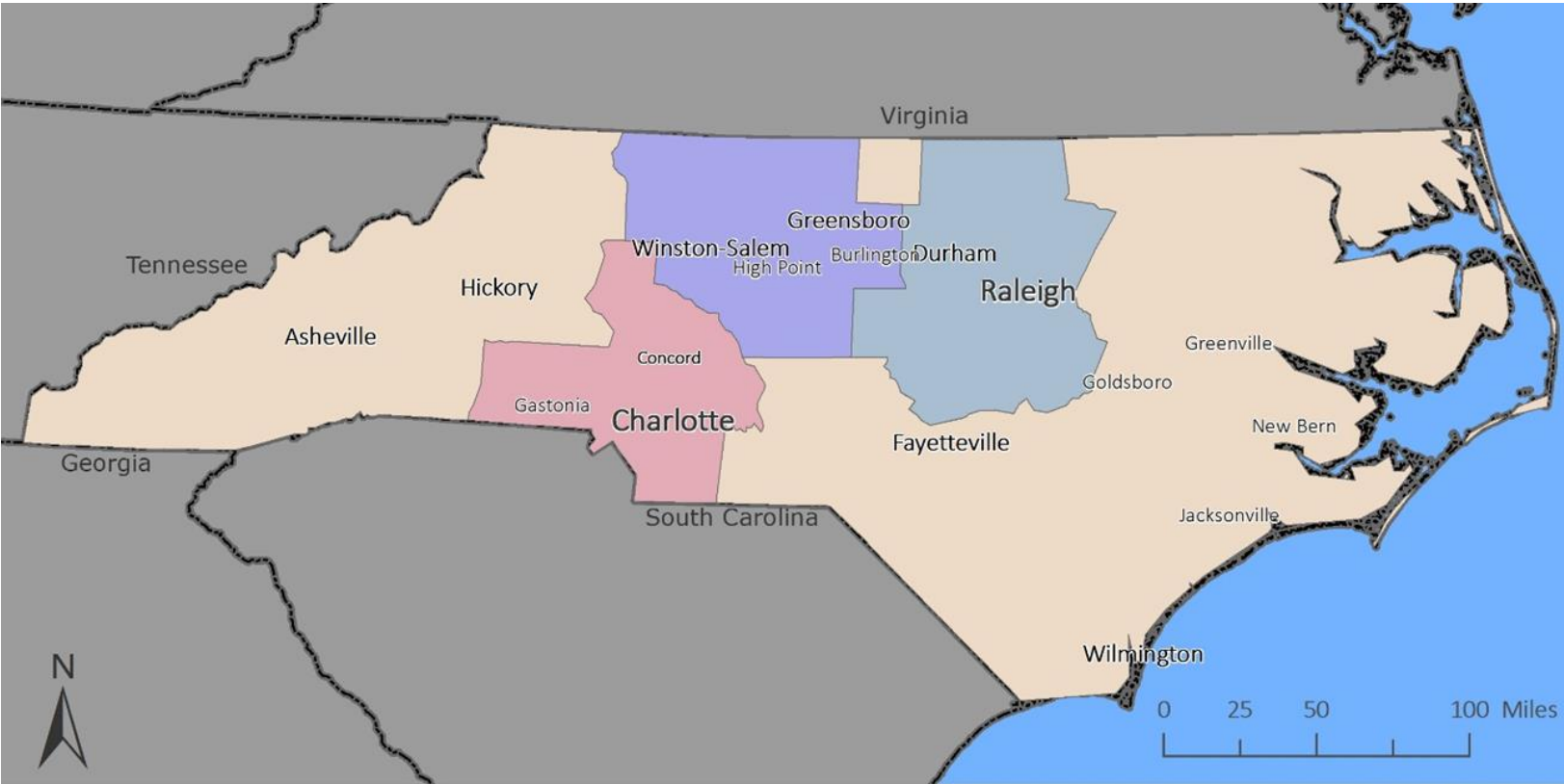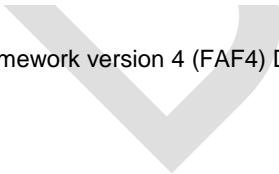

FAF4 Zones in North Carolina

- Charlotte-Concord, NC-SC CFS Area (NC Part)
- Greensboro-Winston-Salem-High Point, NC CFS Area
- Raleigh-Durham-Chapel Hill, NC CFS Area
- Remainder of North Carolina

Source: Freight Analysis Framework version 4 (FAF4) Database; Cambridge Systematics' Analysis.

A.1   TRANSCAD Application

The process to apply disaggregation factors was originally developed for a CS project for the FAF version 2 (FAF2).[7] This process resulted in a disaggregated FAF database that was too large to fit within the 2 GB size limit in MS Access. The disaggregation factors to counties were based on the tons by 2-digit SCTG that are produced in, or attracted to, a county. The disaggregation factors at ports were based on the tons that are imported, or exported, through those ports. The disaggregation factors for border crossing are based on the reported trucks or trains, as appropriate; trucks are used to disaggregate flows where the foreign mode is truck and trains are used to disaggregate flows where the foreign mode is rail. The water port and border flows are therefore based on actual reported flows. Only the county factors are based on tonnages that are computed from equations. However, most of the equations developed for FAF2 contain only one explanatory variable, or only one significant explanatory variable (e.g. the production of tons of SCTG 24-Rubber and Plastic was found to be a function of employment in NAICS 326 Plastics and Rubber Products Manufacturing). When the equation has only one variable, for example 3-digit NAICS (NAICS3) employment, the share of tonnage in a county is essentially the share of that variable in the FAF region.

To support the 2011 FAF Geospatial project for FHWA, the disaggregation code was rewritten in TransCAD, which does not have the space limitations of MS Access. The output, to support the FAF Geospatial assignment to the FAF highway network, was converted from annual tons by all modes to daily trucks. To support other CS projects, the input data was developed for 2012, which is the base year of the FAF4.1. Those same disaggregation factors are applied to base and forecast flows; there are no national forecast of employment by industry, no forecasts of tons by commodity by water port, and no forecasts of trucks or trains by border crossing.

To support the North Carolina Statewide Multimodal Freight Plan, this TransCAD code was re-written to output not trucks, but tons by all modes. To maintain consistency with the region to region FAF4, the output from TransCAD was exported as a CSV file that could be imported into MS Access. Once in MS Access, the mode shares by Origin region, Destination region, and SCTG2 commodity was applied to all of the Origin county, Destination county, and SCTG2 commodity flows within that FAF region.

A.2   Through Flows

The disaggregation process only outputs the flows to, from, and within a study area such as North Carolina. The trips that pass though a study area, but have no cargo stops within the study area, cannot be determined from the FAF4.1 disaggregation matrix alone. The determination of through flows requires additional processing with the transportation network to which those trips would be assigned. Using terminology from CS' Travel Demand (model) Forecasting (TDF) Business Line, the FAF origin-destination (OD) Matrix was expanded (disaggregated) and in order to identify through trips (i.e. windowing) the network links on the North Carolina (study area) border were identified as a cordon line. The output from the windowing (subarea extraction) process is a CSV file that includes all through, to, and from trips that pass through the study area border/cordon line, and the through flows were extracted from this analysis to be incorporated with the disaggregation outputs. A database of to, from, within and through flows was created combining the results of the disaggregation and the windowing processes.

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[7] Cambridge Systematics, "Development of a Computerized Method to Subdivide the FAF2 Regional Commodity OD Data to County Level OD Data" FHWA, January 2009.

A.3 FAF4.1 Disaggregation within MS Access

While it was noted that the complete FAF disaggregation file could not fit within a single 2 GB MS Access database, the disaggregation factions, which apply to an origin or destination, can fit with a single access database. Those disaggregation factors for county-to-county domestic flows were computed separately using the following:

- 2012 County Business patterns data, where employment that was suppressed for a county and NAICS3 was estimated based on the firms identified in that county for that NAICS3 by employment range and the number of employees that is the mode point of that range. For example, if employment was suppressed for a NAICS3 in county z, but it was reported that there are 4 firms in the employment range of 1-4 employees, then it was estimated that there are 4 firms times 2.5 employees (the mid point of that rage), or 10 employees in that NAICS3 in county z.

- 2010 county population from the US Census

- 2012 agricultural statistics for the counties, and

- 2012 coal consumption database in power plants by county.

This data was used in the TransCAD program to estimate the domestic tonnage by SCTG2 commodity that originated in, or was destined to, each FIPS county. Those estimated county tonnages were extracted from TransCAD and imported into MS Access.

The border crossing factors for imports and exports were developed from the 2012 BTS Border Crossing/Entry database. The factors for water ports by SCTG2 was developed from the USACE's Waterborne Commerce database. Prior to 2014, the flows by commodity were only reported in pdf files. Beginning in 2014, flows by commodity were reported electronically by waterway. A crosswalk was developed between the Publication Commodity Codes as reported by USACE and the SCTG2 commodities as used in the FAF. This crosswalk and the waterway information was used to develop the tons by SCTG2 that were imported and exported through each port.[8]

The MS Access database disaggregation database includes a link to the "faf41_data" table in the official FAF 4.1 MS Access database. That "faf41_data" table includes the following fields:

- **Fr_orig:** The foreign origin, if any, for the record. The foreign zones are those specified in the FAF and consist of 8 international zones, two of which are the countries of Canada and Mexico.

- **Dms_orig**: The domestic origin for the record. The domestic zones are the 132 FAF4.1 regions covering the United States. The zones as defined by FAF4.1 are:

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[8] The disaggregation factors for the Port of New York have not yet been developed. Only the consolidated flows fro the Port of New York and New Jersey were reported. It may yet be possible to report the tons imported and exported for some of the Ports that were previously reported in summary form and used in the TransCAD scripts (for example for each SCTG2, one new factor for the combination of Red Hook and Gowanus Creek; one new factor for the combination of Port Newark and Port Elizabeth; one factor for Howland Hook, etc.) These disaggregation factors would only be necessary to disaggregate import and exports by water through the NJ New York City (NJ Part) and NY New York (NY Part). This disaggregation is not needed for North Carolina disaggregations, and those factors were not developed at this time.

- 79 metropolitan regions, which the US Departments of Transportation (USDOT) and Commerce (USDOC) consider to be significant generators of national freight, where the metropolitan areas may include multiple states (for example, the New Jersey, New York and Connecticut portions of the New York City CSA are all separate FAF regions);

- The balance of those 37 states which are outside of those metropolitan areas (the Rhode Island portion of the Boston CSA covers the entire state of Rhode Island and there is no balance of that state); and

- 13 states without large metropolitan areas (the District of Columbia is a "state" portion of Washington DC metropolitan area).

- **Dms_dest**: The domestic destination for the record. The domestic zones are the same as described and defined under "Dms_orig" above.

- **Fr_dest:** The foreign destination, if any, for that record. The foreign zones are the same as those described above under "Fr_orig".

- **Sctg:** The commodity being reported in that record according the Standard Classification of Transported Goods (SCTG). This is reported at a two-digit level.

- **Dms_mode:** The mode used for domestic transportation according to the coding convention in FAF4.1. The coding conventions for mode in FAF4.1 are listed in Table 1.

- **Trade_Type:** The type of movement of that record as: 1- Domestic Only; 2- Import or 3- Export. This information should be consistent with the foreign origins and destinations of that record.

Table A.1   FAF4.1 Modes

FAF4.1 Mode Code	FAF4.1 Mode Name
1	Truck
2	Rail
3	Water
4	Air (include truck-air)
5	Multiple modes & mail *
6	Pipeline
7	Other and unknown

Note: * This replaces the truck-rail (i.e., intermodal rail) mode used in FAF2. It also includes commodities reported as mail and water-rail or water-truck multiple mode movements.

- **TonsXX:** The flow in annual kilotons for that record in the year 20XX. These years include the surveyed flow in 2012, provisional flows fro 2013 and 2014 and forecast flows for 2015, 2020, 2025, 2030, 2035, 2040 and 2045.

- **ValueXX:** The value in annual millions of $2012 in the year 20XX. The same years as above for tons are included for value.

The MS Access disaggregation database queries will:

- Create the crosswalk table for Non-North Carolina zones,

- Extract and create tables of the North Carolina records from the FAF4.1. It is these tables that will be used by the disaggregation queries, and

- Create a table of disaggregated records for the study area.

If there are any border crossings or water ports within the study area, the flows are reported for those facilities. In North Carolina, there are two water ports and no border crossings. This will disaggregate all imports and exports by water. It does not identify the specific facilities that are used by other import or export modes. Typically there is only one freight airport per FAF region and those flows would thus not need to be disaggregated. A disaggregation of air imports and exports was necessary for the "Rest of NC" FAF Zone 379, and the BTS TranStats Database T-100 Market air cargo data for each North Carolina airport was used to disaggregate the FAF air cargo data.

The format of the study area disaggregated table is as follows:

- **Fr_orig:** The foreign origin, if any, for the record. The foreign zones are those specified in the FAF and consist of 8 international zones, two of which are the countries of Canada and Mexico.

- **Dms_orig**: The domestic origin for the record. These will be a county FIPS (YYXXX, where YY is the FIPS code for state and XXX is the FIPS code fro a county in that state) within the study area; border crossings in the study area (1XXX); water ports in the study area (2XXX) and the original FAF region number outside of the study area.

- **Dms_dest**: The domestic destination for the record. The domestic zones are the same as described and defined under "Dms_orig" above.

- **Fr_dest:** The foreign destination, if any, for that record. The foreign zones are the same as those described above under "Fr_orig".

- **Sctg:** The commodity being reported in that record according the Standard Classification of Transported Goods (SCTG). This is reported at a two-digit level.

- **Dms_mode:** The mode used for domestic transportation according to the coding convention in FAF4.1.

- **Trade_Type:** The type of movement of that record as: 1- Domestic Only; 2- Import; or 3-Export. This information should be consistent with the foreign origins and destinations of that record.

- **Tons12:** The flow in annual kilotons for that record in the year 2012.

- **Tons45:** The flow in annual kilotons for that record in the year 2045

- **Value12:** The value in annual millions of $2012 in the year 2012.

- **Value45:** The value in annual millions of $2012 in the year 2045.

Appendix B.   STB Rail Waybill Forecasting Methodology

The FAF4 database contains flows for rail only as well as multiple modes and mail. While rail only mode flows were considered to represent carload rail service type goods movements, multiple modes and mail mode flows were considered to represent intermodal rail service type goods movements, although it can also include other modal combinations. Hence, growth factors in FAF4 for these modes were applied on the 2014 Carload Waybill data to forecast carload and intermodal rail commodity flow tonnages. Growth factors were developed by origin, destination, 2-digit SCTG commodity type, and rail service type. The FAF4 database has a lower geographical resolution (or larger zones) than Carload Waybill data, hence a lookup table for geography was used. The growth factors were applied to the base year (2014) rail traffic Origin-Destination (OD) matrix to prepare a forecast year (2045) rail traffic OD matrix.

B.1   Adjustments to FAF4 based Forecasts

The compounded annualized growth rates (CAGRs) between 2014 and 2045 provided by the FAF4 database for a few commodities were overridden by Cambridge Systematics. The following set of adjustments were made:

1. Growth was adjusted to national commodity type and rail service type only based CAGR for 100 percent of tons of Motorized and Other Vehicles (including parts) and Paper or Paperboard Articles by carload rail service, and 100 percent of tons of Alcoholic Beverages and Denatured Alcohol and Waste and Scrap by intermodal rail service. As a result, the overall CAGR for Motorized and Other Vehicles (including parts), Paper or Paperboard Articles and Waste and Scrap remained almost unchanged, and the overall CAGR for Alcoholic Beverages and Denatured Alcohol changed from 3.6 percent to 3.5 percent.

2. Growth is adjusted to origin, destination, commodity type and rail service type based CAGR for 100 percent of tons of Pharmaceutical Products and Animal Feed and Products of Animal Origin, n.e.c. by intermodal rail service. As a result, the overall CAGR for Pharmaceutical Products changed from 3.7 percent to 3.0 percent, and the overall CAGR for Animal Feed and Products of Animal Origin, n.e.c. remained almost unchanged.

3. Growth is flatlined or CAGR is assumed as zero for 100 percent of tons of Non-Metallic Minerals, n.e.c., Coal and Petroleum Products, n.e.c. and Transportation Equipment, n.e.c. by carload rail service, and 100 percent of tons of Coal and Petroleum Products, n.e.c. and Transportation Equipment, n.e.c. by intermodal rail service. The overall CAGRs for Non-Metallic Minerals, n.e.c., Coal and Petroleum Products, n.e.c. and Transportation Equipment, n.e.c. prior to this adjustment were 1.3 percent, 1.5 percent and 2.9 percent.

Also, as a result, the overall CAGR for all commodities decreased from 0.93 percent to 0.88 percent. The CAGR for carload rail service decreased from 0.81 percent to 0.75 percent, while the CAGR for intermodal rail service decreased from 1.84 percent to 1.79 percent.

B.2   Forecasting Results and Preparation of 2045 OD Matrix

The CAGRs between 2014 and 2045 by commodity type and rail service type after adjustment of the FAF4 based forecasts are summarized in Table B.1. Among carload rail service type commodities, coal is

expected to decline by 35 percent, while basic chemicals are expected to make the largest contribution to tonnage growth. Among intermodal rail service type commodities, mixed freight are expected to be the highest contributors to rail tonnage growth.

The growth factors were applied to the base year (2014) rail traffic OD matrix to prepare a forecast year (2045) rail traffic OD matrix.

Table B.1   North Carolina's 2045 Rail Flows and 2014-2045 Growth Factors by 2-Digit SCTG Commodity Type and Rail Service Type

2-Digit SCTG Commodity Type	2045 Carload Rail Flows (in thousand tons)	Carload Rail Flows CAGR in Tons, 2014-2045	2045 Intermodal Rail Flows (in thousand tons)	Intermodal Rail Flows CAGR in Tons, 2014-2045	2045 Total Rail Flows (in thousand tons)	Total Rail Flows CAGR in Tons, 2014-2045
02: Cereal Grains (including seed)	6,609	0.5%	0.3	1.4%	6,609	0.5%
03: Other Agricultural Products, except for Animal Feed	2,239	1.7%	47	2.5%	2,286	1.8%
04: Animal Feed and Products of Animal Origin, n.e.c.	4,366	2.3%	75	1.1%	4,441	2.2%
05: Meat, Fish, and Seafood, and Their Preparations	28	2.0%	7	2.9%	36	2.2%
06: Milled Grain Products and Preparations, and Bakery Products	1,244	1.8%	43	2.0%	1,287	1.8%
07: Other Prepared Foodstuffs, and Fats and Oils	4,409	2.1%	453	2.0%	4,862	2.1%
08: Alcoholic Beverages and Denatured Alcohol	4,752	3.6%	269	2.0%	5,020	3.5%
10: Monumental or Building Stone	49	2.9%	0	N/A	49	2.9%
11: Natural Sands	699	1.1%	0	N/A	699	1.1%
12: Gravel and Crushed Stone	5,643	0.4%	0	N/A	5,643	0.4%
13: Non-Metallic Minerals, n.e.c.	1,944	0.0%	32	1.1%	1,976	0.0%
14: Metallic Ores and Concentrates	119	0.3%	0.4	-0.3%	120	0.3%
15: Coal	18,062	-1.4%	0	N/A	18,062	-1.4%
17: Gasoline and Aviation Turbine Fuel	157	2.2%	1	2.0%	158	2.2%
18: Fuel Oils	30	-0.5%	0	N/A	30	-0.5%
19: Coal and Petroleum Products, n.e.c.	944	0.0%	2	0.0%	946	0.0%
20: Basic Chemicals	8,338	1.9%	125	3.2%	8,464	1.9%
21: Pharmaceutical Products	0	N/A	137	3.0%	137	3.0%
22: Fertilizers	3,342	1.0%	0	N/A	3,342	1.0%
23: Chemical Products and Preparations, n.e.c.	1,641	2.6%	336	3.0%	1,976	2.7%
24: Plastics and Rubber	6,072	2.6%	463	2.1%	6,535	2.6%
25: Logs and Other Wood in the Rough	250	2.5%	4	3.0%	254	2.5%
26: Wood Products	7,134	1.9%	148	0.9%	7,282	1.9%

2-Digit SCTG Commodity Type	2045 Carload Rail Flows (in thousand tons)	Carload Rail Flows CAGR in Tons, 2014-2045	2045 Intermodal Rail Flows (in thousand tons)	Intermodal Rail Flows CAGR in Tons, 2014-2045	2045 Total Rail Flows (in thousand tons)	Total Rail Flows CAGR in Tons, 2014-2045
27: Pulp, Newsprint, Paper, and Paperboard	5,468	1.3%	102	0.9%	5,570	1.3%
28: Paper or Paperboard Articles	7	1.3%	498	1.6%	505	1.6%
29: Printed Products	0	N/A	7	-0.3%	7	-0.3%
30: Textiles, Leather, and Articles of Textiles or Leather	0	N/A	323	2.1%	323	2.1%
31: Non-Metallic Mineral Products	4,208	1.5%	48	2.3%	4,255	1.5%
32: Base Metal in Primary or Semi-Finished Forms and in Finished Basic Shapes	3,605	1.4%	44	1.2%	3,649	1.4%
33: Articles of Base Metal	66	2.0%	134	2.1%	200	2.1%
34: Machinery	182	4.0%	125	3.6%	307	3.8%
35: Electronic and Other Electrical Equipment and Components, and Office Equipment	242	4.4%	37	4.1%	279	4.4%
36: Motorized and Other Vehicles (including parts)	604	2.2%	83	1.5%	687	2.1%
37: Transportation Equipment, n.e.c.	103	0.0%	5	0.0%	109	0.0%
38: Precision Instruments and Apparatus	0	N/A	69	5.7%	69	5.7%
39: Furniture, Mattresses and Mattress Supports, Lamps, Lighting Fittings, and Illuminated Signs	0	N/A	336	3.7%	336	3.7%
40: Miscellaneous Manufactured Products	19	1.8%	170	2.1%	189	2.0%
41: Waste and Scrap	3,515	1.6%	154	2.3%	3,670	1.6%
43: Mixed Freight	37	1.2%	11,152	1.7%	11,189	1.7%
All Commodities	**96,126**	**0.8%**	**15,431**	**1.8%**	**111,557**	**0.9%**

Source: 2014 Confidential Carload Waybill Sample for North Carolina; Freight Analysis Framework version 4 (FAF4) Database; and Cambridge Systematics' Analysis.