VERMONT
AGENCY OF TRANSPORTATION

VERMONT FREIGHT & RAIL PLANS

FINAL COMMODITY FLOW & ECONOMIC FUTURES

SUBMITTED BY
CAMBRIDGE SYSTEMATICS
VANASSE HANGEN BRUSTLIN, INC.
FITZGERALD & HALLIDAY INC.

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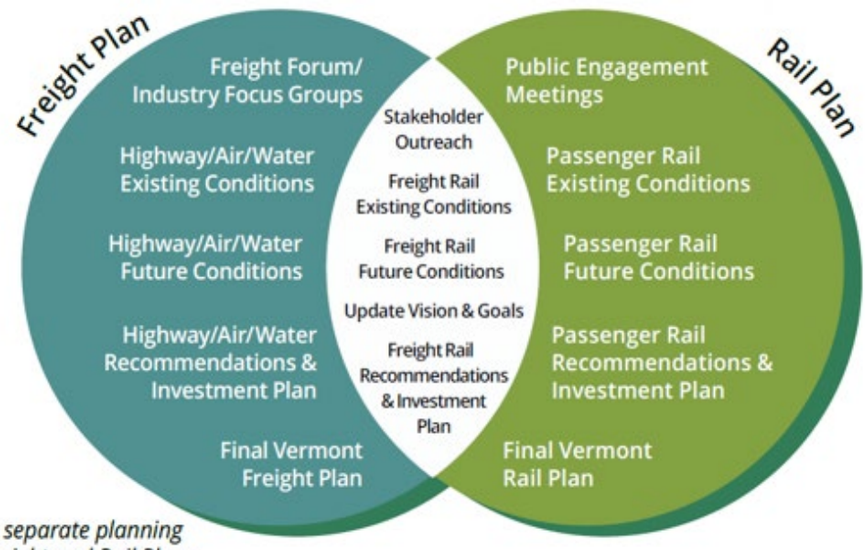
AADT	Annual Average Daily Traffic
AADTT	Annual Average Daily Truck Traffic
AAR	Association of American Railroads
AM	Additive manufacturing
AOT (VTrans)	Vermont Agency of Transportation
BLS	Bureau of Labor Statistics
BTS	Bureau of Transportation Statistics
CDL	Commercial driver licenses
CFS	Commodity Flow Survey
CLP	Clarendon & Pittsford Railroad
CN	Canadian Pacific
CMQ	Central Maine & Quebec Railway
COVID-19	Coronavirus Disease 2019
CP	Canadian Pacific
CUD	Communications Union Districts
FAF	Freight Analysis Framework
FAST	Fixing America's Surface Transportation Act
FHWA	Federal Highway Administration
FSAC	Freight Station Accounting Codes
FRA	Federal Railroad Administration
FTA	Free-trade agreement
GDP	Gross domestic product
GMRC	Green Mountain Railroad
LTL	Less-than-truckload
NAICS	North American Industry Classification System
NECR	New England Central Railroad
NHS	National Highway System
PAR	Pan Am Railways
PAS	Pan Am Southern
POE	Port of Entry
PRIIA	Passenger Rail Investment and Improvement Act
PST	Professional, Scientific, and Technical Services
PTC	Positive Train Control
SCTG	Standard Classification of Transported Goods
SLR	St. Lawrence & Atlantic
STCC	Standard Transportation Commodity Code
STB	Surface Transportation Board
TTTR	Truck Travel Time Reliability
VRS	Vermont Rail System
VTR	Vermont Railway

1.0 INTRODUCTION

In April 2020, the Vermont Agency of Transportation (AOT or VTrans) contracted with Cambridge Systematics to update its State Rail Plan (2015) and State Freight Plan (2012 with a 2017 update) to meet with Federal regulations under the Passenger Rail Investment and Improvement Act (PRIIA) and Fixing America's Surface Transportation (FAST) Act. Although two separate documents, there is a significant amount of overlap between the two efforts, as shown in Figure 1.1.

FIGURE 1.1 VERMONT FREIGHT AND RAIL PLAN ELEMENTS



Source: Cambridge Systematics, 2020.

The State Rail Plan provides a framework for maintaining and enhancing the state rail system. It is important to note that the State Rail Plan focuses on rail freight and intercity passenger service provided by Amtrak. Commuter rail is a form of public transit that is addressed as part of public transit plans.[1]

The State Freight Plan provides a framework for maintaining and enhancing all modes of freight movement in Vermont—rail, highway, air, and water.

This Technical Memo is the second of five which will provide the background material and information necessary to complete the final State Rail Plan and State Freight Plan:

- Technical Memo 1 – Data Collection and Existing Conditions.
- Technical Memo 2 – Commodity Flow and Economic Futures.
- Technical Memo 3 – Vision, Goals, Needs and Potential Initiatives.
- Technical Memo 4 – Passenger Rail Elements (passenger rail forecasting).
- Technical Memo 5 – Prioritization, Recommendations, and Impact
- Final Vermont Rail Plan and Vermont Freight Plan

In addition, extensive public outreach will inform development of both plans and will meet Federal Railroad Admininstration (FRA) requirements for the Vermont Rail Plan.

The remainder of this Technical Memo contains the following Sections:

[1] https://vtrans.vermont.gov/planning/PTPP

- Section 2 – Commodity flows including current and projected, and for all modes as well as a specific look at rail flows.
- Section 3 – Related socio-economic factors in Vermont.
- Section 4 – Highway futures analysis.
- Section 5 – Air futures analysis.
- Section 6 – Global and national key freight trends that may impact goods movement in Vermont.
- Appendix A – Commodity Flow data processing steps

The next Technical Memo will focus on defining the vision and goals of Vermont's rail system as well as identifying needs and gaps between existing and desired conditions and developing a full list of potential initiatives (projects, program or policy changes, studies, etc.) drawn from stakeholder input, analysis conducted in prior Tech Memos (including this one), and other studies such as the prior Rail Plan.

2.0 COMMODITY FLOWS

This section provides an analysis of current and future freight movements that touch on Vermont. The basis for this information is the Freight Analysis Framework (FAF4) dataset provided by the Federal Highway Administration (FHWA). Substituting rail traffic provided in FAF4 was data from the 2018 Surface Transportation Board's (STB) Confidential Carload Waybill Sample. For more information on processing steps, see Appendix A.

The FAF is the most commonly used source to examine current and projected freight flows across all major modes in statewide freight planning efforts. Its success comes from its comprehensive multi-modal coverage, inclusion of a forecast, relative consistent methodology, ready availability, along with Federal sponsorship. Although broadly used, FAF suffers from significant weaknesses, most notably its lack of granularity in geogpraphy and commodity classification, the rather sparse sample size of the Commodity Flow Survey (CFS) that underlies the database, a heavy reliance on modeling to estimate many freight flows, and timeliness.

The CFS that underlies FAF reports shipment characteristics from a sample of business establishments across the country, which is then combined with economic and other data and modeled to reflect the overall volumes of freight flows nationally. FAF4, the latest version currently available, was developed from the 2012 CFS. Release of FAF5, based upon the 2017 CFS, is expected in 2021.

Using the 2012 CFS as a foundation, FAF4 offers a continuous annual time series through the present, including the 2018 base year used for this Rail Plan. Data for historical years are estimated using economic growth rates by industry sector, associated to commodities that are made or used by each sector. As such, apart from FAF4's 2012 base year, data for subsequent historical years are synthetic, meaning that they are modeled, not observed.

The FAF4 database incorporates economic growth projections for future years based on a 2016 IHS Markit forecast. These growth forecasts are in excess of the growth rates most economists would use today, after observing growth trends in U.S. output in recent years and the potential for the economic effects of the COVID-19 pandemic to linger through the early 2020s. In addition, short-term robust growth in rail freight from a small number of Vermont shippers who contribute a large proportion of Vermont rail freight traffic, and whose traffic patterns are likely more irregular than consistent, appears to have influenced long-term rail freight forecasted growth rates. As Figure 2.1 shows, the estimated rate of growth in freight tonnage originating and/or terminating in Vermont between 2012 and 2018 is 0.65 percent per year, compounded, while the projected compounded annual growth rate through 2045 is 1.95 percent. The FAF4 forecasted commodity flows shown in this memorandum, therefore, are likely to show more growth in freight tonnage and value than a forecast developed today. This memo should be considered to represent a very bullish, or upper-bound scenario.

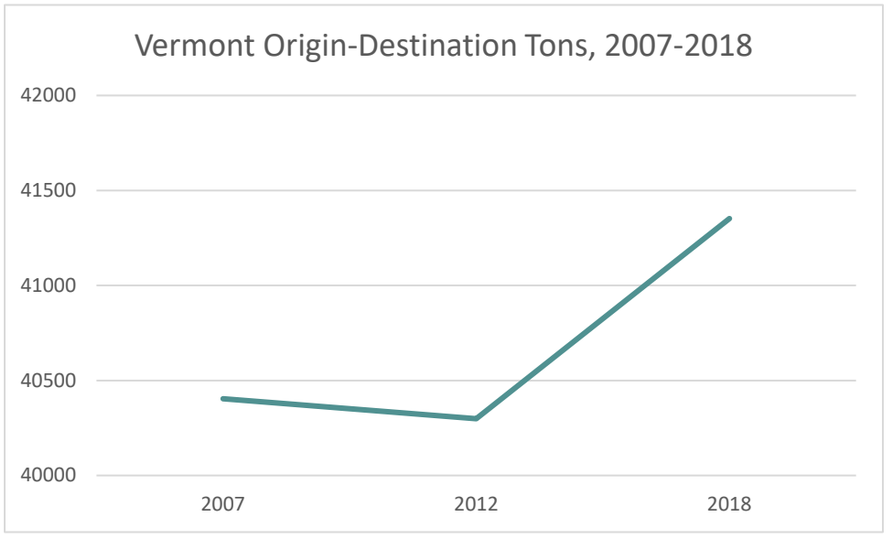
The 2012 Vermont Freight Plan utilized freight flow data from Transearch, a commercial product marketed by IHS Markit. Transearch, updated annually, draws on the CFS along with a broad range of additional data sources to model a far more detailed representation of freight flows than is available through the FAF. FAF uses a different commodity classification system and different modal definitions. There is also a difference in definition of trips recorded in the origin-destination matrix. In Transearch, each link of a multi-leg journey is a discrete trip. For example, a shipment moving from California to Rutland by rail and then from Rutland to Montpelier by truck would be recorded twice in the transearch database—a rail move from California to Rutland and a truck move from Rutland to Montpelier. FAF recognizes that the two segments are linked, and would report this flow as a trip from California to Montpelier by "multiple modes."

The transition from Transearch to FAF also affects analysis of through flows—flows moving through the State of Vermont between origin and destination points outside the state. Whereas the Transearch package licensed for the 2012 Vermont Freight Plan included county-level detail in Vermont and surrounding states, FAF geographic units are much larger. Because FAF does not include estimates of through traffic, such estimations must be achieved by performing analysis of FAF commodity flows assigned to a modal network. Large geographic zones, therefore, can result in assignments of some traffic around, rather than through, Vermont. While supplemental rail waybill data from the Surface Transportation Board can help to pinpoint

rail origins and destinations, the loss of geographic specificity in FAF potentially leads to an under-counting of through flows moving by truck.[2]

These differing features between the two source datasets present practical issues that prevent a meaningful comparative analysis of the two datasets. Instead, a comparison of the basic statistics from previous versions of the FAF database, including FAF3, with a 2007 base year, the 2012 base year of FAF4, and the projected 2018 FAF4 data used as the primary source of commodity flow information for the 2021 Vermont Freight Plan and Vermont Rail Plan, has been prepared and is presented below. According to FAF estimates for 2007, 2012, and 2018, commodity tonnage with an origin and/or a destination in the State of Vermont declined by approximately 0.3 percent between 2007 and 2012. Due to the effects of the 2008-2009 Recession and recovery, this finding is not unrealistic. Between 2012 and 2018, FAF estimates approximately 3 percent increase in freight tons originating and/or terminating in Vermont. This growth is approximately 0.65 percent compounded annually. As shown later in this memorandum, FAF anticipates 1.95 percent growth annually between 2018 and 2045, which is substantially greater growth than recent historic trends show.

FIGURE 2.1 VERMONT ORIGIN-DESTINATION TONS, 2007-2018, ACCORDING TO FAF FORECAST

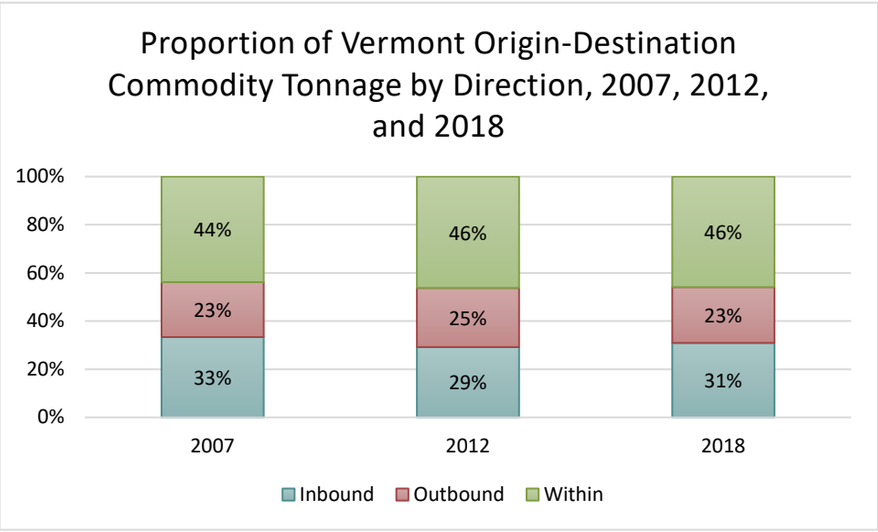


Source: FAF

The distribution of projected freight tons by direction of movement (inbound, outbound, and within Vermont) and the distribution of projected freight tons by transportation mode are fairly consistent between the three historic analysis years, as Figures 2.2 and 2.3 show. As shown later in this memorandum, the FAF forecast anticipates an increase in the relative share of tons moved by rail by 2045, due to very aggressive projected growth rates for rail freight. Because the base year volume of rail freight moved in Vermont is small relative to other modes, it is influenced by short-term fluctuations in volume. A single shipper increasing (or decreasing) its volume of railcars shipped or received can result in a large percentage increase (or decrease) in traffic over historic years. This observation in recent years in Vermont, along with the economic outlook discussed previously, appears to have contributed to a very high rate of increase – and likely unrealistic - in projected rail freight volume through 2045.

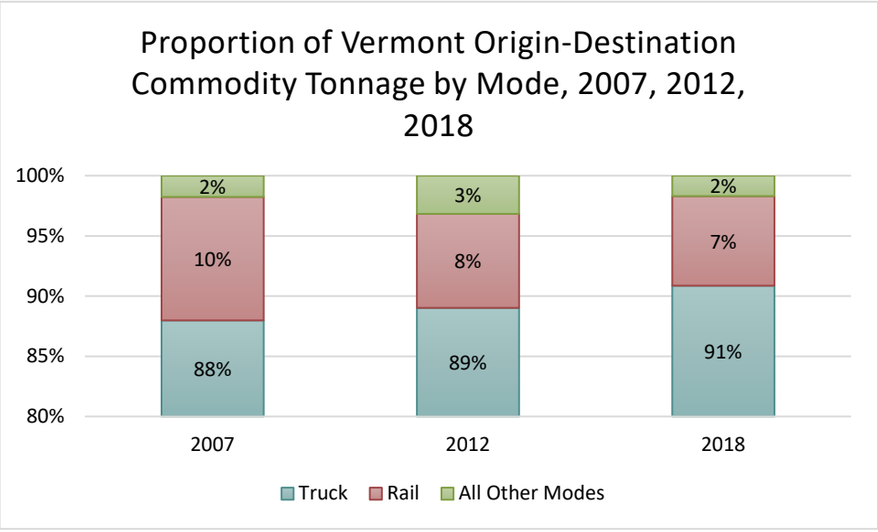
[2] More information about the FAF4 methodology can be found in the FAF4 Users' Guide, available from: https://faf.ornl.gov/fafweb/data/FAF4%20User%20Guide.pdf

FIGURE 2.2 PROPORTION OF VERMONT ORIGIN-DESTINATION COMMODITY TONNAGE BY DIRECTION, 2007, 2012, AND 2018



Source: FAF

FIGURE 2.3 PROPORTION OF VERMONT ORIGIN-DESTINATION COMMODITY TONNAGE BY MODE, 2007, 2012, AND 2018



Source: FAF

2.1 Overview – All Modes Current

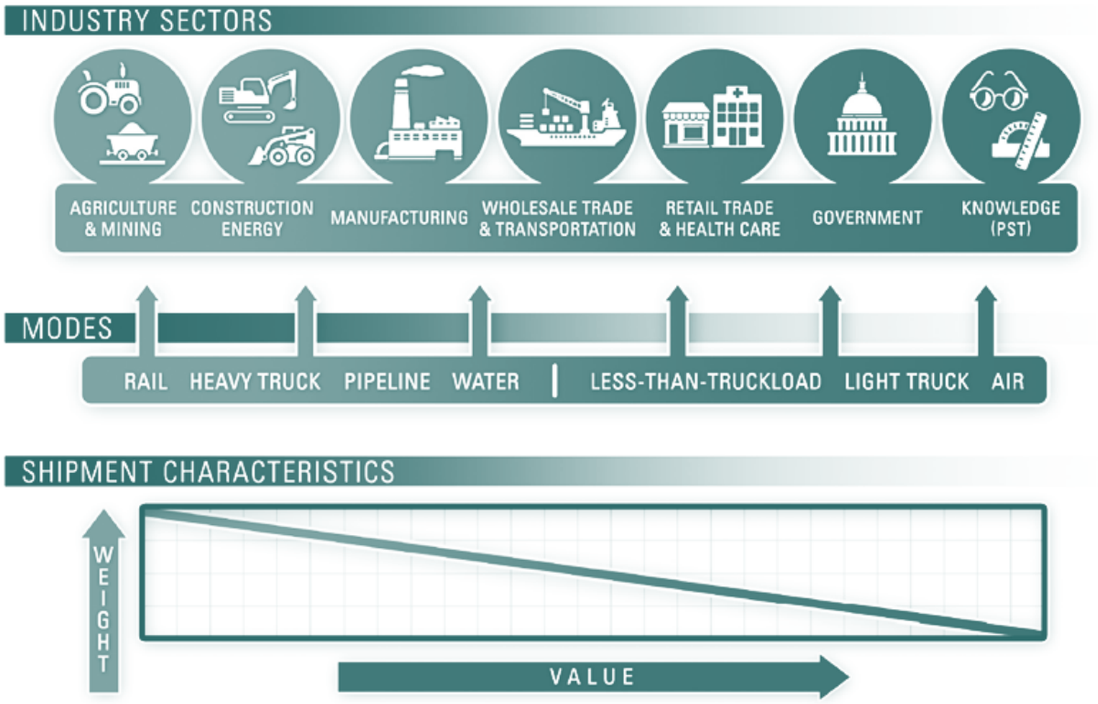
An examination of freight flows by mode provides an important snapshot into the characteristics of Vermont's multi-modal freight system. Mode splits are identified by both tonnage and value for 2018 and 2045 for flows moving by truck, rail, water, air (including first-mile and last-mile moves of air cargo by truck), multiple modes and mail (Shipments reported as Multiple Modes can include anything from containerized cargo to coal moving from mine to railhead by truck and rail to harbor. The "Mail" component recognizes that shippers who use parcel delivery services typically do not know what modes were involved after the shipment was picked up).[3]

Figure 2.4 shows the relationship between mode and a number of industry sectors. Though not set in stone, industries such as agriculture and mining, construction, energy, and manufacturing tend to rely more on rail

[3] "Freight Analysis Framework Version 4: User's Guide for Release 4.0," U.S. Department of Transportation, 2015, available from: https://faf.ornl.gov/fafweb/data/FAF4%20User%20Guide.pdf.

and heavy truck to move bulky, lower value goods. Air, parcel delivery, and less-than-truckload (LTL) shipments tend to carry higher value goods for industries such as retail, health care, and scientific or professional services clients.

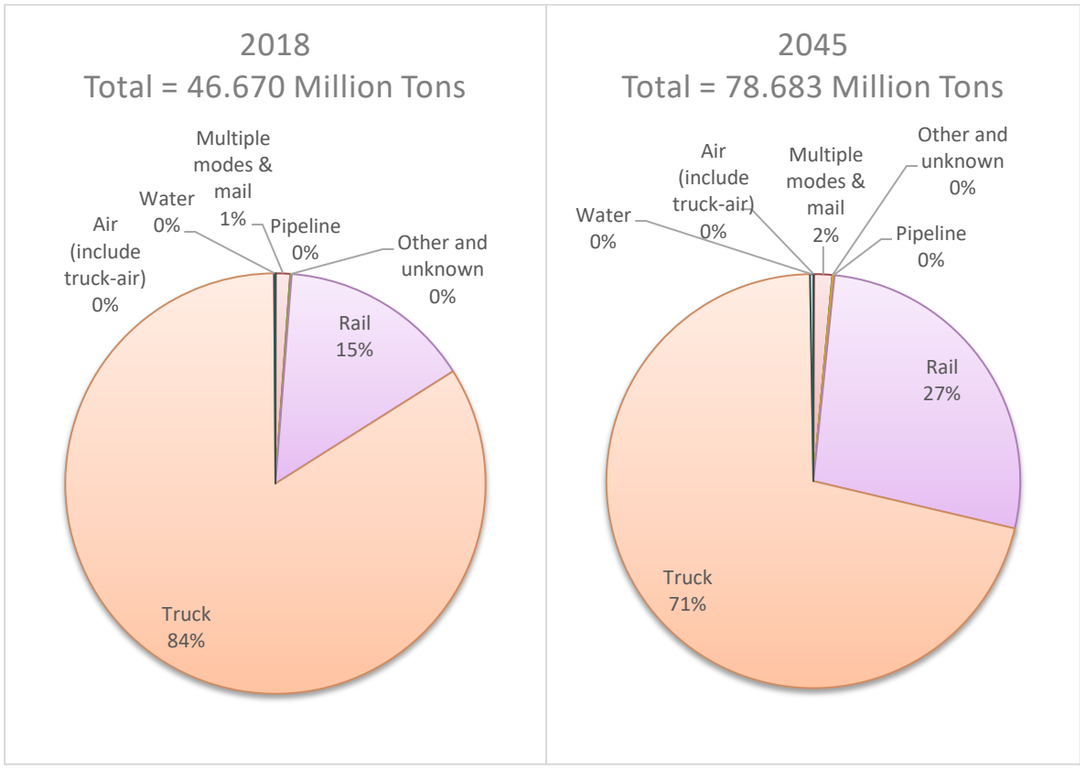
FIGURE 2.4 COMMON FREIGHT MODES BY INDUSTRY SECTOR



Note: PST includes the professional, scientific, and technical services industry sectors.

As shown in Figure 2.5, the total tonnage transported within Vermont in 2018 was 46.67 million tons. The vast majority of this tonnage was transported by trucks (84 percent), followed by rail (15 percent). All remaining modes contributed neglibily to total tonnage. Through 2045, the key shift in mode split comes through an increase in the market share of railroad to 27 percent, over a quarter of all tonnage. As such, trucks are expected to carry 71 percent of all tonnage. In terms of total tonnage across all modes, a 68 percent increase is also expected through 2045 from just under 47 million tons to over 78 million tons. As such, all modes are expected to see an increase tonnage, including those contributing negligbly to total tonnage.

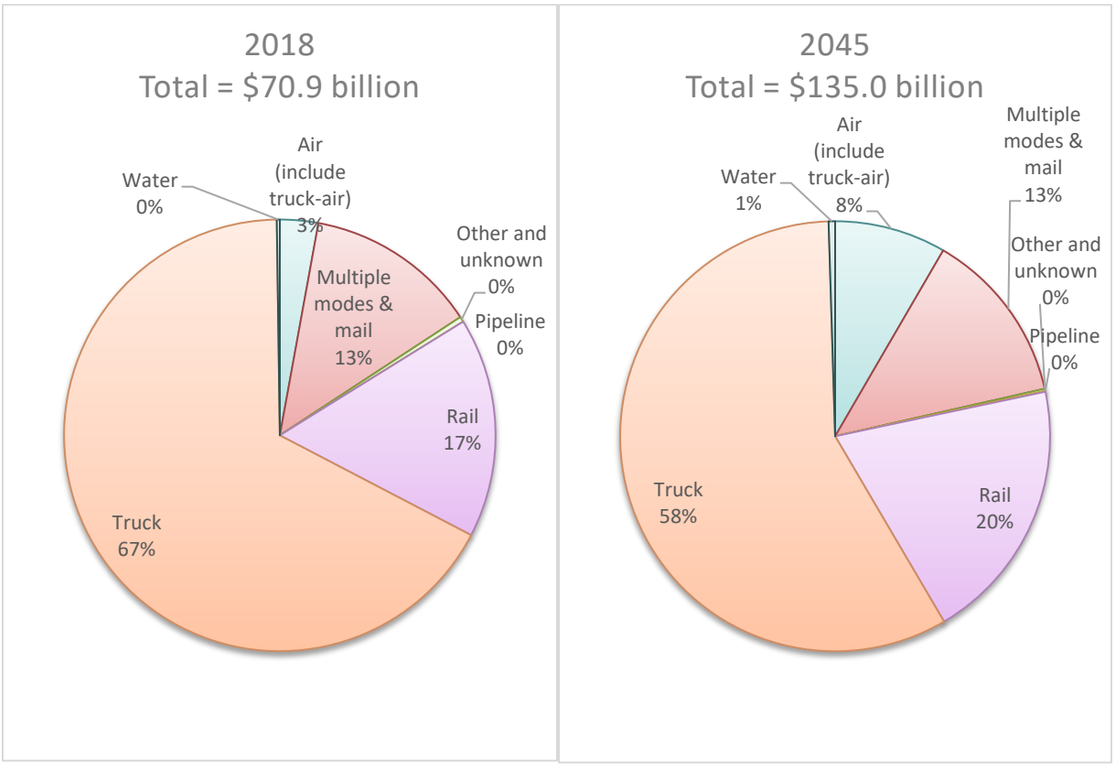
FIGURE 2.5 VERMONT MODE SPLIT BY TONNAGE (2018 AND 2045)



Source: FAF, STB Confidential Waybill Sample; Analysis by Cambridge Systematics, 2020.

Analyzing freight flows by dollar value, as opposed to tonnage, produces somewhat similar results. As shown in Figure 2.6, the total value of tonnage transported within Vermont in 2018 was approximately $70.9 billion. While trucks still account for a majority (67 percent in 2018), multiple modes and mail (13 percent) and air (three percent) provide a more sizable contribution. At 17 percent, rail value comprised a similar amount to that of tonnage. Through 2045, the most significant changes in market share of total value appear to be related to truck and air modes. While truck is expected to decline by 9 percent to under 60 percent, the air share is expected to more than double to eight percent. A sizable increase is also expected for rail (+3 percent from 17 percent to 20 percent), while multi-modal is expected to remain constant at 13 percent. Overall, an approximate doubling in total value across all modes is expected through 2045 from just under $71 billion to $135 billion. This rate of growth is close to the projected growth in value of goods moved nationally. As such, all modes are expected to see an increase in value, including those contributing neglibly to total value.

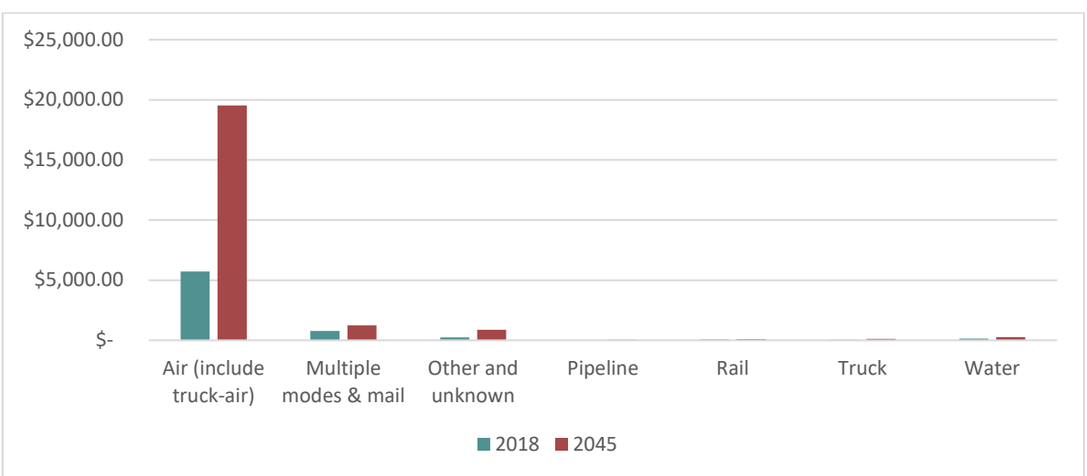
FIGURE 2.6 VERMONT MODE SPLIT BY VALUE (2018 AND 2045)



Source: FAF, STB Confidential Waybill Sample; Analysis by Cambridge Systematics, 2020.

As the above figures indicate, there are some notable disparities between tonnage and value market shares by mode. Figure 2.7 combines these indicators to derive value per ton across all modes. This is important given that different modes will carry different types of commodities, based on factors of speed, cost, reliability and total demand. As Figure 2.4 shows, air-transported commodities are by far the most valuable, with value per ton of at least $5,000 in 2018. Commodities such as pharmaceuticals, high value electronics, mixed freight/packages, and certain food products are commonly carried by air. These goods are are significantly lighter but also much more valuable on a per unit basis than other commodities such as aggregates and raw fuel. The second-highest mode was multiple modes and mail, at just over $1,000 per ton. Remaining modes, including truck and rail which dominate both in terms of total tonnage and value, carry significnatly lower unit value commodities, such as general merchandise, raw materials, aggregates, and timber. As expected, these trends are expected to remain in place through 2045, although increases in value per ton are expected across all modes. The most significant increase is expected for air-transported commodities with value per ton approaching $20,000, an increase in the order of magnitude of four times 2018 figures.

FIGURE 2.7 VERMONT VALUE PER TON BY MODE (2018 AND 2045)



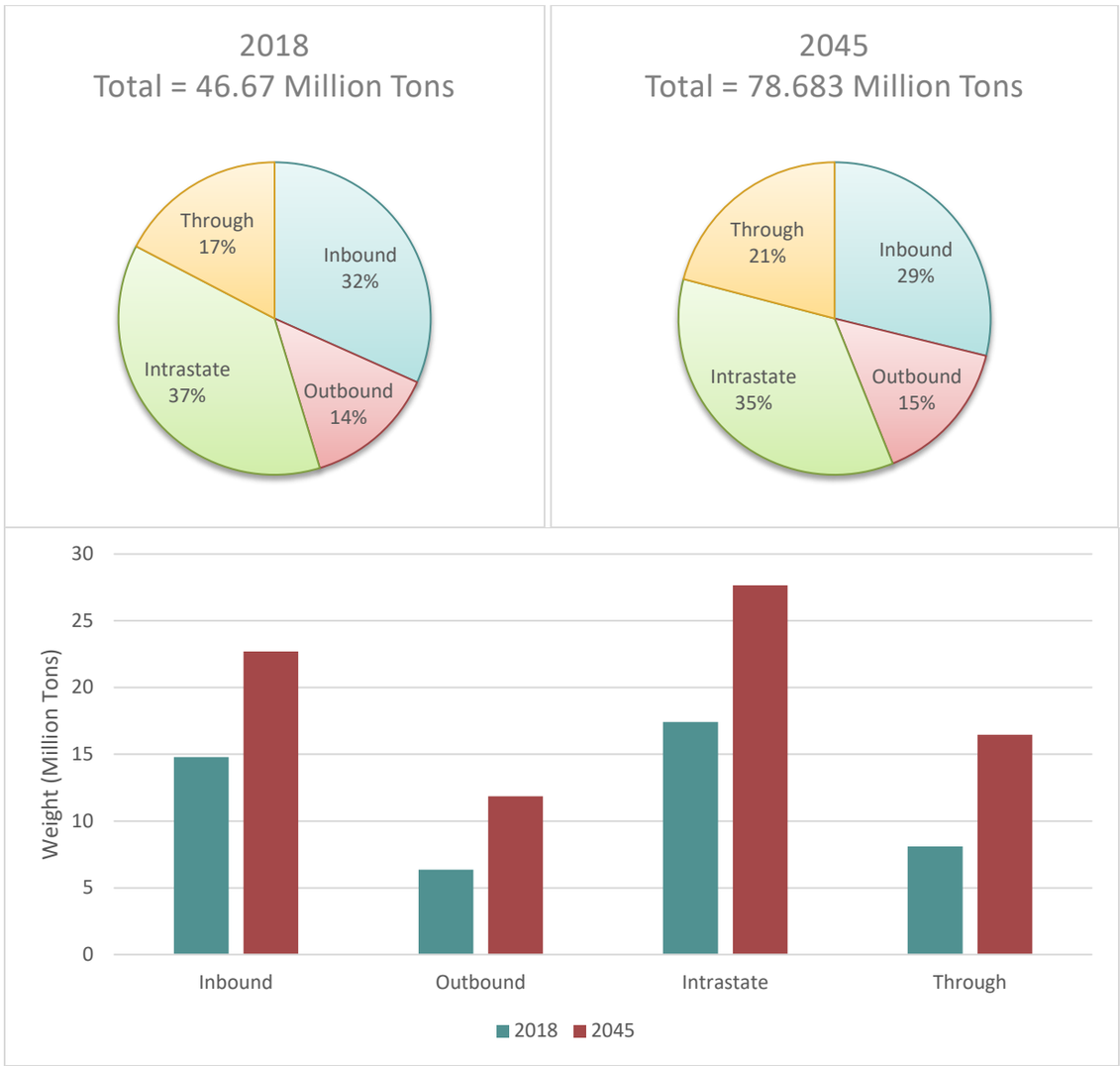
Source: FAF, STB Confidential Waybill Sample; Analysis by Cambridge Systematics, 2020.

Direction of Travel

Direction of Travel refers to the flow of freight within Vermont, based on origin and destination patterns. Based on identified FAF movement, four directions of movement are analyzed by tonnage and value: Inbound, Outbound, Intrastate (exclusively within Vermont), and Through (passing through but not originating or terminating within Vermont). This information is shown in Figure 2.5 and Figure 2.6 for both 2018 and 2045.

As Figure 2.8 shows, across all modes, intrastate travel comprises the largest proportion of freight tonnage in Vermont at 37 percent, followed by inbound freight (32 percent). In 2018, these proportions indicated tonnage levels of approximately 17 million and 15 million tons respectively. Of the additional directions of travel, through traffic comprised 17 percent of total tonnage, and outbound comprised the smallest proportion at 14 percent. Both of these directions were below 10 million tons each. Although some slight shifts in these proportions are expected through 2045, these overall trends are expected to remain intact. Between 2018 and 2045, the largest increase in proportion of total tonnage is expected for through traffic (+4 percent), followed by outbound traffic (+1 percent). On the other hand, slight decreases are expected for intrastate (-2 percent) and inbound (-3 percent) tonnage. Based on the significant increase in total tonnage to almost 80 million tons, notable increases are expected for all four directions of movement. As such, increases of between six million and 10 million tons, depending on direction, are expected.

FIGURE 2.8 VERMONT FREIGHT TONNAGE BY DIRECTION (2018 AND 2045)

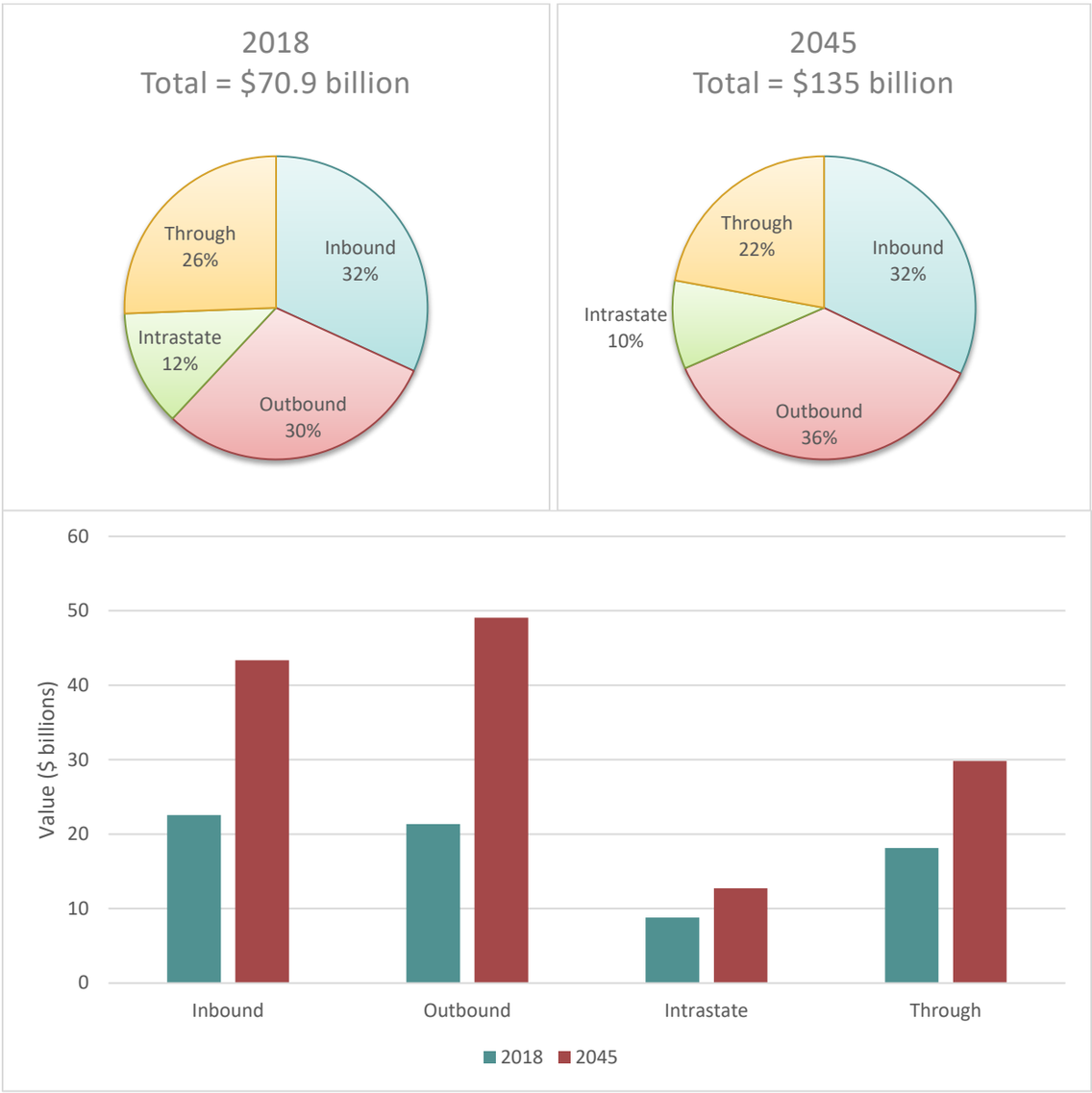


Source: FAF, STB Confidential Waybill Sample; Analysis by Cambridge Systematics, 2020.

Figure 2.9 below examines the same directions of movements based on value as opposed to tonnage. In terms of proportions of all directional movements, these results differ slightly from those of tonnage. While inbound freight still accounts for approximately one-third of all value, outbound freight also appears to account for a similar proportion, both with a 2018 value of approximately $20 billion. This is the case despite outbound freight accounting for the lowest proportion of tonnage, indicating that Vermont's exports tend

to be of lighter weight but higher value. On the other hand, intrastate commodities appear to have the opposite characteristics given a comparatively lower proportion of all value. Through 2045, these trends are largely expected to remain in place, with outbound freight actually increasing in proportion of value by six percent and intrastate freight decreasing by two percent. Based on the significant increase in total value to approximately $135 billion, notable increases are expected for all four directions of movement. As such, increases of up to approximately $28 billion, depending on direction, are expected.

FIGURE 2.9 VERMONT FREIGHT VALUE BY DIRECTION (2018 AND 2045)

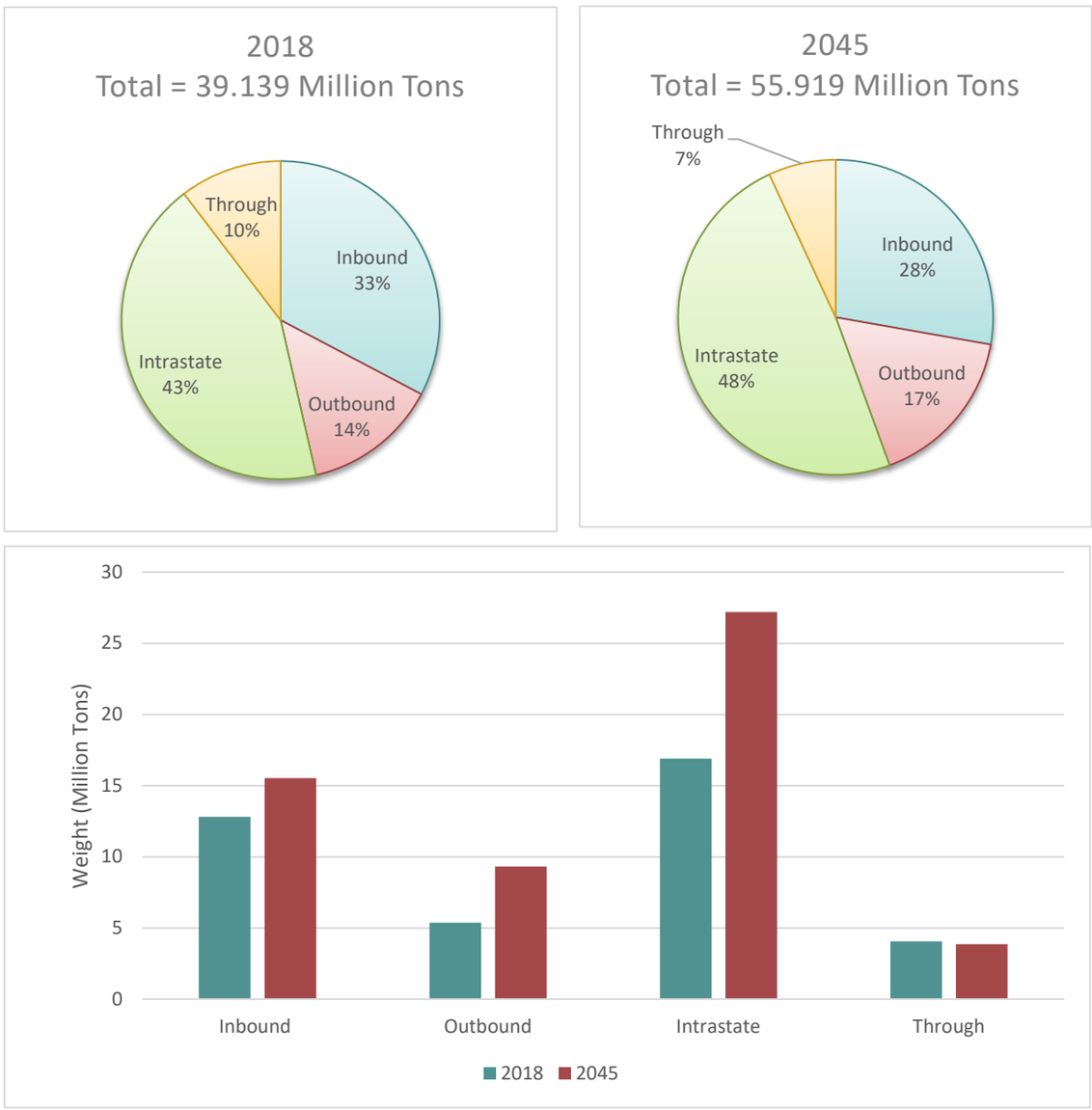


Source: FAF, STB Confidential Waybill Sample; Analysis by Cambridge Systematics, 2020.

Given the additional focus of this plan on rail in further sections, there is also merit in discussing direction of travel in relation to trucks. This is especially the case given the signfiicant proportion of freight, both in terms of value and tonnage, transported by trucks. As such, Figure 2.10 and Figure 2.11 below break out those figures, specifically for trucks. As both figures show, truck tonnage and value figures are relatively similar to those for all modes. This is expected given that truck moves comprise the majority of freight tonnage and value.

Of the approximately 39 million tons transported by truck, just over 75 percent (approximately 30 million tons) was in the form of intrastate and inbound freight in 2018. The share of inbound and intrastate flows by truck is higher than the inbound and intrastate moves by other modes, due in large part, to the relatively short distance of most inbound and intrastate trips. Rail, water, and air are typically more cost efficient for longer distances, often 400 miles or more, depending upon the commodity specifications, freight rates, and other factors. Through 2045 however, intrastate tonnage is expected to increase as a proportion of all tonnage to 48 percent (approximately 30 million tons).

FIGURE 2.10 VERMONT FREIGHT TRUCK TONNAGE BY DIRECTION (2018 AND 2045)

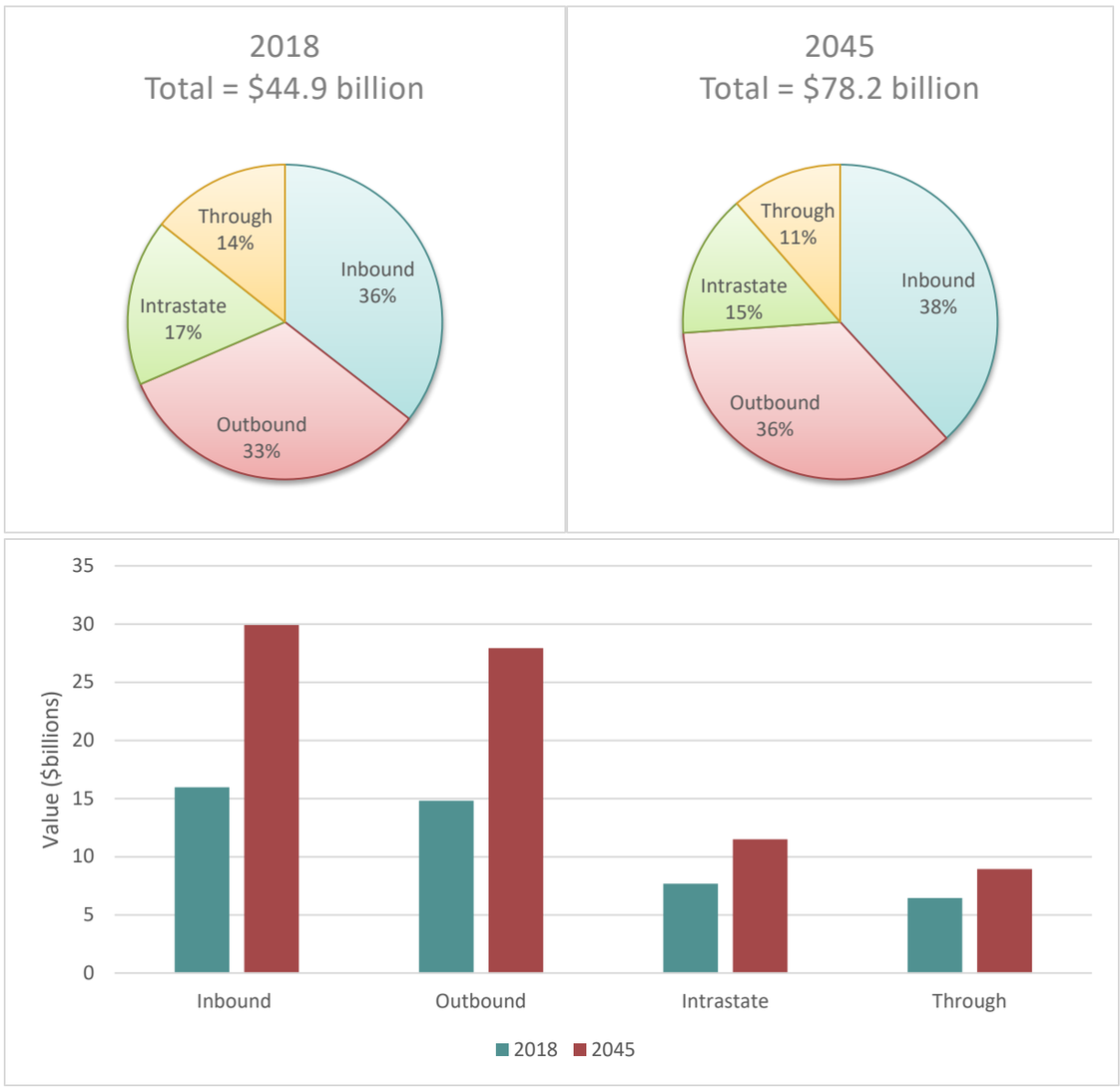


Source: FAF, STB Confidential Waybill Sample; Analysis by Cambridge Systematics, 2020.

Trucks moved approximately $45 billion worth of goods in 2018, and are expected to move $78 billion worth of goods by 2045. In terms of value, truck moves comprised approximatly $45 billion, a figure expected to rise to just over $78 billion by 2045. Trucks move a smaller proportion of through traffic than flows moving in other directions, as much of the freight passing through Vermont travels by rail. Through 2045, outbound and inbound moves are expected to comprise a larger proportion (approximately 75 percent or $58 billion) of all moves, with slight reductions in the proportion of intrastate (-2 percent) and through (-3 percent) moves.

Combined with the observed projections of truck moves by weight, this projection suggests that the highway networks that connect Vermont shippers and receivers sending intrastate shipments, and connections to out-of-state origins and destinations of inbound and outbound freight will become increasingly important over time.

FIGURE 2.11 VERMONT FREIGHT TRUCK VALUE BY DIRECTION (2018 AND 2045)



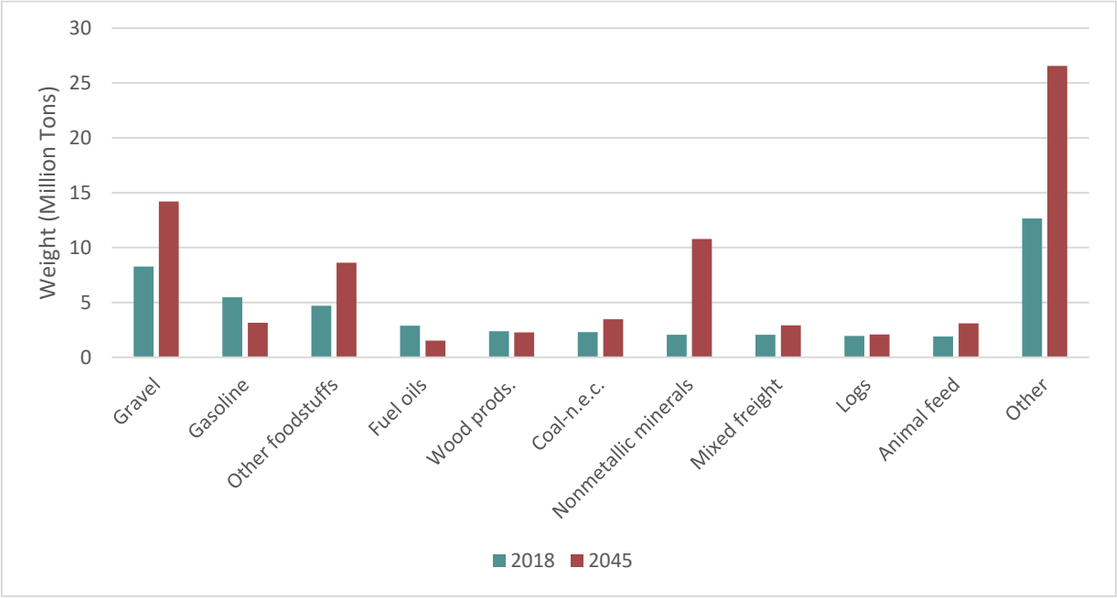
Source: FAF, STB Confidential Waybill Sample; Analysis by Cambridge Systematics, 2020.

Top Commodities

Top commodities transported in Vermont are identified using the Standard Classification of Transported Goods (SCTG) system of codes with the FAF. This information is provided by both tonnage and value within Figure 2.12 and Figure 2.13. In particular the top ten commodities for each category are identified, including expected changes in market share for these commodities from 2018 to 2045.

Based on tonnage, gravel and gasoline are among the top commodities, with 2018 annual totals of over five million tons. Additional significant commodities in terms of tonnage include "other foodstuffs" (or products of food manufacturing), fuel oils, wood, coal, and nonmetallic minerals, including marble, slate, granite, and sandstone. Between 2018 and 2045 however, multiple changes in tonnage and market share are expected among these top commodities. Gravel currently is the top commodity with nearly 15 million tons moved in 2018 and is expected to remain the top commodity through 2045. The most significant growth is expected for nonmetallic minerals, which is expected to be the second-highest transported commodity by 2045. These commodities support construction activity in Vermont and in other parts of the northeastern United States. Notable growth is also expected for other foodstuffs commodities. Declines in transported tonnage are expected for gasoline and fuel oil, consistent with projections that anticipate continued improvement vehicle fuel economy, adoption of alternative fuels, and relatively low growth in per capita vehicle miles traveled nationwide. Overall however, the majority of commodities are expected to see tonnage growth, as is denoted by the significant growth for 'Other' commodities.

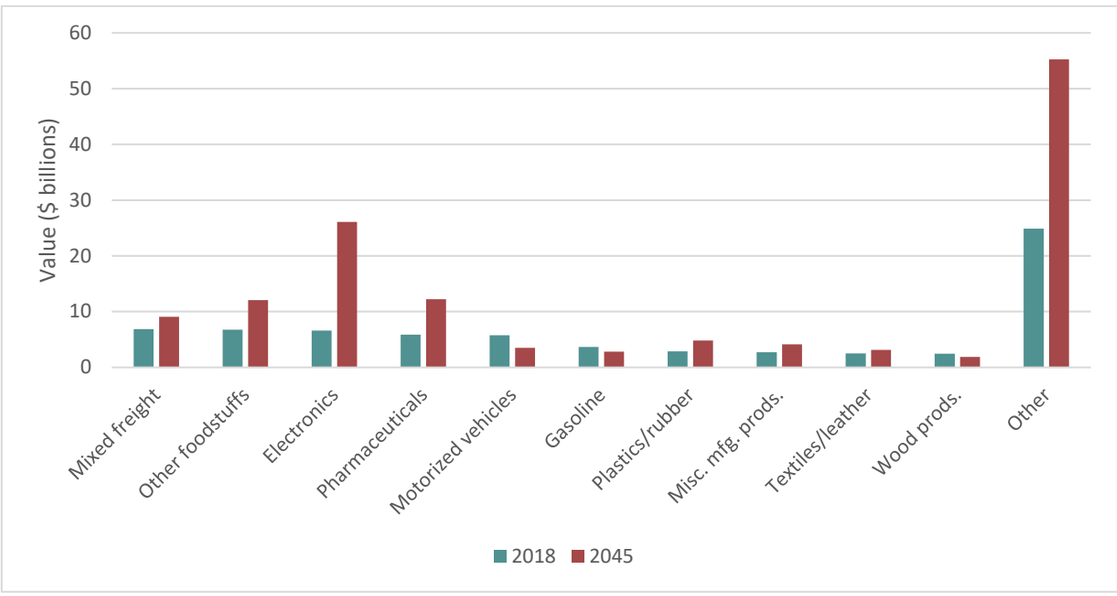
FIGURE 2.12 VERMONT TOP COMMODITIES BY TONNAGE (2018 AND 2045)



Source: FAF, STB Confidential Waybill Sample; Analysis by Cambridge Systematics, 2020.

On the basis of value, the top commodities include mixed freight, food, electronics, pharmaceuticals, and motorized vehicles, each of which comprising relatively similar total values of $5.5 to $7 billion. From 2018 to 2045, the largest expected growth in value is expected for electronics. In the case of this commodity, total value is expected to quadruple to over $25 billion, likely due to both increases in the value and quantity of such commodities. A doubling of total value is also expected for food and pharmaceuticals as well. Together, these three commodities are expected to comprise the most valuable commodities transported in Vermont. Overall however, the majority of commodities are expected to see growth in value, as is denoted by the significant growth for 'Other' commodities.

FIGURE 2.13 VERMONT TOP COMMODITIES BY VALUE (2018 AND 2045)



Source: FAF, STB Confidential Waybill Sample; Analysis by Cambridge Systematics, 2020.

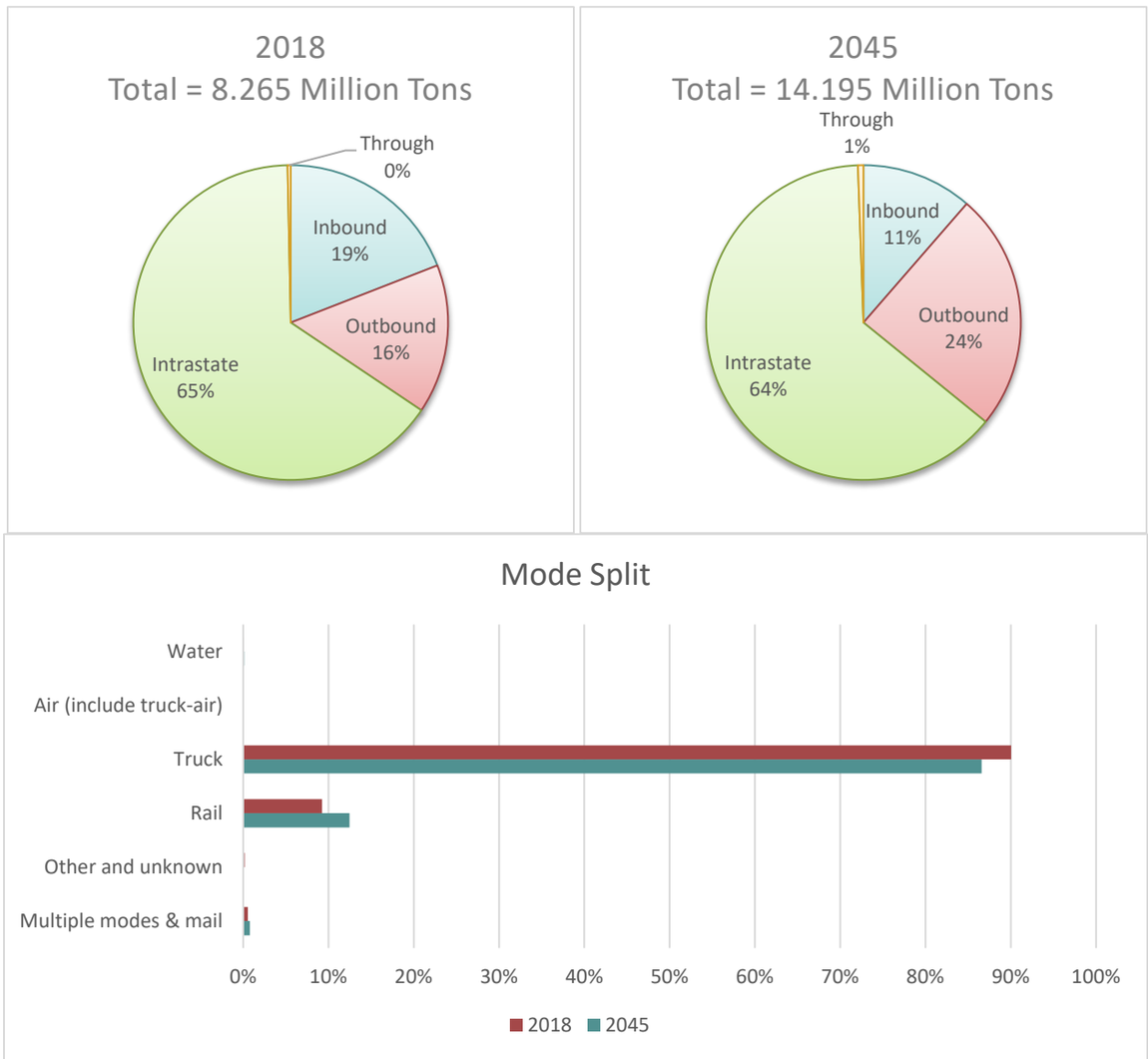
Key Top Commodities - Tonnage

Given the large tonnages for gravel and products of food manufacturing, it is worth examining the characteristics of these two very different commodities, including where and how they are moved. Although nonmetallic minerals are expected to comprise a larger proportion of total tonnage, it is expected that both direction and mode splits would be similar to that of gravel.

Figure 2.14 profiles gravel tonnage in terms of direction of travel and move type, including expected changes between 2018 and 2045. Intrastate travel within Vermont is expected to account for a majority of gravel

tonnage at approximately 65 percent through 2045. The most notable change in move type is expected for outbound tonnage, given an increase in proportion of all gravel tonnage from 16 percent to 24 percent. It should be noted that almost all intrastate gravel tonnage is transported by truck, which offers short travel time and low cost compared to rail for short distance trips. Almost 90 percent of outbound gravel tonnage is transported by rail, which is typically more competitive for longer distance trips. This disparity in modes based on direction of travel helps to explain the slight decrease in market share of truck (from 90 percent to 87 percent) and slight increase for rail (from nine percent to 12 percent) between 2018 and 2045.

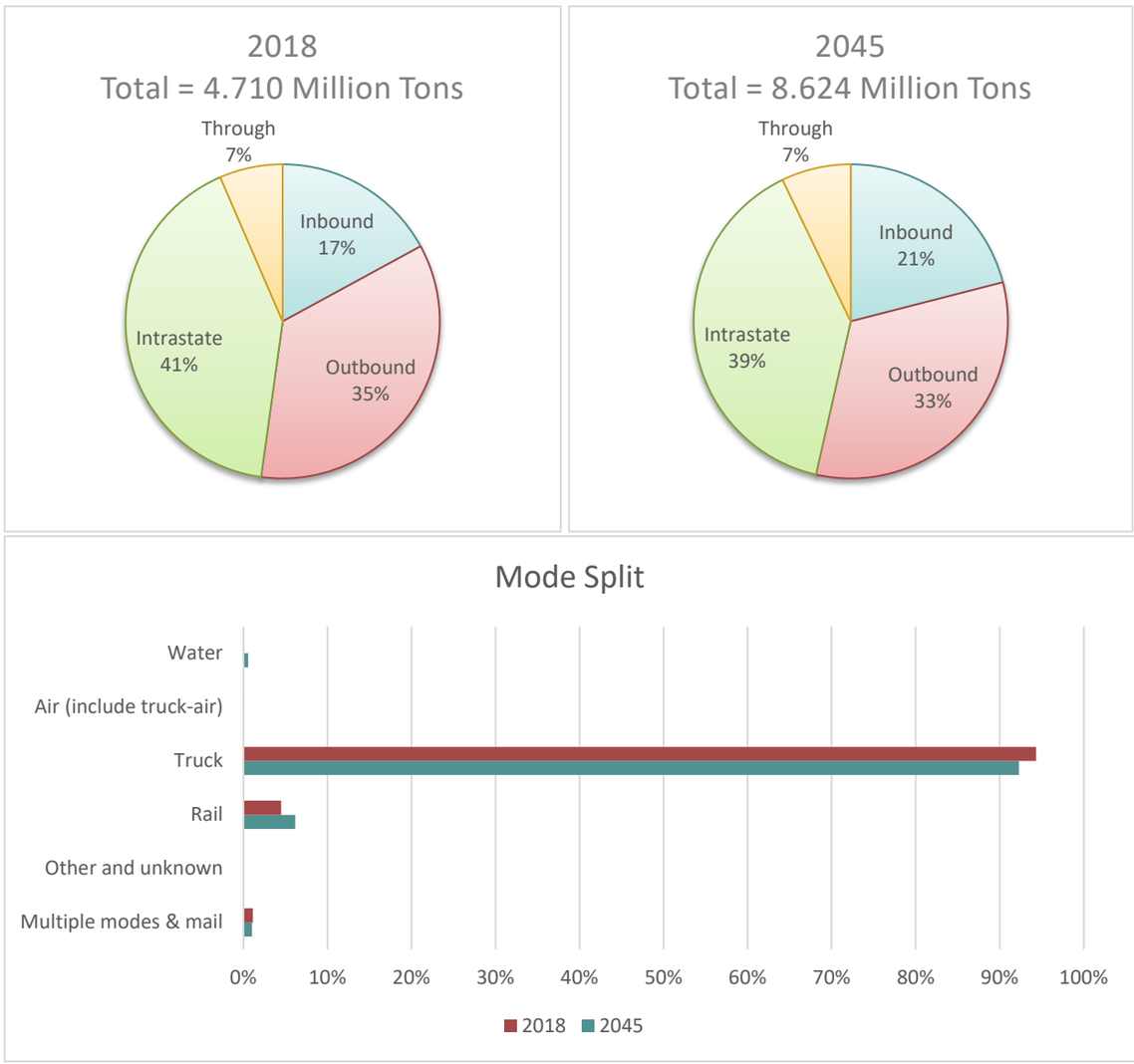
FIGURE 2.14 GRAVEL COMMODITY PROFILE (2018 AND 2045)



Source: FAF, STB Confidential Waybill Sample; Analysis by Cambridge Systematics, 2020.

Figure 2.15 profiles other foodstuffs tonnage in terms of direction of travel and move type, also including changes between 2018 and 2045. Unlike gravel which is primarily comprised of intrastate moves, food is moved notably across all directions (particularly intrastate, outbound, and inbound), a trend expected to remain in place through 2045. The most notable change in move type is expected for inbound tonnage, given an increase in proportion of all food tonnage from 17 percent to 21 percent. In terms of mode choice, truck comprises the majority of all food tonnage, across all directions, with a market share of over 90 percent. With only a slight increase in market share for rail of two percent, and negligible changes for the remaining modes, this trend is expected to remain in place through 2045.

FIGURE 2.15 OTHER FOODSTUFFS COMMODITY PROFILE (2018 AND 2045)

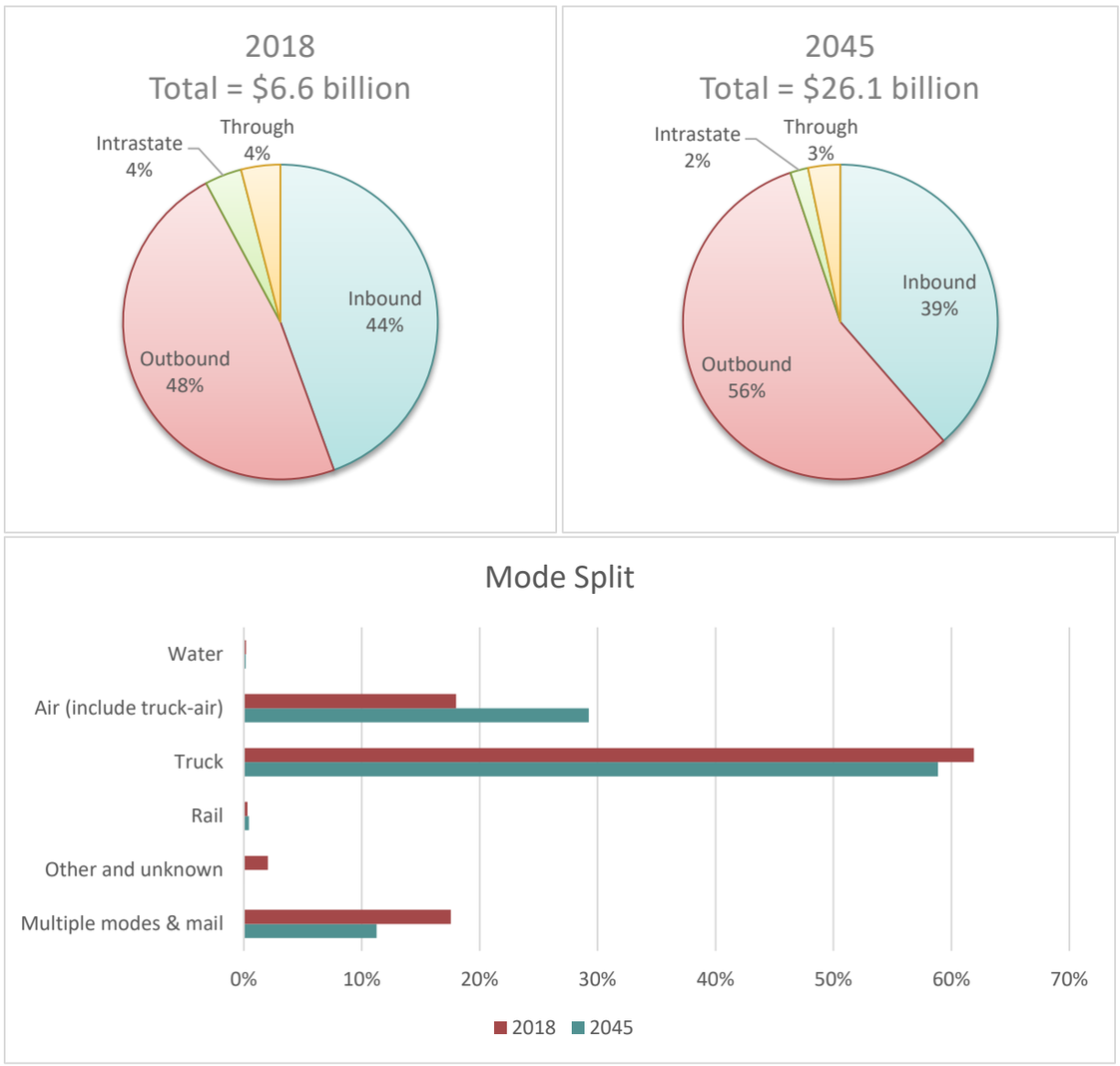


Source: FAF, STB Confidential Waybill Sample; Analysis by Cambridge Systematics, 2020.

Key Top Commodities - Value

Similar to tonnage, the top commodities in 2045 (electronics and pharmaceuticals) are given additional consideration. Figure 2.16 profiles electronics in terms of direction of travel and move type, including expected changes between 2018 and 2045. Both outbound and inbound moves are expected to account for over 90 percent of electronics in terms of values through 2045, with outbound moves increasing by eight percent and inbound moves decreasing by five percent from 2018. In terms of mode splits, while truck comprises the highest proportion at over 50 percent through 2018 and 2045, a significant increase in air mode to approximately 30 percent is expected. Much of this increase stems from the increase in outbound electronics, which tend to be high-value products. Vermont is home to several electronics manufacturing facilities, including BioTek Instruments, which produces bioanalytics equipment and software, and facilities operated by Global Foundries and GE Aviation, which produce equipment and devices for what is expected to be a growing market of business clients and consumers. On the other hand, a decrease in the proportion of value transported by multi-modal is expected from 18 percent to 11 percent. This decrease stems from the proportional decrease in inbound electronics.

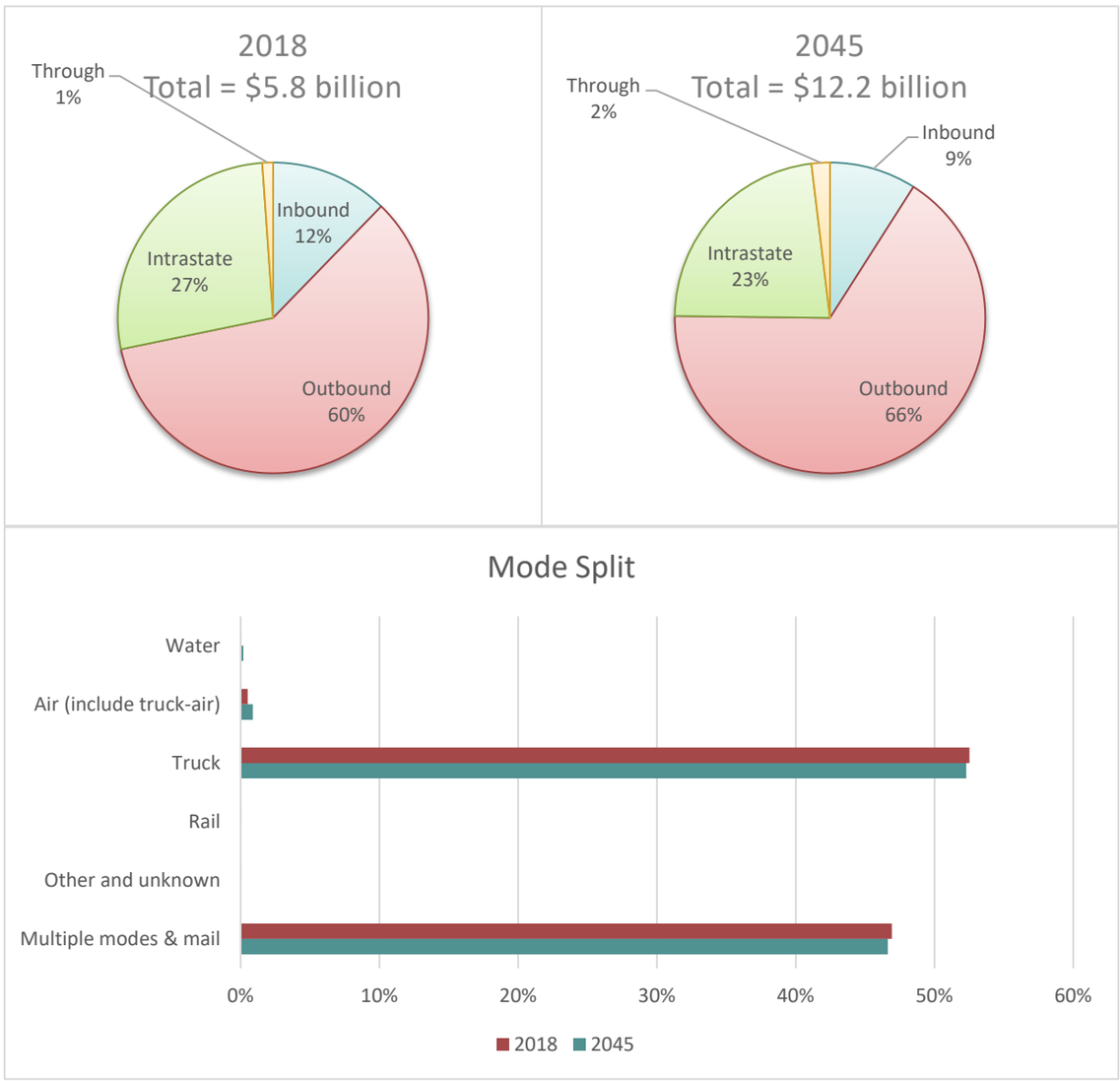
FIGURE 2.16 ELECTRONICS COMMODITY PROFILE (2018 AND 2045)



Source: FAF, STB Confidential Waybill Sample; Analysis by Cambridge Systematics, 2020.

Figure 2.17 profiles pharmaceuticals by value in terms of direction of travel and move type, also including changes between 2018 and 2045. In the case of pharmaceuticals, outbound moves comprise the majority of its total value at 60 percent and 66 percent in 2018 and 2045 respectively. This is followed by intrastate (27 percent in 2018 and 23 percent in 2045). Mode splits are expected to remain relatively constant through 2045, consisting primarily of truck and multi-modal moves. Of these modes, multi-modal is primarily used for outbound electronics (comprising 60 percent of such directional moves), while truck is used for the majority of remaining moves. While the commodity flow data does not offer enough specificity to determine the composition of pharmaceuticals by product type, noting the pharmaceutical companies located in Vermont may reveal some clues. Vermont is home to manufacturing facilities for Mylan Technologies in St. Albans, Edge Pharma in Colchester, and PharmaLogic in Williston, and wholesalers such as Burlington Drug Company in Milton.

FIGURE 2.17 PHARMACEUTICALS COMMODITY PROFILE (2018 AND 2045)



Source: FAF, STB Confidential Waybill Sample; Analysis by Cambridge Systematics, 2020.

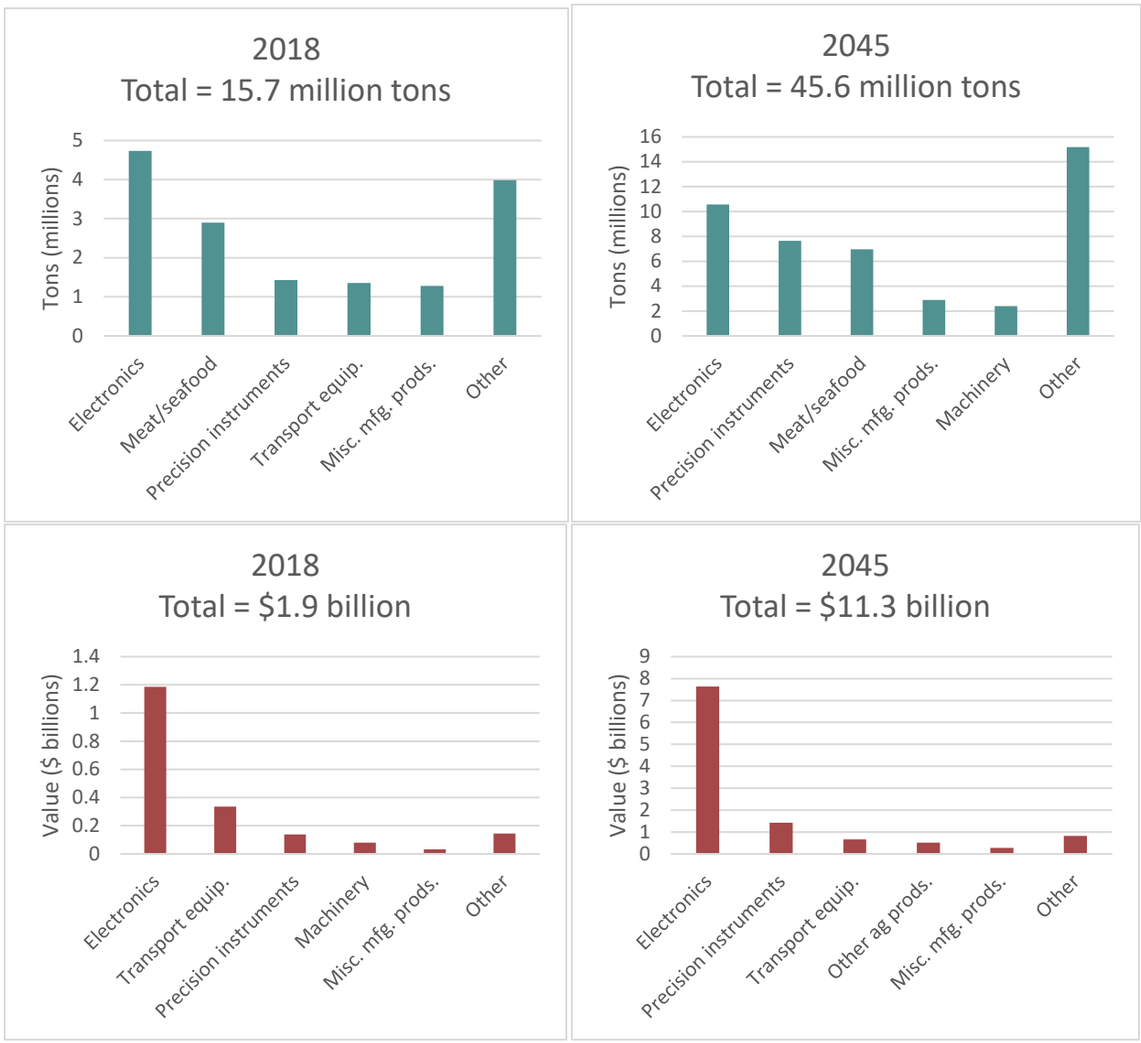
Top Commodities by Mode

Lastly, top commodities are identified for those modes of transport that comprise more than one percent of market share for either tonnage or value through 2045. Omitting pipeline and water modes, top commodities are identified for air, multi-modal, and truck modes. Rail commodity flows are dealt with separately in Section 2.3.

Air

Top commdities transported by air are identfied in Figure 2.18, for both value and tonnage. In terms of tonnage, top commodities include electronics, machinery, and similar products, as well as meat/seafood products, a trend expected to remain in place through 2045. Together, these top commodities account for well over half of all air tonnage. On the basis of value, electroncis are by far the top commodity, accounting for well over half of all air value. Besides electronics, similar high-value commodities such as equipment and precision instruments are within the top five, along with agricultural products in 2045. Given that the top commodities for both tonnage, and especially value, comprise large proportions of total figures, air is likely used for transporting a narrower range of commodities in Vermont. These commodities tend to be processed or finished products of higher value.

FIGURE 2.18 TOP COMMODITIES BY AIR (2018 AND 2045)



Source: FAF, STB Confidential Waybill Sample; Analysis by Cambridge Systematics, 2020.

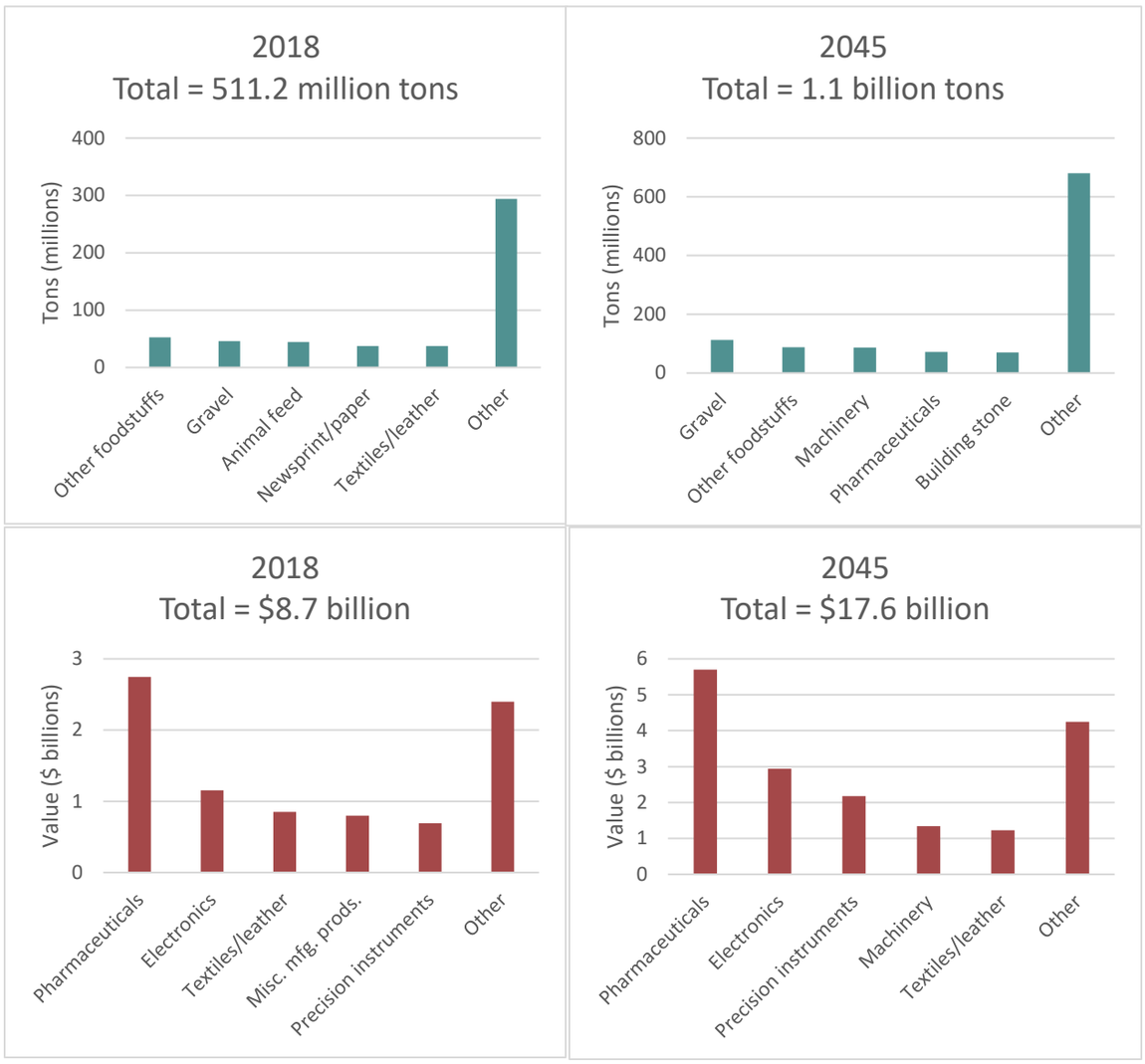
Multiple Modes and Mail

Shipments reported as Multiple Modes can include anything from containerized cargo to coal moving from mine to railhead by truck and rail to harbor. The "Mail" component recognizes that shippers who use parcel delivery services typically do not know what modes were involved after the shipment was picked up.[4]

Top multiple modes and mail commodities are identified in Figure 2.19. This mode moves a broad mix of different commodity types. Top commodities by tonnage in 2018 and 2045 include "other foodstuffs" (products of food manufacturing) and gravel. Unlike other modes, the top five commodity groups, when ranked by tons moved, do not represent the majority of tonnage moved by multiple modes and mail. Pharmaceuticals is the top commodity group moved by multiple modes and mail, when ranked by value of goods moved.

[4] "Freight Analysis Framework Version 4: User's Guide for Release 4.0," U.S. Department of Transportation, 2015, available from: https://faf.ornl.gov/fafweb/data/FAF4%20User%20Guide.pdf.

FIGURE 2.19 TOP MULTIPLE MODES AND MAIL COMMODITIES (2018 AND 2045)

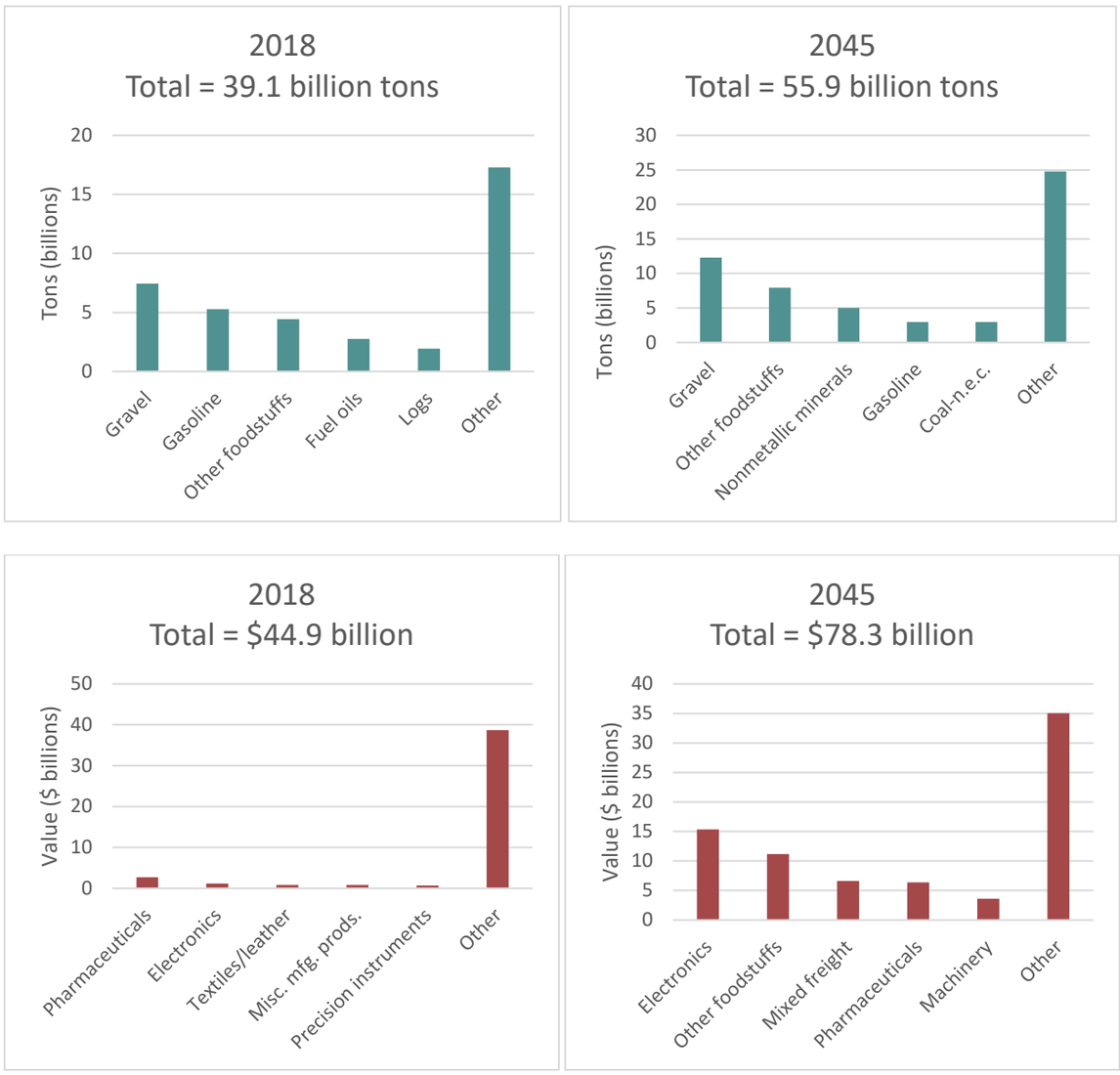


Source: FAF, STB Confidential Waybill Sample; Analysis by Cambridge Systematics, 2020.

Truck

Top commodities transported by truck are identified in Figure 2.20. Similar to rail, on the basis of tonnage, raw, heavy materials including aggregates, oils, and wood comprise much of the top commodities, along with food. Through 2045, these top commodities are expected to comprise approximately half of all tonnage. In terms of value, top commodities consist of electronics, pharmaceuticals, food, and mixed freight, similar to the case with other modes. However, while the trend is expected to dimishish somewhat through 2045, these top commodities comprise less than half of total value, indicating that trucks are used to transport a wide variety of goods. This observation is further reflected by the likely significant role that trucks play throughout all portions of short- and long-distance Vermont supply chains, along with their large modal market share.

FIGURE 2.20 TOP COMMODITIES BY TRUCK (2018 AND 2045)

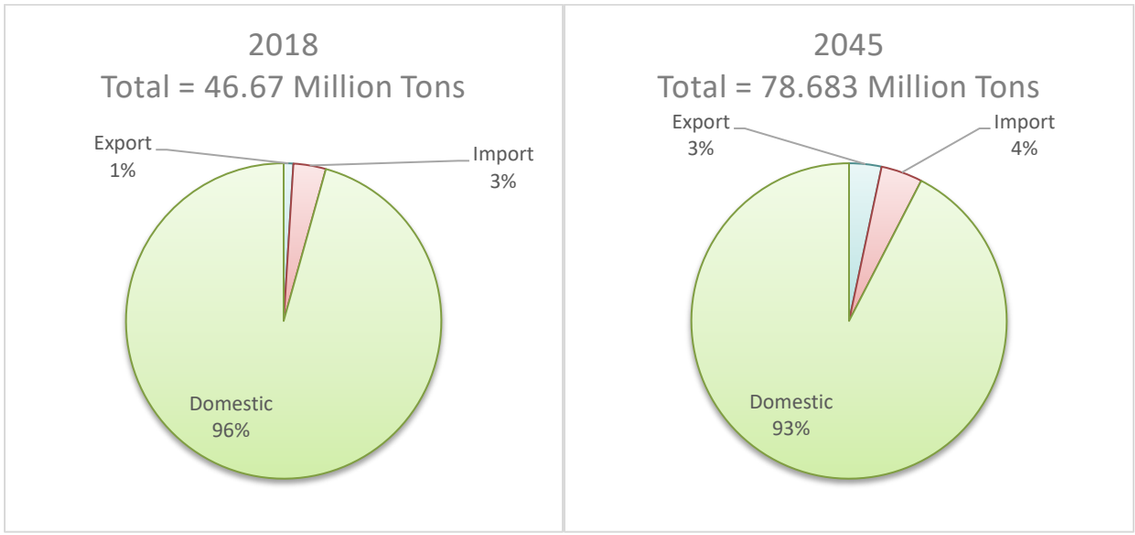


Source: FAF, STB Confidential Waybill Sample; Analysis by Cambridge Systematics, 2020.

Trade

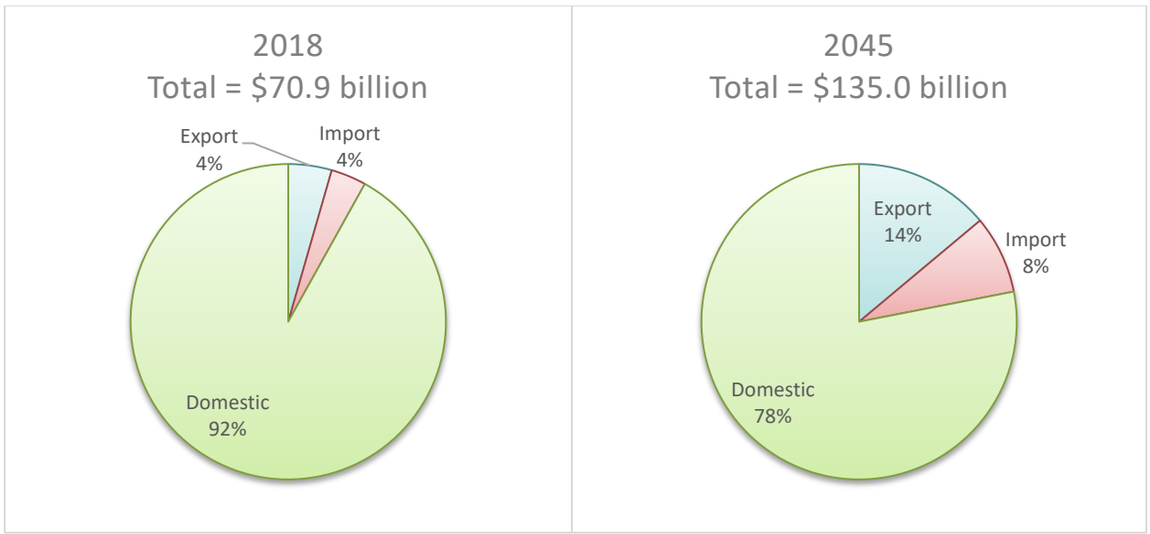
As shown in Figure 2.21 and Figure 2.22, domestic trade comprises the majority of freight traffic in Vermont, both in terms of tonnage and value. While both imports and exports are expected to increase, domestic trade is still expected to account for over 90 percent of total tonnage. On the other hand, the proportion of total value for imports, and exports, is expected to increase more significantly. The value of import/export goods are expected to grow as a share of total value of goods moved in Vermont, from eight percent to 22 percent, between 2018 and 2045. This projected trend suggests that international trade will continue to consist largely of high-value products, including machinery and electronics, transportation equipment, and wood products, which are among the top commodities by value crossing the border today.

FIGURE 2.21 VERMONT FREIGHT TONNAGE BY TRADE TYPE (2018 AND 2045)



Source: FAF, STB Confidential Waybill; Analysis by Cambridge Systematics (2020).

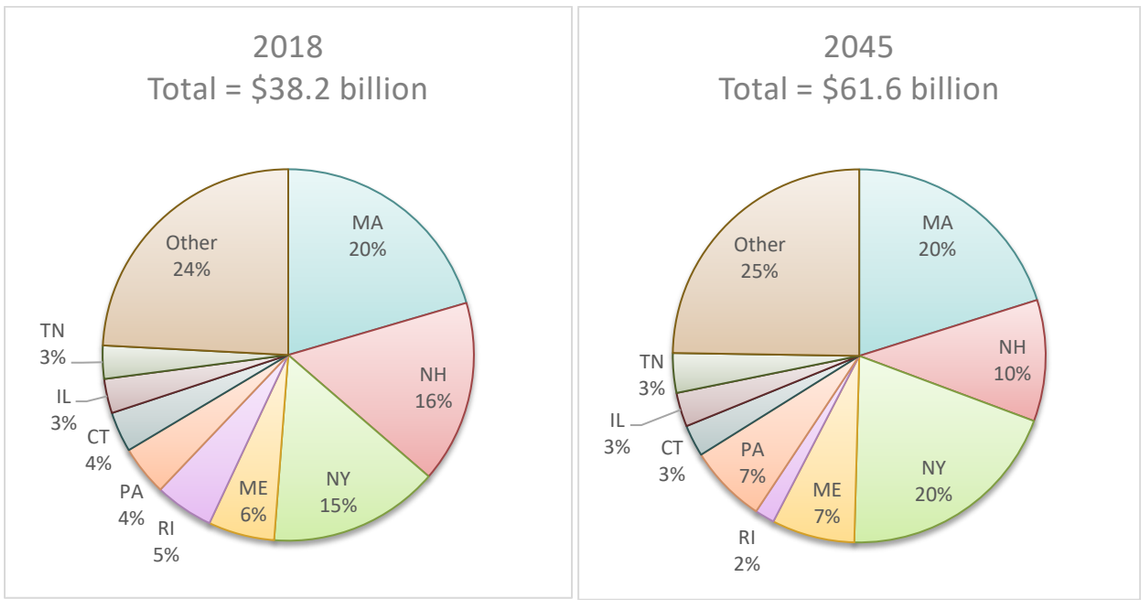
FIGURE 2.22 VERMONT FREIGHT VALUE BY TRADE TYPE (2018 AND 2045)



Source: FAF, STB Confidential Waybill Sample; Analysis by Cambridge Systematics, 2020.

Within the context of domestic trade, Vermont's top trading partners, by dollar value, are identified in Figure 2.23. Note that this chart does not show the slightly less than half of all trade that occurs internally within Vermont, a proportion which is expected to remain largely constant through 2045, even when accounting for expected increases in tonnage and value. Outside of Vermont, the top states for trade are largely comprised of states directly adjacent to, or near Vermont, including Massachusetts, New York, and New Hampshire. Outside of New England and the Northeast, the top states for domestic trade are Tennessee and Illinois, although both account for only two percent of total trade each. In 2018, those states outside of the top ten accounted for 13 percent of all trade. In 2045, the composition of states accounting for Vermont's top trading partners is expected to remain similar. Amongst the top states however, increases are expected for New York (+2 percent), Pennsylvania (+2 percent), and Maine (+1 percent), while decreases are expected for New Hampshire (-2 percent) and Rhode Island (-1 percent). For those states outside of the top ten in 2045, the proportion of total trade is expected to remain constant at 13 percent.

FIGURE 2.23 VERMONT DOMESTIC TRADING PARTNERS BY VALUE (2018 AND 2045)

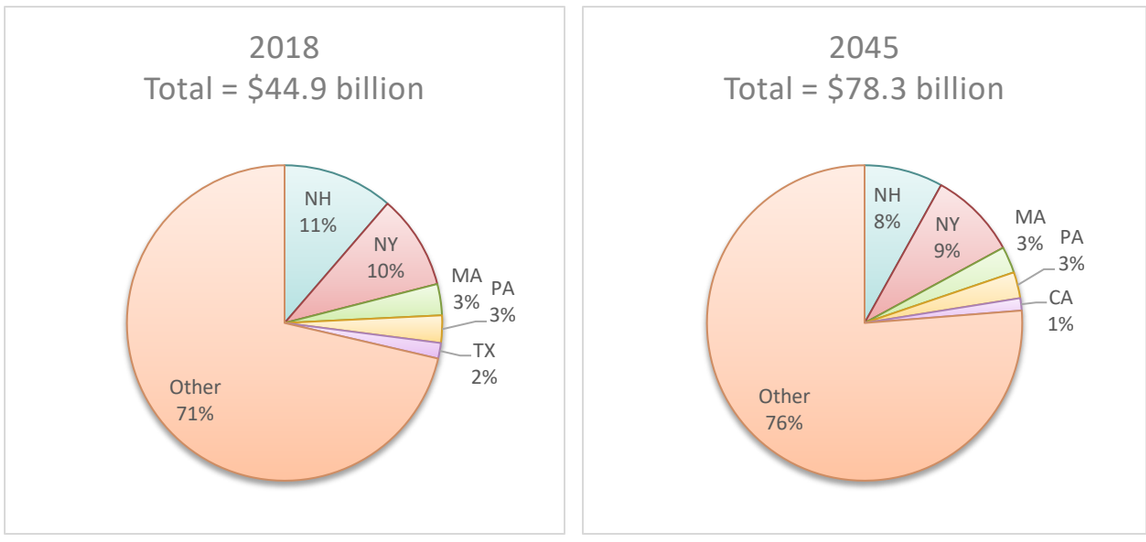


Source: FAF, STB Confidential Waybill Sample; Analysis by Cambridge Systematics, 2020.

Given that Vermont's top domestic trading partners are largely influenced by geographic proximity, These results are further broken out to show trading partners for freight flows moved by truck.

The largest trading partners by truck, as expected, are those states which directly border Vermont. In 2018, New Hampshire, New York, and Massachusetts comprised 24 percent, a figure expected to decline somewhat to 20 percent in 2045. With the exception of Pennsylvania at three percent, the remaining states are expected to comprise low market shares of two percent or less through 2045. This indicates that truck is used to transport goods between Vermont and all portions of the continental United States.

FIGURE 2.24 VERMONT DOMESTIC TRADING PARTNERS BY VALUE – TRUCK (2018 AND 2045)



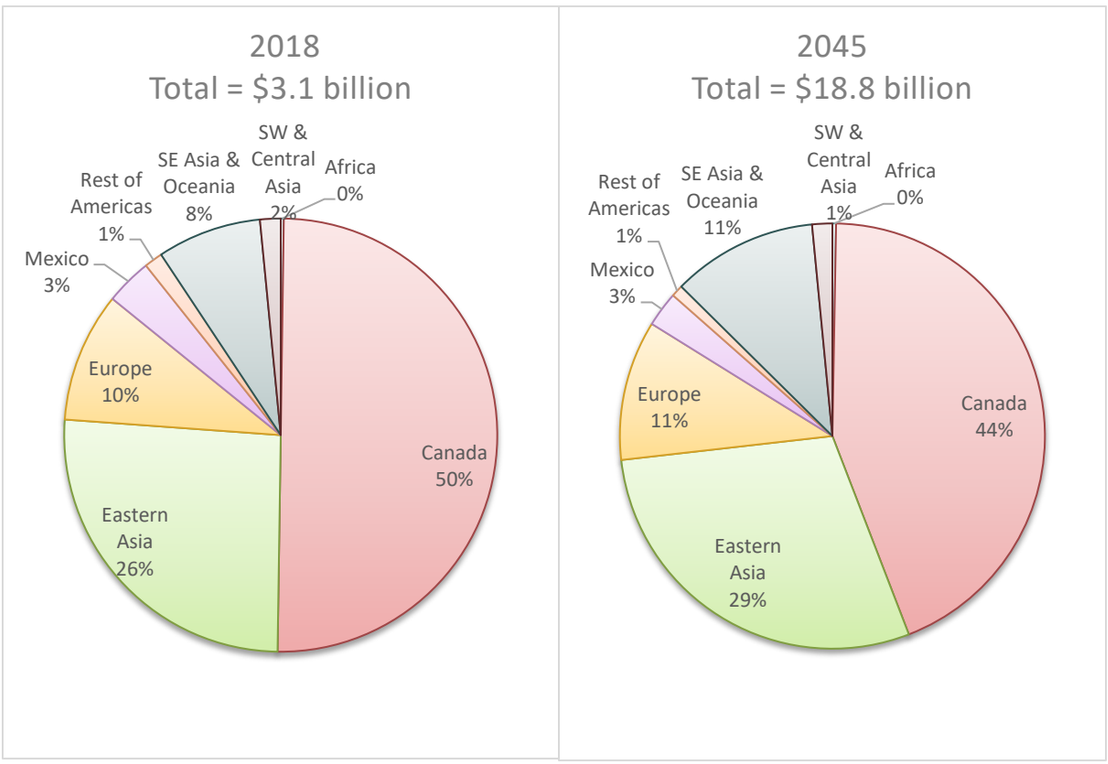
Source: FAF, STB Confidential Waybill Sample; Analysis by Cambridge Systematics, 2020

Trade with international partners is shown in Figure 2.25. Canada and Eastern Asia comprise approximately 75 percent of total trade by value. This is largely expected given the sharing of a land border between Canada and Vermont, and the large volume of Asian trade through U.S. marine terminals on the West and East coasts, some of which ultimately terminates in Vermont. For the most part, this trend is expected to remain in place through 2045, although some minor changes are expected. While Canada's proportion of all trade is expected to decline slightly to 44 percent from 50 percent, Eastern Asia's market share is expected to rise to almost 30 percent. Slight increases in market share are also expected for Southeastern Asia/Oceania (+3 percent), and Europe (+1 percent), while Mexico and the Rest of the Americas are expected to remain constant.

The forecasted proportion of trade by international region was developed prior to the implementation of additional tariffs between the U.S. and China in 2018 and the transition from the North American Free Trade

Agreement to the United States-Mexico-Canada Agreement. As Section 6.1 describes, these and future foreign trade agreements can substantially influence future freight flows between Vermont and foreign trade partners. Further, changes in logistics networks in response to COVID-19 could lead to longer-term shifts in materials sourcing and production locations, in an effort to improve supply chain reliability and reduce lead times.

FIGURE 2.25 VERMONT INTERNATIONAL TRADING PARTNERS BY VALUE (2018 AND 2045)



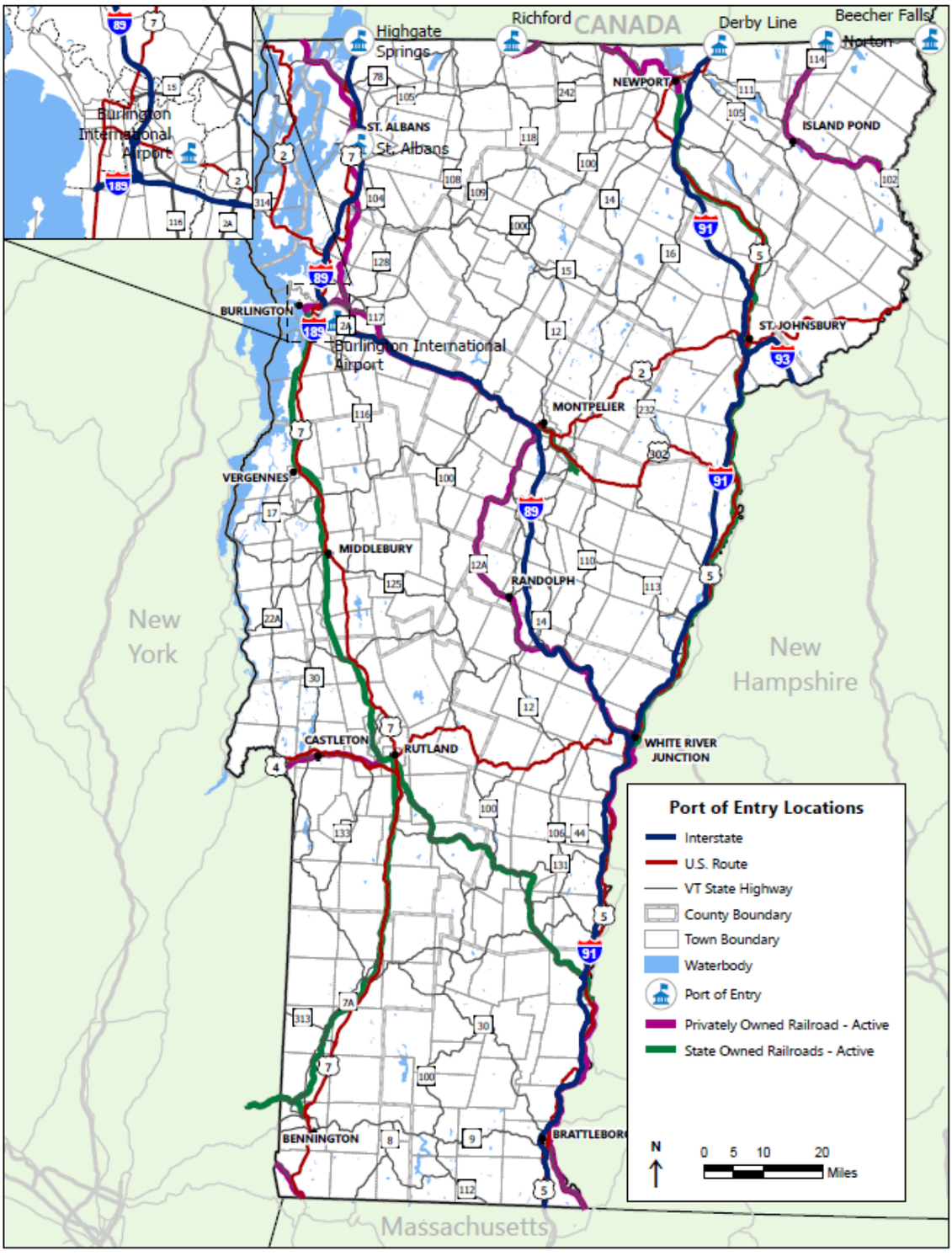
Source: FAF, STB Confidential Waybill Sample; Analysis by Cambridge Systematics, 2020.

Vermont-Canada Trade

As discussed above, trade with Canada accounts for approximately half of Vermont's foreign trade. Vermont has fifteen international Ports of Entry (POE) on the U.S.-Canada border, five of which are available for commercial freight clearances—Beecher Falls (truck), Norton (truck and rail), Derby Line (truck), Richford (truck and rail), and Highgate Springs (truck and rail). In addition, inland Ports of Entry are located at Burlington International Airport and St. Albans.[5] These locations are shown in Figure 2.26.

[5] Note that additional Canada-Vermont trade entered the state through a non-Vermont Port of Entry.

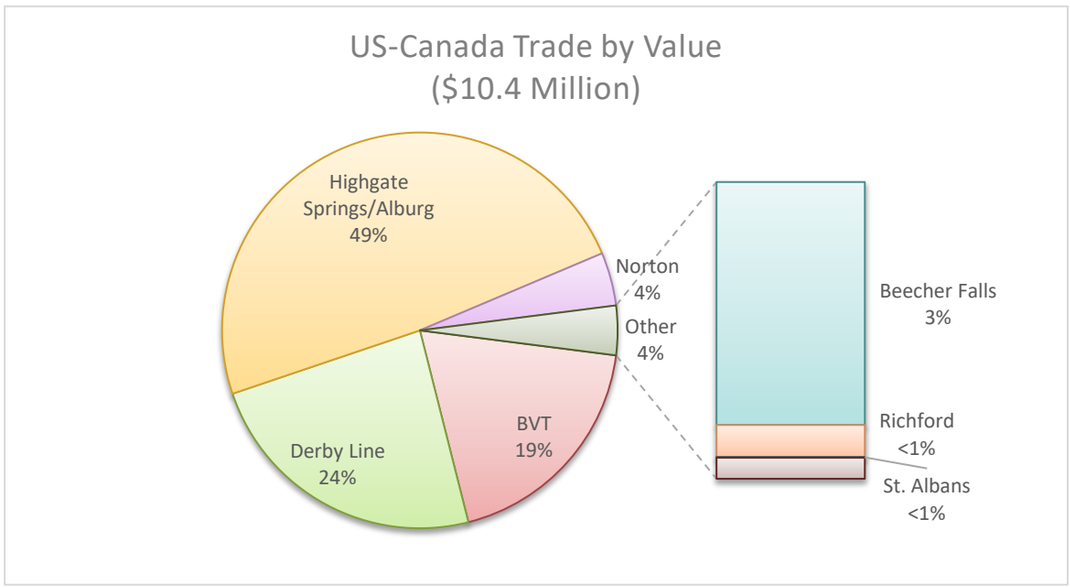
FIGURE 2.26 VERMONT-CANADA PORTS OF ENTRY

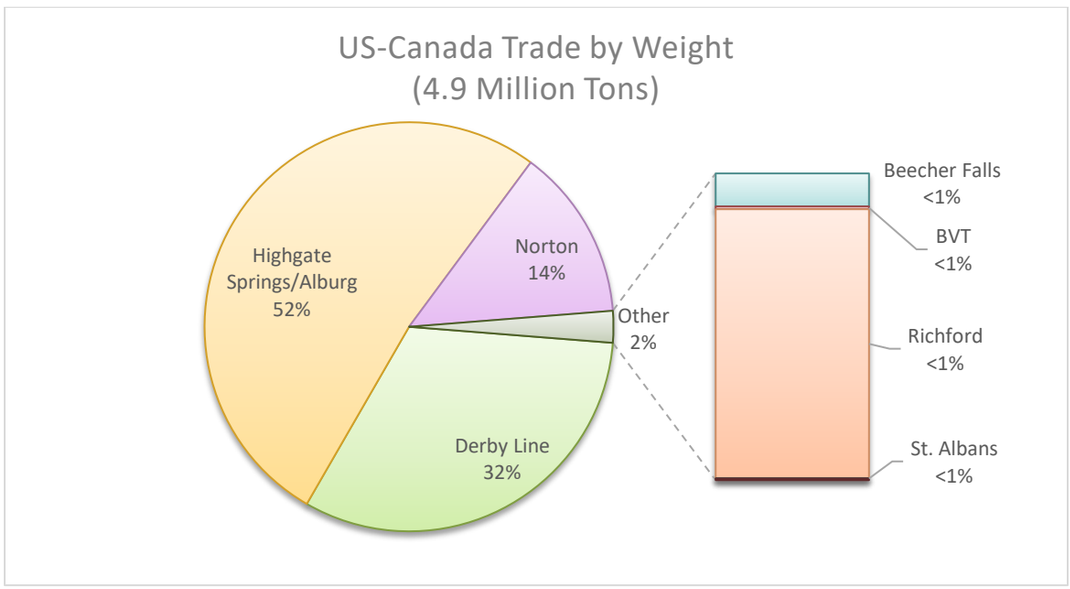


Source: VTrans, US Customs and Border Protection

In total, approximately $10.4 billion in goods weighing 4.9 million tons crossed the Quebec-Vermont border in 2019. The Highgate Springs crossing on I-89 is by far the busiest, processing approximately 49 percent of goods by value and 52 percent of goods by weight in 2019. The Derby Line (I-91) and Norton (VT 114) crossings also process a substantial amount of goods as does the Burlington International Airport (by value). The remaining POEs all process three percent or less of the total volume of goods.

FIGURE 2.27 VERMONT-CANADA TRADE BY VERMONT PORT OF ENTRY (2019)





Source: US BTS; Analysis by Cambridge Systematics, 2020.

Machinery accounts for nearly half of the total goods by value at the Highgate Springs crossing while mineral products and wood/wood products are the largest goods moving by weight. Across all POEs, machinery/electrical goods, transportation vehicles and equipment, and wood and wood products account for approximately 64 percent of the total value moved while wood and wood products and mineral products account for approximately 64 percent of the total weight moved.

Trucks move approximately 70 percent of all shipments by value and weight through these POEs, but rail also plays a critical role, especially for heavier, lower value commodities. Highgate Springs saw just more than 900,000 tons of goods in 2019 moved by rail (Canadian National), while Norton processed just more than 522,000 tons (St. Lawrence & Atlantic).

The on-going Autoroute 35 project in Quebec is likely to have an impact on future trade through these POEs. Once complete, this project will link the entire route between Boston and Montreal with a limited access freeway (I-93, I-89, Autoroute 35, Autoroute 10). An 8.3 mile stretch between Saint-Sebastian, QC and the Vermont border (I-89) remains incomplete. Analysis of the project indictates that the new route will increase the attractiveness of this corridor for international trade and divert both freight and passenger traffic from nearby POEs in Champlain, NY and Derby Line, VT to the Highgate Springs crossing.

Completion of Autoroute 35 is expected to result in the addition of 345 automobile trips and 106 truck trips in the southbound direction at the Highgate Springs POE on an average day. About 45 percent of the

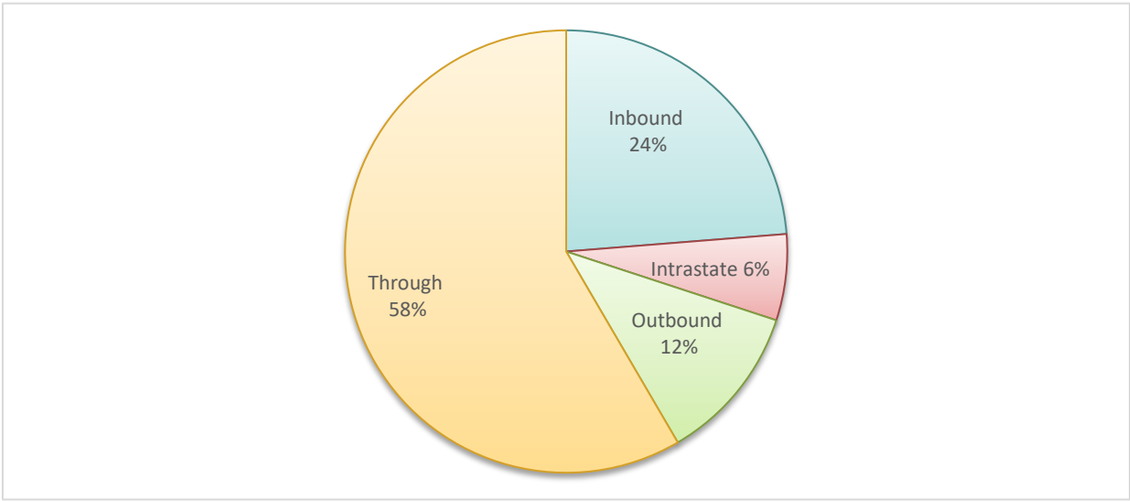
automobile and 58 percent of the truck trip increase would be due to shifting traffic patterns from the Champlain POE to the Highgate Springs POE. The remaining additional trips are attributable to induced travel demand resulting from the improved highway link. In the northbound direction, 382 automobile trips and 44 truck trips are expected to be added to the average daily traffic volume. About 47 percent of this traffic is attributable to shifting traffic patterns and 53 percent to induced travel demand. The majority of additional truck trips are projected to move through Vermont to origins/destinations in Massachusetts or beyond, with approximately 40 of the additional 106 inbound truck trips stopping within the State.[67]

The recent acquisition of the former Canadian Montreal & Quebec Railways (CMQ) by Canadian Pacific (CP) and a projected sale of PanAm Railways may also result in some shifts in rail freight flows in Vermont. This is particularly the case with CP's line from Farnham Quebec to Newport Vermont, part of a through route to White River Junction and connections with NECR and PAS. CP has multiple routing options available for traffic that can efficiently use this route, and thus brings a level of uncertainty to its future prospects.

2.2 Current Freight Rail Commodity Flows

The rail system in Vermont carried 6.9 million tons in 2018. Of these total tons, approximately 1.6 million tons (24 percent) arrived in Vermont from other states or North American countries, 797,000 tons (12 percent) travelled from Vermont to other states or North American countires, and 435,000 tons (6 percent) traveled within Vermont. Through rail traffic accounted for 4.0 million tons or 58 percent of overall rail traffic. The figure below displays the rail traffic by direction and weight for 2018.

FIGURE 2.28 RAIL VOLUME BY DIRECTION AND WEIGHT (2018)



Source: STB Confidential Waybil Sample; Analysis by Cambridge Systematics, 2020.

Rail Traffic by Direction

Analyzing the direction of rail traffic gives insight into how the state uses specific commodities, how rail shipments affect Vermont's commerce, and the importance of the Vermont rail system to the nation and interstate commerce. Rail traffic that is inbound to the state involves companies that reside within Vermont's border, and receive goods by rail from locations outside of Vermont—this traffic is essentially a state import. Consumers and business must pay for goods received, as such, inbound rail shipments represent the payments that Vermont consumers and businesses are spending money on and being shipped by rail. Vermont's outbound rail traffic are goods that companies within Vermont's border are shipping by rail to locations outisde of Vermont—this traffic is essentially a state export. Outbound rail shipments represent goods that Vermont is being paid to produce and that are shipped by rail. Similarly, traffic that is considered intrastate refers to rail traffic that is being sent by companies within Vermont to locations within Vermont.

[6] Autoroute 35 Phase II Technical Report.

[7] Note that the recent sale of the former CMQ to CP and the pending sale of PAS may also shift these trends cross-border trends.

Intrastate rail shipments represent goods that Vermont both produces and receives, thereby displaying the products and goods that state trades within itself. Through traffic refers to traffic that originates outside of Vermont and terminates outside of Vermont and travels through Vermont in order to reach the designated destination. Through traffic represents the importance of Vermont's rail system to other states and the nation, an observation that has helped the State to compete for grants to improve the rail network . Since through traffic neither originates or terminates in Vermont, it does not represent money received or spent by the state's industries, rather it represents the wear and tear on Vermont's rail infrastructure that is to the benefit of other states and supports the fluidity of the overall national rail network.

One complication to the directional analysis of rail traffic in Vermont is the international border that Vermont shares with Canada. While most of the waybill data entries accurately demonstrate that rail traffic orginates in Vermont and terminates in Canada, some of the outbound traffic to Canada incorrectly lists a border junction in Vermont as the termination, even though the goods ended up across the border. These transborder shipments were screened from the waybill analysis by identifying Vermont's border junctions, and screening the shipments by origin, destination, and commodity to determine if the shipment is actually a transborder shipment to Canada.

Of total rail tonnage carried to, from, within and across Vermont in 2018, 89 percent of tonnage was carried in railcars and 11 percent in intermodal containers. All of the domestic intermodal containers and trailers traveling through Vermont in 2018 were associated with Pan Am Southern's (PAS) Patriot Corridor betweeen Mechanicville, NY and Massachusetts. This segment traverses Vermont in the far southwestern corner of the state. International shipping containers are transported on the St. Lawrence and Atlantic (Genesee & Wyoming), which traverses the Northeast Kingdom of Vermont between Portland, Maine and Montreal.

Top Rail Commodities

The top commodities carried by rail in Vermont in 2018 are shown in the tables below by direction and by weight using Standard Transportation Commodity Code (STCC) categories. The largest commodity in 2018 by tonnage was clay, concrete, glass or stone products accounting for 16 percent (1.1 million tons) of the rail tonnage moved in 2018; 66 percent of these rail shipments are outbound traffic to several states including Maine which had the highest concentration. The next top commodity is lumber or wood products which make up 15 percent (1 million tons) of the rail tonnage moving in the state; the majority of this commodity is through traffic, but there is also a substantial amount of intrastate traffic. Petroleum or coal products make up 12 percent (863,000 tons), followed by pulp, paper or allied products and nonmetallic minerals which each make up 10 percent (about 700,000 tons) of the total rail tons in 2018. Food or kindred products, and chemicals or allied products each comprised nine percent of total tons shipped (about 615,000 tons). The remaining top commodities, freight all kinds (that is, miscellaneous mixed shipments usually moving as intermodal shipments through the state), primary metal products, waste or scrap materials, transportation equipment, farm products, and others, accounted for two percent or 887,000 tons in 2018.

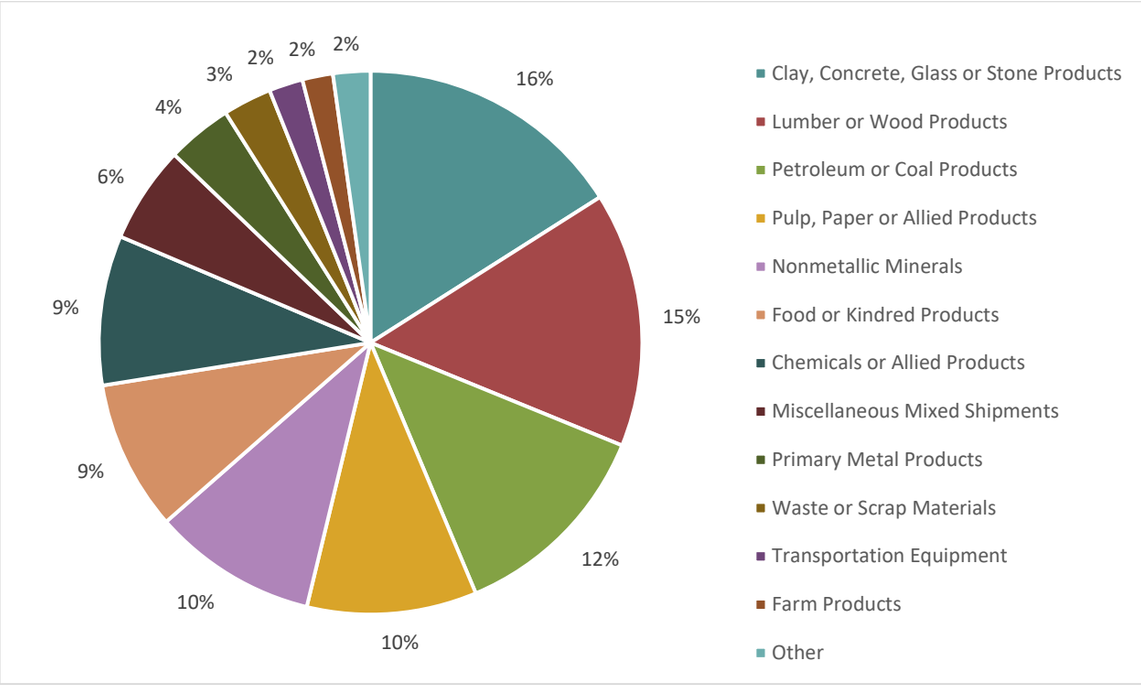
TABLE 2.1 TOP RAIL COMMODITIES 2018 DIRECTION (IN THOUSANDS OF TONS)

STCC	Commodity	Inbound	Outbound	Intrastate	Through	Total	Percent
32	Clay, Concrete, Glass or Stone Products	15	728	8	355	1,105	16%
24	Lumber or Wood Products	182	0	296	569	1,047	15%
29	Petroleum or Coal Products	574	8	20	260	863	12%
26	Pulp, Paper or Allied Products	13	0	0	685	698	10%
14	Nonmetallic Minerals (Raw material)	464	40	100	71	675	10%
20	Food or Kindred Products	274	7	3	332	616	9%
28	Chemicals or Allied Products	69	7	0	539	615	9%
46	Miscellaneous Mixed Shipments	0	0	0	399	399	6%
33	Primary Metal Products	14	0	0	254	268	4%
40	Waste or Scrap Materials	0	4	0	196	200	3%
37	Transportation Equipment	1	3	4	132	140	2%

STCC	Commodity	Inbound	Outbound	Intrastate	Through	Total	Percent
1	Farm Products	29	0	4	93	126	2%
23	Apparel, or Other Finished Textile Products or Knit Apparel	0	0	0	39	39	1%
42	Containers, Carriers or Devices, Shipping, Returned Empty	0	0	0	38	38	1%
	Other	3	0	0	73	76	0
Total		**1,639**	**797**	**435**	**4,035**	**6,906**	**100%**

Source: STB Confidential Waybil Sample; Analysis by Cambridge Systematics, 2020.

FIGURE 2.29 TOP RAIL COMMODITIES BY WEIGHT (2018)



Source: STB Confidential Waybil Sample; Analysis by Cambridge Systematics, 2020.

Commodities shipped by rail out of Vermont are concentrated in clay, concrete, glass or stone products which is 91 percent of all outbound traffic by tonnage. This concentration of outbound traffic has been true in other years of analysis such as 2002 and 2011. Intrastate traffic is similarly concentrated in a small number of commodities, such as lumber and wood products, and nonmetallic minerals. Inbound and through rail shipments are more evenly distributed across many commodity groups.

Top Rail Trading Partners

Analysis of Vermont's "trading partners" aggregated county, regional and state designations in the source database into state-level statistics for the nearby states of Maine, New Hampshire, Connecticut, Massachussetts, New York, New Jersey, and Pennsylvania. States in the rest of the U.S. were aggregated into U.S. Census regions. The analysis also includes flows to and from Canada and Mexico. These trading partners for rail movements inbound and outbound of Vermont by volume of tons in 2018 are shown in Figure 2.30.

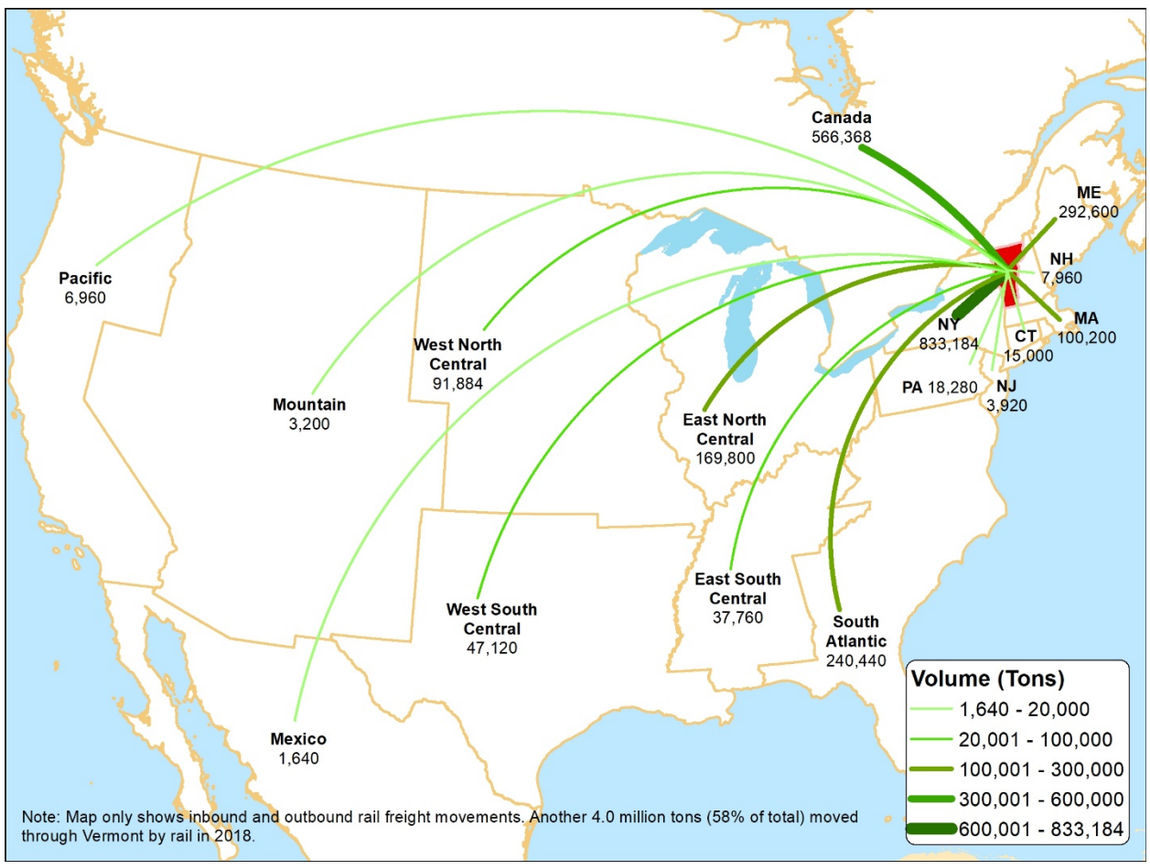
Vermont's top rail trading partners are New York, Canada, Maine, and the South Atlantic region (in that order). Trade with those regions accounted for 79 percent (1.9 million tons) of total inbound and outbound rail tonnage in 2018. New York accounted for the most trade, 34 percent (833,000 tons) or total inbound and outbound rail tonnnage in 2018, and the vast majority (97 percent) of these flows was traffic arriving to Vermont from New York (inbound) and are mainly comprised of nonmetallic minerals such as rock salt, and to a lesser extent petroleum products and transportation equipment.

Canada is Vermont's second largest rail trading partner, accounting for 23 percent (566,000 tons) of the total inbound and outbound rail tonnage in 2018. Eighty-six percent of Vermont's trade with Canada from Canada to Vermont (inbound) consisting mainly of petroleum or coal products, lumber or wood products,

food or kindred products, and farm products. The remaining 13 percent travels from Vermont to Canada (outbound).

Maine is Vermont's third largest trading partner, accounting for 12 percent (293,000 tons) of the total inbound and outbound rail tonnage in 2018. These movements move primarily in the outbound direction and are comprised of limestone slurry used in the production of paper.

FIGURE 2.30 VERMONT RAIL TRADING PARTNERS BY WEIGHT (2018)



Source: STB Confidential Waybil Sample; Analysis by Cambridge Systematics, 2020.

Rail Through Traffic

The top origin-destination pairs for the rail tonnage traveling through Vermont are detailed in the table below. Most of the rail traffic travelling through Vermont originates or terminates in Canada, Massachusetts, Conneticut, and New Hampshire.

TABLE 2.2 TOP RAIL THROUGH ORIGIN-DESTINATION PAIRS, 2018 WEIGHT (IN THOUSANDS OF TONS)

Origin	Destination	2018 Tons (000's)	Percent
PQ	MA	426	11%
IL	MA	400	10%
MA	IL	263	7%
PQ	NH	160	4%
IL	CT	130	3%
PQ	ME	129	3%
PQ	CT	129	3%
NY	NH	116	3%
ON	ME	96	2%
ME	PA	93	2%
Other		2,092	52%

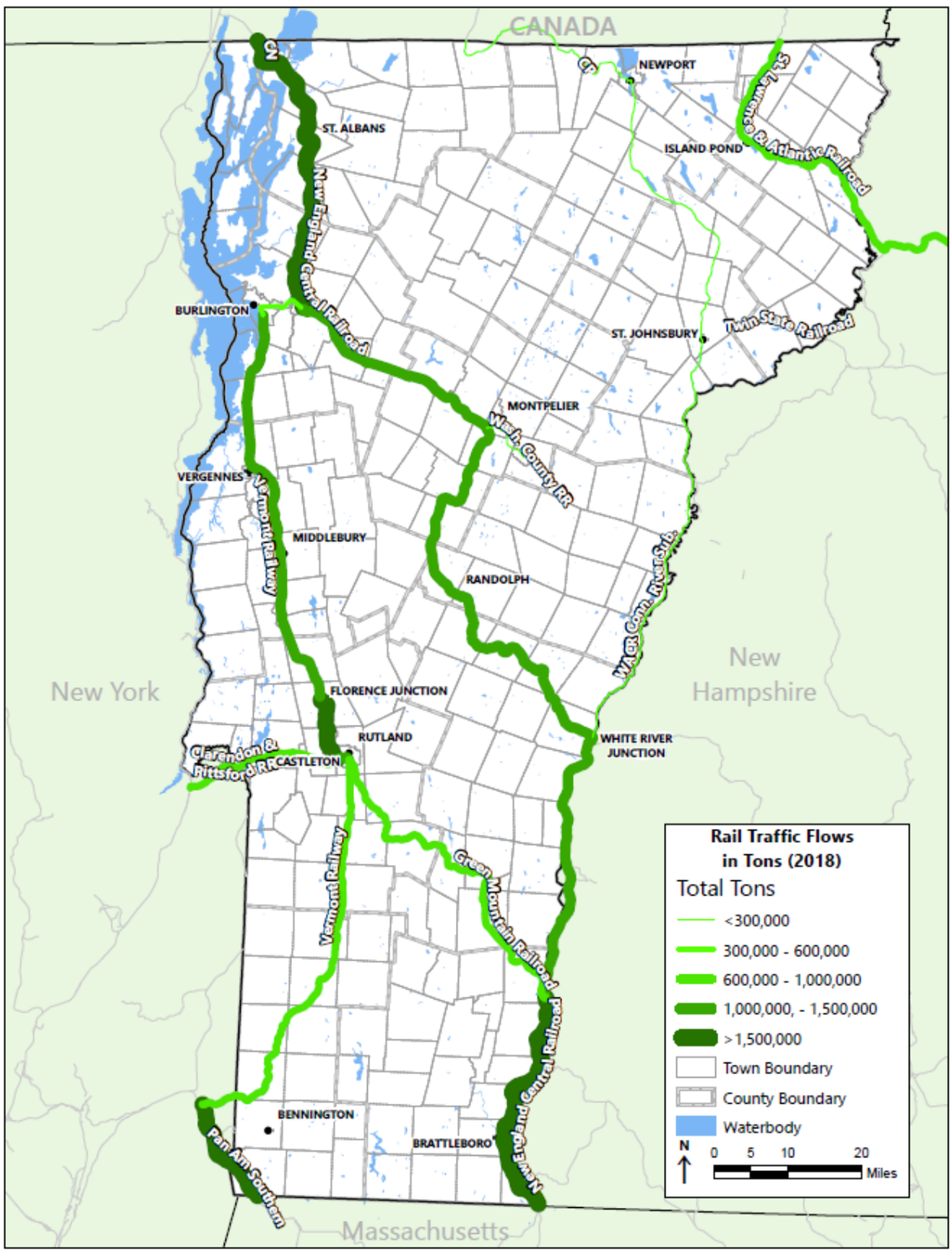
Total	**4,035**	**100%**

Source: STB Confidential Waybil Sample; Analysis by Cambridge Systematics, 2020..

Rail Flows

Figure 2.31 represents the volume of traffic travelling on Vermont's rail system in 2018. The majority of Vermont's rail traffic was through traffic (58 percent or 4.0 million tons in 2018). The PAS line that traverses the southwest corner of the State carries the majority of through traffic (56 percent of all through traffic or 2.3 million tons). This segment is seven-miles long and links the Albany, New York area with eastern Massachussetts, New Hampshire and Maine. The remaining through traffic mostly traveled along the New England Central Railroad (NECR) from Canada in the northwest to exchanges with Massachussetts in the southeast corner of Vermont (1.1 million tons) or along the St. Lawrence & Atlantic (SLR) in the northeast corner of the State (592,000 tons).

FIGURE 2.31 2018 RAIL TRAFFIC FLOWS, IN TONS



Source: STB Confidential Waybil Sample; Analysis by Cambridge Systematics, 2020.

Outbound and inbound traffic is concentrated between Florence Junction (location of Omya) and Rutland on the Vermont Railways (VTR), 75 percent of all outbound traffic travels on this segment, and 54 percent of all inbound traffic. Intrastate traffic is concentrated on the NECR between its interchange with Canadian National (CN) near the Canadian border and Burlington—69 percent of intrastate traffic by tonnage uses these segments. The VTR segments between Rutland to Bellows Falls and Burlington to Rutland also carry 25 percent and 29 percent of intrastate traffic.

2.3 Future Freight Rail System Commodity Flows

Between 2018 and 2045, the total rail freight traffic over Vermont's rail system is projected to reach 21 million tons, a 208 percent increase. This same traffic measured in terms of units, is expected to reach 406 thousand railcars, a 163 percent increase. The differences between the growth rates of traffic by units versus tons reflects the changing characterists of rail traffic. Intermodal shipments are expected to grow more rapidly, which increases the number units more than tonnage. Intermodal shipments are often more voluminous than heavy as intermodal contains more finished products than the raw materials that are shipped in bulk by carload.

These forecasts may be affected by changes in institutional relationships and ownership of key infrastructure in and surrounding Vermont. For example, CP's acquisition of the CMQ has introduced a Class I railroad into the northern portion of the State. The pending sale of Pan Am Railways (PAR) could further change the landscape and the service offerings that will be available to Vermont shippers.

Rail Traffic by Direction

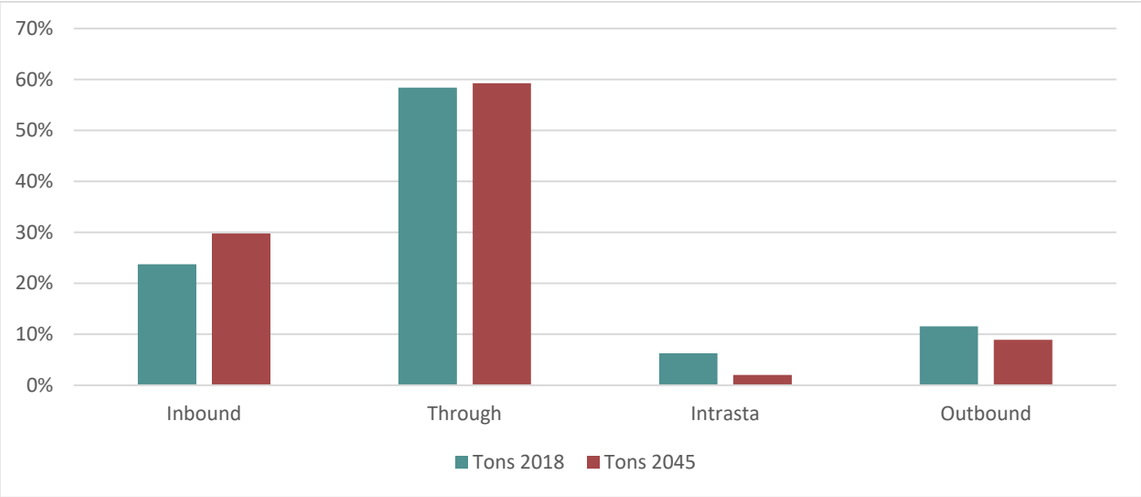
Rail traffic by direction is shown in Table 2.3 for 2018 and 2045. Figure 2.32 displays the proportion of rail traffic by tonnage and direction for 2018 and 2045. In 2018, 58 percent of rail traffic by weight was through traffic. In 2045, through traffic is expected to continue to comprise a majority of rail traffic in Vermont, approximately 59 percent. Intermodal tonnage is expected to grow 145 percent to 1.8 million tons in 2045, accounting for eight percent of total rail traffic by tons. Carload traffic is expected to comprise 92 percent of total rail traffic by tons in 2045, a projected growth of 216 percent to 19.5 million tons in 2045.

TABLE 2.3 RAIL TONNAGE BY DIRECTION, 2018 AND 2045 (IN THOUSAND OF TONS)

Direction	2018	2045	% Change 2018-2045
Inbound	1,639	6,338	287%
Through	4,035	12,606	212%
Intrastate	435	430	-1%
Outbound	797	1,896	138%
Total	**6,906**	**21,270**	**208%**

Source: STB Confidential Waybil Sample; FAF4; Analysis by Cambridge Systematics, 2020.

FIGURE 2.32 DIRECTION OF RAIL FREIGHT FLOWS BY WEIGHT, 2018 AND 2045



Source: STB Confidential Waybil Sample; FAF4; Analysis by Cambridge Systematics, 2020.

Top Rail Commodities

Nine of the top ten commodities in 2018 are expected to remain in the top ten commodities in 2045, as shown in Table 2.4 and Figure 2.33. Waste and scrap materials, the tenth commodity in 2018, will fall from the top 10 down to the 11th spot, and farm products rises from the 12th commodity in 2018 to the 9th commodity in 2045. The table below summarizes the expected changes for rail commodities by tonnage between 2018 and 2045. The top commodity by tonnage in 2018 was clay, concrete, glass, or stone products, and this commodity is expected to be the third largest commodity in 2045. Lumber or wood products and petroleum or coal products which were the second and third largest commodities in 2018 are expected to drop to the sixth and eighth spots by 2045.

In 2018 the top ten commodities accounted for 94 percent of the total rail traffic by tons, and 97 percent in 2045. Lumber or wood products and petroleum or coal products comprised 15 percent and 12 percent respectively of the 2018 tonnage. These commodities are expected to exhibit slow growth over the next twenty-five years, and their shares are expected to decrease to three percent and two percent respectively by 2045. Pulp, paper or allied products and nonmetallic minerals are expected to increase substantially between 2018 and 2045, 797 percent and 719 percent respectively. Farm products will nearly triple between 2018 and 2045, a 278 percent increase.

TABLE 2.4 RAIL COMMODITIES, 2018 AND 2045 (IN THOUSANDS OF TONS)

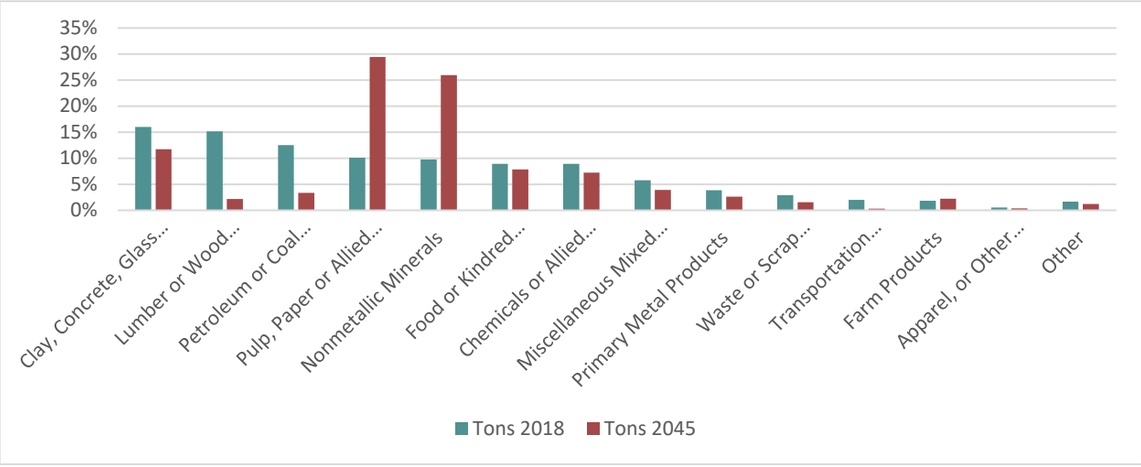
STCC	Commodity	2018 Tons	2045 Tons	% Change 2018-2045
32	Clay, Concrete, Glass or Stone Products	**1,105,320**	**2,500,198**	126%
24	Lumber or Wood Products	**1,047,420**	**465,248**	-56%
29	Petroleum or Coal Products	**862,868**	**709,699**	-18%
26	Pulp, Paper or Allied Products	**698,040**	**6,261,182**	797%
14	Nonmetallic Minerals	**675,136**	**5,526,296**	719%
20	Food or Kindred Products	**616,440**	**1,666,345**	170%
28	Chemicals or Allied Products	**614,942**	**1,536,762**	150%
46	Miscellaneous Mixed Shipments	**398,680**	**831,651**	109%
33	Primary Metal Products	**268,400**	**553,668**	106%
40	Waste or Scrap Materials	**200,088**	330,589	65%
37	Transportation Equipment	139,560	69,764	-50%
01	Farm Products	125,716	**475,215**	278%
23	Apparel, or Other Finished Textile Products or Knit Apparel	39,440	82,005	108%

42	Containers, Carriers or Devices, Shipping, Returned Empty	37,760	78,768	109%
30	Rubber or Miscellaneous Plastics Products	30,600	54,956	80%
36	Electrical Machinery, Equipment or Supplies	11,200	37,601	236%
41	Miscellaneous Freight Shipments	6,800	8,778	29%
39	Miscellaneous Products of Manufacturing	5,600	12,157	117%
09	Fresh Fish or Other Marine Products	5,280	11,732	122%
25	Furniture or Fixtures	4,800	11,029	130%
34	Fabricated Metal Products	3,400	9,780	188%
35	Machinery	2,800	9,679	246%
27	Printed Matter	2,000	6,348	217%
38	Instruments, Photographic Goods, Optical Goods, Watches or Clocks	1,600	2,671	67%
48	Hazardous Wastes	1,520	17,722	1066%
22	Textile Mill Products	400	510	28%
Total		**6,905,810**	**21,270,351**	**208%**

Note: ***Bold*** *text indicates the top ten commodities.*

Source: STB Confidential Waybil Sample; FAF4; Analysis by Cambridge Systematics, 2020.

FIGURE 2.33 DISTRIBUTION OF RAIL COMMODITIES BY WEIGHT (2018 AND 2045)



Source: STB Confidential Waybil Sample; FAF4; Analysis by Cambridge Systematics, 2020.

Table 2.5 and Figure 2.34 show the distribution of commodities by equipment type or units (e.g., boxcars, flatcars, intermodal units, etc.). The top commodity in 2018 by units was freight-all-kinds (i.e., miscellaneous mixed shipments moving as intermodal shipments) accounting for 25 percent or 39,000 containers of the total rail units. By 2045, freight-all-kinds are expected to grow 109 percent to 81,000 containers—a 20 percent share of the 2045 rail units. Pulp, paper or allied products accounted for 12 percent or 18,000 units in 2018 and is expected to grow 471 percent to 104,000 units (26 percent of the total 2045 rail units). Another commodity with a substantial growth factor is nonmetallic minerals, which is expected to increase 700 percent between 2018 and 2045, representing 4 percent of the total 2018 rail units and 14 percent of the total 2045 rail units.

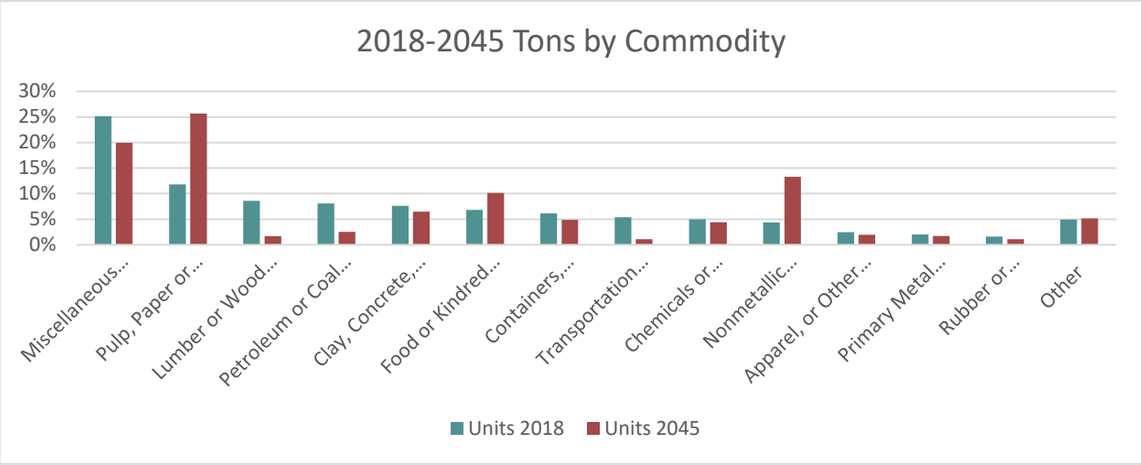
TABLE 2.5 RAIL COMMODITIES BY UNIT (2018 AND 2045)

STCC	Commodity	2018 Units	2045 Units	Percent Change 2018-2045
46	Miscellaneous Mixed Shipments	38,760	80,854	109%
26	Pulp, Paper or Allied Products	18,240	104,114	471%
24	Lumber or Wood Products	13,300	6,763	-49%
29	Petroleum or Coal Products	12,500	10,310	-18%

STCC	Commodity	2018 Units	2045 Units	Percent Change 2018-2045
32	Clay, Concrete, Glass or Stone Products	11,720	26,355	125%
20	Food or Kindred Products	10,556	41,240	291%
42	Containers, Carriers or Devices, Shipping, Returned Empty	9,440	19,692	109%
37	Transportation Equipment	8,272	4,351	-47%
28	Chemicals or Allied Products	7,680	17,925	133%
14	Nonmetallic Minerals	6,736	53,857	700%
23	Apparel, or Other Finished Textile Products or Knit Apparel	3,840	7,984	108%
33	Primary Metal Products	3,120	7,047	126%
30	Rubber or Miscellaneous Plastics Products	2,520	4,363	73%
40	Waste or Scrap Materials	2,156	4,306	100%
01	Farm Products	1,536	5,338	248%
36	Electrical Machinery, Equipment or Supplies	1,120	3,760	236%
39	Miscellaneous Products of Manufacturing	560	1,216	117%
25	Furniture or Fixtures	480	1,103	130%
41	Miscellaneous Freight Shipments	440	815	85%
34	Fabricated Metal Products	360	1,032	187%
35	Machinery	280	968	246%
09	Fresh Fish or Other Marine Products	200	400	100%
27	Printed Matter	200	635	217%
38	Instruments, Photographic Goods, Optical Goods, Watches or Clocks	160	267	67%
48	Hazardous Wastes	80	933	1066%
22	Textile Mill Products	40	51	28%
Total		**154,296**	**405,677**	**163%**

Source: STB Confidential Waybil Sample; FAF4; Analysis by Cambridge Systematics, 2020.

FIGURE 2.34 DISTRIBUTION OF RAIL COMMODITIES BY UNITS (2018 AND 2045)



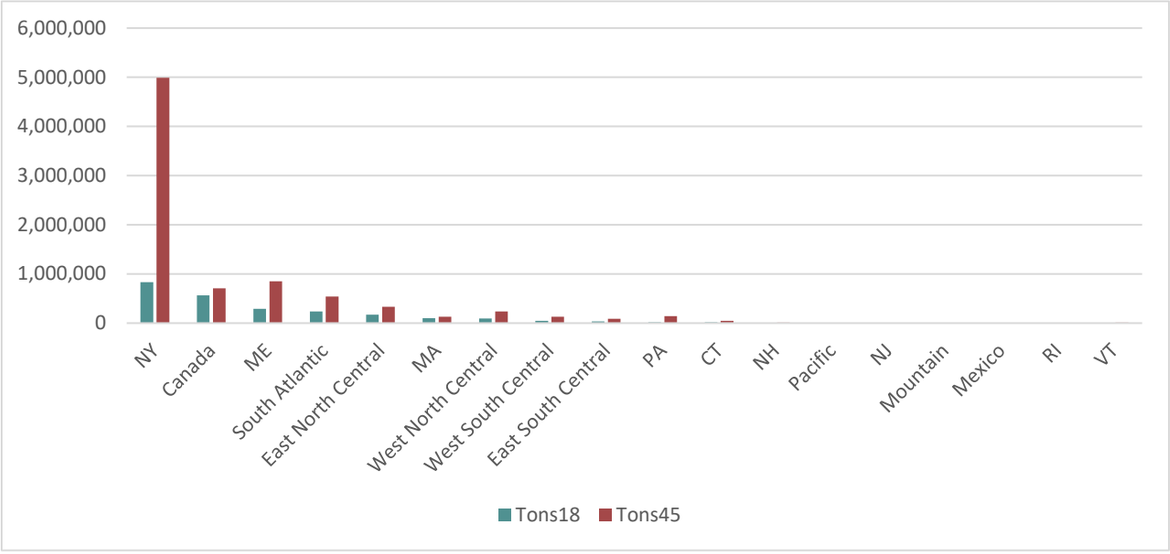
Source: STB Confidential Waybil Sample; FAF4; Analysis by Cambridge Systematics, 2020.

Top Rail Trading Partners

Figure 2.35 shows the current and future tonnage for Vermont's top rail trading partners in 2018 and 2045. These trading partners represent other states or countries that are receiving or shipping rail traffic from or to Vermont, it excludes through and intrastate traffic. By 2045, New York and Maine are projected to

account for 71 percent of traffic by tons. This an increase in concentration from 2018, during which the two states accounted for only 46 percent of the total traffic by tons. In 2018, Canada and the South Atlantic accounted for 33 percent of the total traffic by tons, by 2045, these shares will be reduced to 16 percent, despite projected growth (25% with Canada and 125% with the South Atlantic) in the volume of goods traded wth each of these two regions over the forecast period.

FIGURE 2.35 TOP RAIL TRADING PARTNERS BY TONS (2018 AND 2045)



Source: STB Confidential Waybil Sample; FAF4; Analysis by Cambridge Systematics, 2020.

New York will continue to be the top trading partner in 2045 and Maine will come in a close third to Canada. New York trade traffic with Vermont is projected to grow 499 percent to 5.0 million tons (61 percent) of Vermont's inbound and outbound rail traffic by tons. This substantial increase is driven by the high growth of traffic inbound to Vermont from New York. By 2045, Vermont's trade with Canada is expected to increase 25 percent to 710,000 tons, though the large growth in trade with New York means the share of total trade will decrease to nine percent. By 2045, trade with Maine is expected to increase by 191 percent to 851,000 tons, though again the large increase in trade with New York means the share of trade will decrease to 10 percent. By 2045, South Atlantic shipments are expected to grow by 125 percent to 540,000 tons representing seven percent of the inbound and outbound trade.

2.4 Rail Customer Diversity Analysis

In the 2015 Vermont Rail Plan, it was established that the vast majority of Vermont's rail tonnage is handled by a small number of rail users, that rail traffic projections are sensitive to changes to these large rail users, and that Vermont is interested in diversifying and expanding the railroad customer base so that rail traffic would be less dependent on a small number of shippers. The following analysis presents a methodology for measuring rail user diversity over time and presents how rail diversity has changed since the 2015 Vermont Rail Plan. For the purposes of this study, diversity is an indicator of the balance and proportion of rail traffic volumes between Vermont's rail users.

Estimation of Rail Users

As specific rail users or companies are not revealed in the STB waybill data, a proxy for the number of rail users was developed. Identification of potential customers was accomplished by using a combination of Freight Station Accounting Codes (FSAC) to identify the origin and destination of the waybills and two-digit STCC, as most rail users typically handle a small number of distinct commodites. The estimation of rail users was approximated by the direction of rail traffic and the unique combinations of commodities (STCC2) and FSAC. A single FSAC identifies a freight station that may serve multiple shippers. Adding commodity at the 2-digit STCC level aids in identifying multiple shippers at a single FSAC. While a more granular commodity classification could potentially reveal additional shippers, the greater granularity substantially raises the risk

of estimating more rail customers than are actually present at a particular station. Using STCC-2 with FSAC strikes a balance between commodities and freight stations that is appropriate for Vermont shippers.[8,9]

Rail User Diversity Index

The index used to measure rail user diversity is simple in concept and used to measure diversity within several contexts. In ecosystems, the index is called the Simpson index and is used to measure the diversity across a population. In economics, the index is called the Herfindahl–Hirschman index and is used to measure the proportion of market share across firms to identify monopolies. The rail user diversity index developed for this study measures the evenness of proportions of volumes shipped or received by rail users in Vermont. The rail user diversity index ranges between zero and one. A low index indicates more diversity (less concentration), and a high index indicates low diversity (more concentration). The index can approach zero as the number of rail users (*N*) increases. The minimum for the index is always 1/*N* and the larger that *N* is, the closer the index is to zero, and as the index approaches zero the diversity improves. The rail user diversity index formula is below.

$$Rail\ User\ Diversity\ Index\ (D) = \sum_{i=1}^{N} s_i^2$$

Where *N* is the number of rail users as approximated using the combination of FSAC and STCC2 discussed in Section 0 and s_i is the market share of the rail user. Market share is defined as the annual tons per rail user by direction, divided by the overall tons moved in that direction, as shown in the formula below.

$$Market\ share\ (s_i) = \frac{tons_{per\ rail\ user,\ \ by\ direction}}{total\ tons_{all\ rail\ users,\ \ by\ direction}}$$

In general terms, the rail user diversity index results can be classified in the following categories:

- D below 0.01 indicates a highly competitive industry,
- D below 0.15 indicates an unconcentrated industry,
- D between 0.15 to 0.25 indicates moderate concentration,
- D above 0.25 indicates high concentration.[10]

The reciprocal diversity index provides a more basic understanding of diversity by indicating the equivalent number of equal-sized firms in the market. A small rail user diversity index indicates a competitive industry without dominant rail users. A large rail user diversity index indicates a concentrated industry dominated by a small number of rail users. When firms have unequal shares, the reciprocal of the index indicates the "equivalent" number of rail users of equal volumes of traffic. The reciprocal diversity index formula is below.

$$Reciprocal\ Diversity\ Index = Equivalent\ Number\ of\ Equal\ Volume\ Rail\ Users = \frac{1}{D}$$

Rail User Diversity Analysis

The rail user diversity analysis was applied to Vermont rail traffic for the years 2016, 2017, and 2018. The first step to calculate the rail user diversity index is to estimate the number of rail users by direction (*N*). Only the rail users receiving goods in Vermont or shipping goods from Vermont were assessed. Intrastate traffic has Vermont rail users at both ends of the rail shipment, and the shipper and receiver are identified individually. The number of rail users by direction and year are shown in Figure 2.36 and Table 2.6 The number of inbound rail users increased 24 percent and the number of outbound rail users decreased seven percent

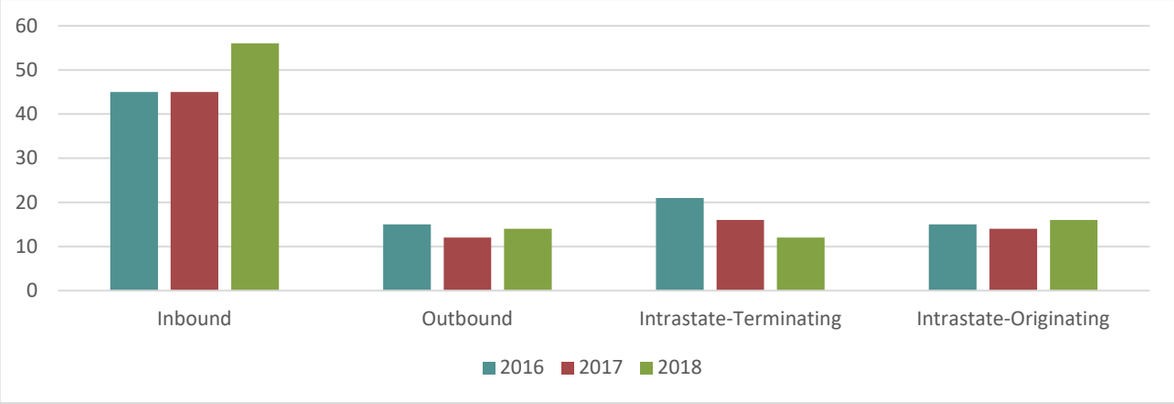
[8] United State Interstate Commerce Commission. "Interstate Commerce Commission Reports: Decisions of the Interstate Commerce Commission of the United States." U.S. Government Printing Office, 1987. Digitized Feb 25, 2013.

[9] U.S. FHWA. "Appendix C: Intermodal Transportation and Inventory Cost Model." Comprehensive Truck Size and Weight Limits Study - Modal Shift Comparative Analysis Technical Report. June 2015. https://ops.fhwa.dot.gov/freight/sw/map21tswstudy/technical_rpts/mscanalysis/app_c_cost_model.htm

[10] https://en.wikipedia.org/wiki/Herfindahl%E2%80%93Hirschman_Index#cite_note-5

between 2016 and 2018. Intrastate rail shippers increased seven percent and intrastate receivers declined 43 percent between 2016 and 2018, which indicates that the Vermont businesses shipping products within Vermont has increased slightly, but the number of Vermont businesses receiving products from within Vermont has decreased significantly. Between 2016 and 2018, Vermont shippers (Outbound and Intrastate-Originating rail users) have remained constant and receivers (Inbound and Intrastate-Terminating rail users) have increased.

FIGURE 2.36 NUMBER OF RAIL USERS BY DIRECTION AND YEAR



Source: STB Confidential Waybill, 2016-2018.

TABLE 2.6 NUMBER OF RAIL USERS BY DIRECTION AND YEAR

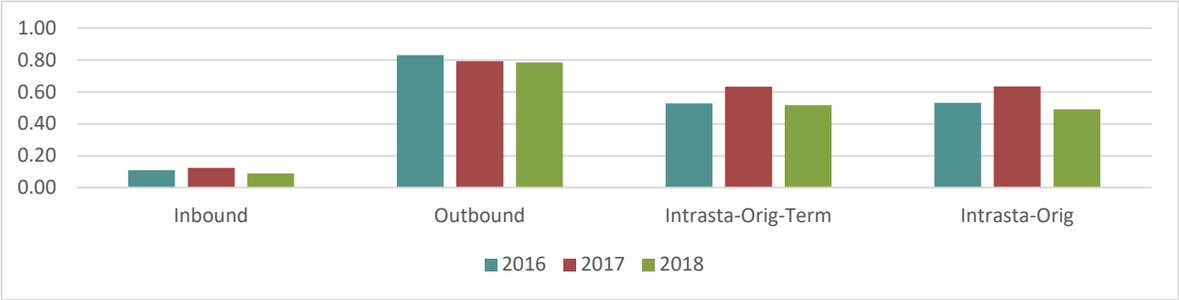
DIRECTION	2016	2017	2018	3-YEAR PERCENT CHANGE
Inbound (receiver)	45	45	56	24%
Outbound (shipper)	15	12	14	-7%
Intrastate-Terminating (receiver)	21	16	12	-43%
Intrastate-Originating (shipper)	15	14	16	7%

Source: STB Confidential Waybill, 2016-2018.

After calculating the number of rail users by direction and year, the index is calculated by squaring the sum of market share (s_i) for each rail user by direction and year. The rail user diversity index by year and direction is shown in Figure 2.37 and Table 2.7. Key observations of this analysis include:

- The inbound rail user diversity index indicates the rail traffic being received in Vermont is unconcentrated among rail users and exhibits more shipper diversity than rail traffic moving in other directions;
- Outbound traffic exhibits the least diversity, with fewer rail users contributing to outbound rail flows. Between 2016 and 2018;
- Intrastate traffic remains highly concentrated for both the shippers and receivers. Intrastate receivers had a two percent improvement in diversity between 2016 and 2018 and intrastate shippers had an eight percent improvement.
- Rail traffic moving in all directions (inbound, outbound, and intrastate) experienced an improvement in rail user diversity between 2016 and 2018. Between 2016 and 2018, rail user diversity for inbound traffic improved by 20 percent, outbound rail user diversity improved by five percent, and rail user diversity for intrastate traffic improved by eight percent for shippers and two percent for receivers.

FIGURE 2.37 RAIL USER DIVERSITY INDEX BY YEAR AND DIRECTION



Source: STB Confidential Waybill, 2016-2018.

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TABLE 2.7 RAIL USER DIVERSITY INDEX BY YEAR AND DIRECTION

DIRECTION	2016	2017	2018	3-YEAR PERCENT CHANGE
Inbound (receiver)	0.11	0.12	0.09	-20%
Outbound (shipper)	0.83	0.79	0.78	-5%
Intrastate-Terminating (receiver)	0.53	0.63	0.52	-2%
Intrastate-Originating (shipper)	0.53	0.63	0.49	-8%

Source: STB Confidential Waybill, 2016-2018.

Note: Rail User Diversity Index Values:

- *Below 0.01 indicates a highly competitive industry,*
- *Between 0.01 and 0.15 indicates an unconcentrated industry,*
- *Between 0.15 to 0.25 indicates moderate concentration,*
- *Above 0.25 indicates high concentration.*

Combining the number of rail users shown in with the rail user diversity index results in Table 2.7 provides more insight into how the changes in rail user diversity relate to changes to the number of rail users versus an improvement in the balance of rail traffic between rail users. Key conclusions include:

- The number of inbound rail users increased 24 percent and diversity improved by 20 percent between 2016 and 2018. These results indicate the inbound rail traffic is rather equally proportioned between rail users and that the new rail users helped balance out the diversity even more.

- There was some improvement in the balance of outbound traffic among rail users even though the number of rail users decreased. The diversity index for outbound rail users improved by five percent and the number of outbound rail users decreased slightly from 15 to 14 (a seven percent decline) between 2016 and 2018. Despite the modest improvement, outbound flows remain highly concentrated.

- The rail user diversity for intrastate-terminating rail users improved by two percent while the number of rail users decreased 43 percent between 2016 and 2018. The number of rail users declined but the proportions between the rail users became more equal—the group is still highly concentrated and the reduction in rail users only had a small effect on the diversity.

- The number of intrastate-originating rail users increased by seven percent between 2016 and 2018 and the rail user diversity index improved by eight percent. The increased number of rail users helped to improve the diversity, but there are still some dominant rail users in that group that are skewing the diversity.

The reciprocal rail user diversity index provides simpler perspective on the rail user diversity index by indicating the equivalent number of equal volume rail users in each direction. The results of the reciprocal

diversity index by direction and year are shown in Table 2.8. From this viewpoint, the inbound rail users experienced the most significant change between 2016 and 2018, indicating a 24 percent increase in the equivalent number of equal volume rail users. Each of the directions experienced a positive change to the equivalent number of equal volume rail users.

TABLE 2.8 RECIPROCAL DIVERSITY INDEX (EQUIVALENT NUMBER OF EQUAL VOLUME RAIL USERS)

DIRECTION	2016	2017	2018	3-YEAR PERCENT CHANGE
Inbound (receiver)	9	8	11	24%
Outbound (shipper)	1	1	1	6%
Intrastate-Terminating (receiver)	2	2	2	2%
Intrastate-Originating (shipper)	2	2	2	8%

Source: STB Confidential Waybill, 2016-2018.

The categorical results of the rail user diversity by year and direction are shown in Table 2.9 below. There have not been categorical changes between these years. Rail user diversity has improved for each direction, but only inbound traffic can be considered unconcentrated, and this has not changed since 2015.

TABLE 2.9 RAIL USER DIVERSITY BY YEAR AND DIRECTION

DIRECTION	2016	2017	2018
Inbound (receiver)	Unconcentrated industry	Unconcentrated industry	Unconcentrated industry
Outbound (shipper)	High concentration	High concentration	High concentration
Intrastate-Originating (shipper)	High concentration	High concentration	High concentration
Intrastate-Terminating (receiver)	High concentration	High concentration	High concentration

Source: STB Confidential Waybill, 2016-2018.

3.0 RELATED SOCIO-ECONOMIC FACTORS

3.1 Overview

Freight plays a large role in Vermont's economy, and the performance of Vermont's economy influences freight demand and output. Growth in population and consumer spending fuel demand for durable goods and other consumer products and construction materials to build or improve homes. Growth in consumer demand contributes to growth in manufacturing, wholesale, retail, and other industry sectors that produce and distribute those goods. Growth in those industry sectors contributes to more population and economic growth, and the continues. Approximately 1/3rd of Vermont's jobs and gross domestic product (GDP) are derived from the eight industries identified as freight-reliant. That number grows to approximately 40 percent in terms of number of employers and total salary brought home by workers in those industries.

Other socio-economic factors, includingaverage income, educational attainment, the cost of energy, and labor productivity, also play a role in the State's economic competitiveness with other states, and are among the factors that many freight-generating businesses consider when deciding where and when to move or expand

Table 3.1 below highlights some of these socio-economic factors and compares Vermont to neighboring states and the U.S. Compared to neighboring states, Vermont offers comparable levels of taxation and educational attainment.Vemont's agricultural and mining/quarying industries have higher labor productivity (meaning fewer employees and associated labor costs per dollar of output) than neighboring states,, though the manufacturing and transportation/warehousing sectors in Vermont have lower labor productivity than neighboring states and the U.S. Education levels, tax rates, and energy costs are relatively level between Vermont and its neighbors, as were pre-COVID unemployment rates. Vermont average wages are lower than neighboring states though the state lacks the major urban centers which contribute to higher wages in New York and Massachusetts.

TABLE 3.1 COMPARITIVE SOCIO-ECONOMIC STASTISTICS

COMPETITIVE ELEMENT	METRIC	VERMONT	NEW HAMPSHIRE	MASSACHUSETTS	NEW YORK	UNITED STATES
Labor Productivity: Employees per Million Gross Product (2019)	Agriculture (including forestry/fishing)	8.1	9.5	12.4	9.6	*7.5*
	Mining, Quarrying, Oil & Gas	3.6	10.4	3.2	5.4	*2.1*
	Manufacturing	9.3	7.1	4.7	6.1	*9.5*
	Transportation & Warehousing	11.7	11.1	8.0	8.0	*8.0*
Wage Rate (2019)	Annual Average Wage	$49,328	$58,698	$75,453	$75,354	*$59,219*
Labor Force (2019)	Unemployed Rate	2.4%	2.5%	2.9%	4.0%	*3.7%*
Educational Attainment (2018)	Percent of adults (age 25+) with a bachelor's degree or higher	38.7%	36.8%	44.5%	37.2%	*32.1%*
Level of Taxation (2019)	Effective State and Local Tax Rate on Median U.S. Household	11.44%	10.02%	10.87%	13.92%	*10.78%*
Energy Cost (2018)	Total Energy Price per 2015 Dollars per Million Btu	$23.09	$24.54	$24.90	$21.15	*$18.62*

Sources: U.S. BEA, U.S. BLS, U.S. EIA, U.S. Census. Level of taxation from Wallethub.com.

Note: Labor productivity is calculated as industry GDP divided by employment. The lower the number, the fewer employees are required to produce $1 million in GDP, signifying a more productive industry.

Note: Green shading indicates best value in a given category, red indicates the worst value in a given category, orange represents the two middle vlaues in each category.

3.2 Demographic and Economic Growth Factors

Population

Table 3.2 shows Vermont's population by county for 2010 (last Census) and 2017-2019 (US Census Estimates). Vermont's population has been relatively steady over the last ten years, decreasing in total by approximately 0.3 percent. However, there have been shifts at the county level with growth in Chittenden (Burlington), Grand Isle, Lamoille, and Franklin counties and reductions in all other counties. Rutland County has seen the largest percent drop of any county in the State, decreasing by 5.51 percent. The counties with growth are all in the northwest of the State and include the areas in and around Burlington which is the State's largest city.

TABLE 3.2 VERMONT POPULATION (2010, 2017-2019)

COUNTY	2010 POP.	2017 POP.	2018 POP.	2019 POP.	TOTAL CHANGE IN POP. (2010-2019)	% CHANGE POP. (2010-2019)
ADDISON	36,821	36,900	36,873	36,777	-44	-0.12%
BENNINGTON	37,125	35,675	35,520	35,470	-1,655	-4.34%
CALEDONIA	31,227	30,141	30,236	29,993	-1,234	-3.76%
CHITTENDEN	156,545	163,031	163,571	163,774	7,229	4.47%
ESSEX	6,306	6,184	6,234	6,163	-143	-2.36%
FRANKLIN	47,746	48,969	49,258	49,402	1,656	3.31%
GRAND ISLE	6,970	6,975	7,110	7,235	265	4.13%
LAMOILLE	24,475	25,360	25,295	25,362	887	3.46%
ORANGE	28,936	28,964	28,888	28,892	-44	-0.18%
ORLEANS	27,231	26,811	26,859	27,037	-194	-0.76%
RUTLAND	61,642	59,006	58,596	58,191	-3,451	-5.51%
WASHINGTON	59,534	58,253	58,079	58,409	-1,125	-1.95%
WINDHAM	44,513	42,851	42,635	42,222	-2,291	-5.12%
WINDSOR	56,670	55,224	55,204	55,062	-1,608	-2.72%
TOTAL	**625,879**	**624,344**	**624,358**	**623,989**	**-1,890**	**-0.30%**

Source: US Census.

Based on the 2010 Census, Vermont's Department of Health projected a 2030 population of approximately 670,000 persons. However, that estimate appears to be high considering that recent demographic trends show a slight decrease in population since 2010.[11]

However, where people choose to live over the next decade may shift as COVID-19 continues to impact the United States. For example, many in the business world predict that COVID-19 will increase opportunities for people to work and learn remotely, potentially increasing population in areas with lower costs of living.[12] In addition, people may be more interested in living in rural or small towns instead of larger cities due to the

[11] https://dail.vermont.gov/sites/dail/files/documents/vt-population-projections-2010-2030.pdf

[12] https://www.fastcompany.com/90486053/all-the-things-covid-19-will-change-forever-according-to-30-top-experts

ease of transmission. As of August 2020, Vermont has the lowest positivity rate in the U.S.[13] All of these factors may make Vermont more appealing, driving future population growth.

Gross Domestic Product, Employment, and Location Quotient

Table 3.3 shows gross domestic product (GDP) by county for 2014-2018. This is an overall measure of the productivity of industries within each county and includes all sectors of employment. Between 2010 and 2018, Addison County saw the sharpest GDP growth of all Vermont counties, growing almost double the amount of the next highest county, Lamoille. While Addison County is served by freight rail on the Vermont Rail System (VRS) network (and will have a passenger rail stop in Middlebury beginning 2021), there is currently no active rail infrastructure in Lamoille County. Chittenden and Franklin counties in Northeastern Vermont also saw greater than five percent GDP growth over the past decade and are both well served by the NECR and VRS. However, Rutland County, which has a high density of rail infrastructure, including the VTR, Clarendon & Pittsford (CLP) and Green Mountain Railroad (GMRC) as well as Amtrak service to New York City, has seen some of the state's slowest GDP growth, and has concurrently lost the most residents of any county in the state between 2010 and 2019.

TABLE 3.3 VERMONT GROSS DOMESTIC PRODUCT (2014-2018), CHAINED 2012 DOLLARS

COUNTY	2014 GDP ($ BILLIONS)	2015 GDP ($ BILLIONS)	2016 GDP ($ BILLIONS)	2017 GDP ($ BILLIONS)	2018 GDP ($ BILLIONS)	% CHANGE 2014-2018 GDP
ADDISON	$1.354	$1.380	$1.472	$1.517	$1.520	12.29%
BENNINGTON	$1.470	$1.468	$1.484	$1.485	$1.523	3.59%
CALEDONIA	$1.015	$0.999	$1.024	$1.013	$1.024	0.91%
CHITTENDEN	$9.871	$10.037	$10.219	$10.256	$10.466	6.02%
ESSEX	$0.133	$0.135	$0.135	$0.135	$0.136	2.53%
FRANKLIN	$1.651	$1.723	$1.712	$1.714	$1.734	5.01%
GRAND ISLE	$0.154	$0.153	$0.153	$0.155	$0.156	1.15%
LAMOILLE	$1.028	$1.053	$1.057	$1.061	$1.101	7.13%
ORANGE	$0.721	$0.735	$0.742	$0.733	$0.754	4.63%
ORLEANS	$0.924	$0.938	$0.908	$0.950	$0.968	4.82%
RUTLAND	$2.425	$2.456	$2.477	$2.481	$2.470	1.86%
WASHINGTON	$3.363	$3.312	$3.438	$3.419	$3.403	1.20%
WINDHAM	$2.168	$2.242	$2.211	$2.168	$2.176	0.37%
WINDSOR	$2.245	$2.276	$2.332	$2.325	$2.325	3.55%
TOTAL	**$28.521**	**$28.906**	**$29.365**	**$29.411**	**$29.756**	**4.33%**

Source: US BEA, Table CAGDP1.

Table 3.4 shows the concentration of establishments (est.) and employees (emp.) by county and by North American Industry Classification System (NAICS) sector for freight-reliant industries. These industries rely on the state's freight system on a daily basis to support their core business functions. Retail trade dominates as this category and includes everything from a local store on a small village street to large multi-national retailers such as Walmart. Chittenden County with the State's population hub centered around Burlington dominates across most categories, but Addison and Franklin counties both have high numbers in the agriculture/forestry sector, and Rutland, Washington, and Windsor counties have substantial numbers of firms and employees across multiple sectors including manufacturing and wholesale trade.

The concentration of employees by Census Tract within these industry groups is also shown in Figure 3.1. The greatest concentrations are found in the western part of the state along the VTR line and along US 7.

[13] https://vtdigger.org/2020/08/09/vermont-bucks-the-trend-of-rural-covid-growth/

Outside this, the Brattleboro area and smaller areas near Montpelier, Barre, White River Junction, and St. Johnsbury also appear.

TABLE 3.4 VERMONT ESTABLISHMENTS AND EMPLOYEES BY COUNTY AND INDUSTRY (2018)

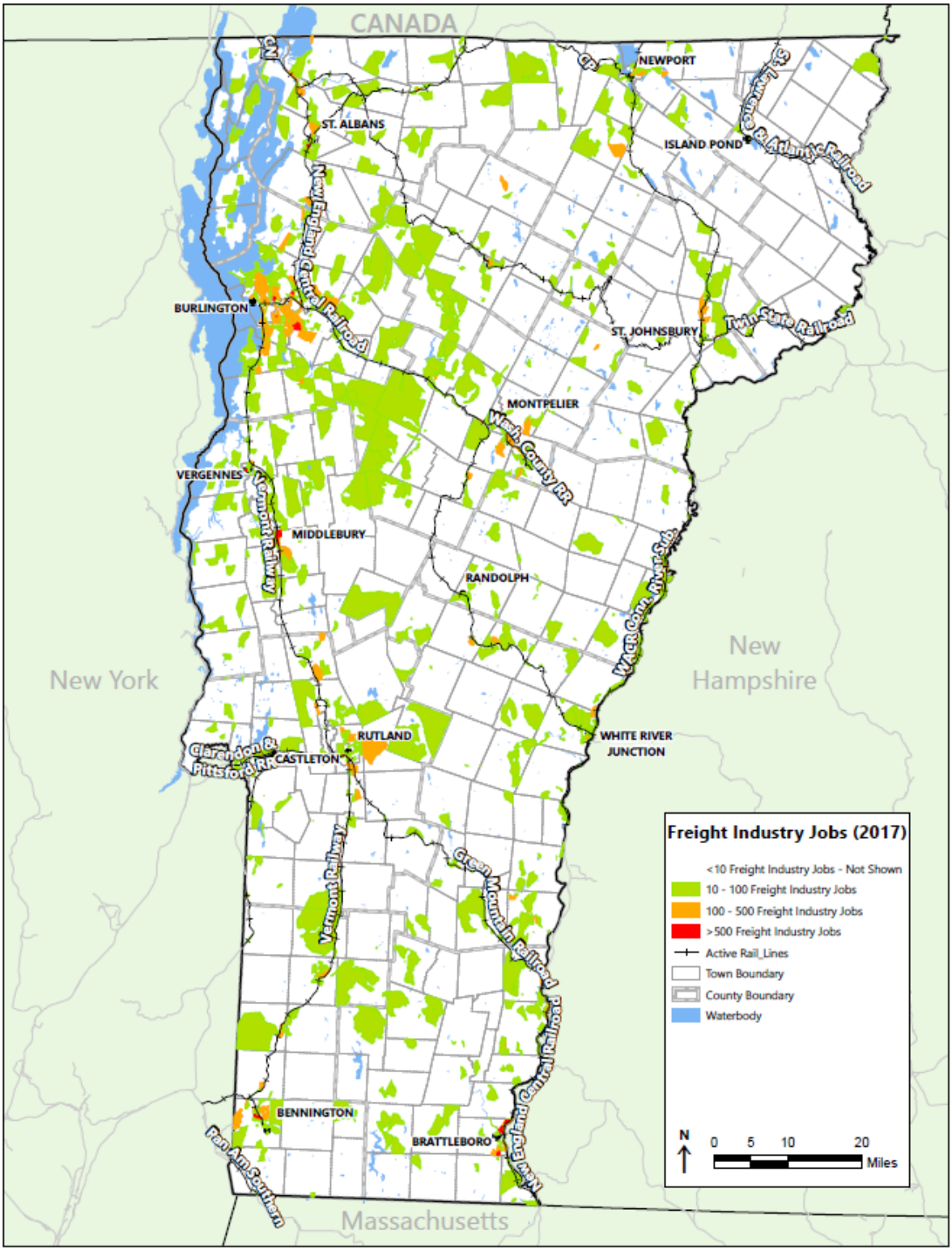
COUNTY	AGRICULTURE, FORESTRY, FISHING, AND HUNTING (11)		MINING, QUARRYING, AND OIL AND GAS EXTRACTION (21)		UTILITIES (22)		CONSTRUCTION (23)		MANUFACTURING (31-33)		WHOLESALE TRADE (42)		RETAIL TRADE (44-45)		TRANSPORTATION AND WAREHOUSING (48-49)	
	ESTABL.	EMP.	ESTABL.	EMP.	ESTABL.	EMP.	ESTABL.	EMP.	ESTABL.	EMP.	ESTABL.	EMP.	ESTABL.	EMP.	ESTABL.	EMP.
ADDISON	83	667	5	39	3	0	193	863	70	1920	64	200*	154	1,937	33	313
BENNINGTON	14	88	ND	ND	3	0	169	635	77	2,294	69	181	224	2,594	26	142*
CALEDONIA	21	100*	2	0	4	38	128	566	59	1,254	42	210	142	1,581	26	247
CHITTENDEN	44	234	5	46	5	0	639	5,201	254	9,583	430	3,403	773	12,278	137	2,201*
ESSEX	14	149	ND	ND	1	0	18	42	9	142	6	6*	16	77	8	22
FRANKLIN	78	566	3	25	5	32	150	529	56	2,588	66	517	166	2,284	52	822
GRAND ISLE	8	34*	1	0	1	0	39	111	7	57	12	10*	23	171	10	70
LAMOILLE	18	157*	2	0	3	0	158	790	43	550	53	171	143	1,450	25	98*
ORANGE	36	273	4	14	1	0	136	600	43	688	42	231	77	785	18	30*
ORLEANS	35	251*	2	0	3	0	137	638	44	1,329	36	159*	131	1,637	38	346
RUTLAND	32	90	17	313	6	380	290	1,459	106	2,938	124	735	350	3,624	48	665
WASHINGTON	24	129	6	62	9	210	257	1,301	123	2,261	150	887	316	3,962	43	507
WINDHAM	37	263*	2	0	5	99	220	975	96	2,341	98	997	213	2,456	42	438
WINDSOR	44	165	8	57	9	86	295	1,251	112	1,845	105	713	253	2,614	45	446
UNKNOWN/ UNDEFINED	5	34	ND	ND	ND	ND	51	301	10	36	171	598	17	83	15	83

Source: US BLS CQEW (2018). Note "ND" indicates there were no establishments or employees reported.

"0" indicates that returns were suppressed due to the limited number of firms in the industry/county.

**Indicates the value is a summary of available 3-digit NAICS sub-codes. The estimate is likely low due to some sub-codes being suppressed.*

FIGURE 3.1 VERMONT FREIGHT RELIANT INDUSTRY EMPLOYMENT BY CENSUS TRACT (2017)



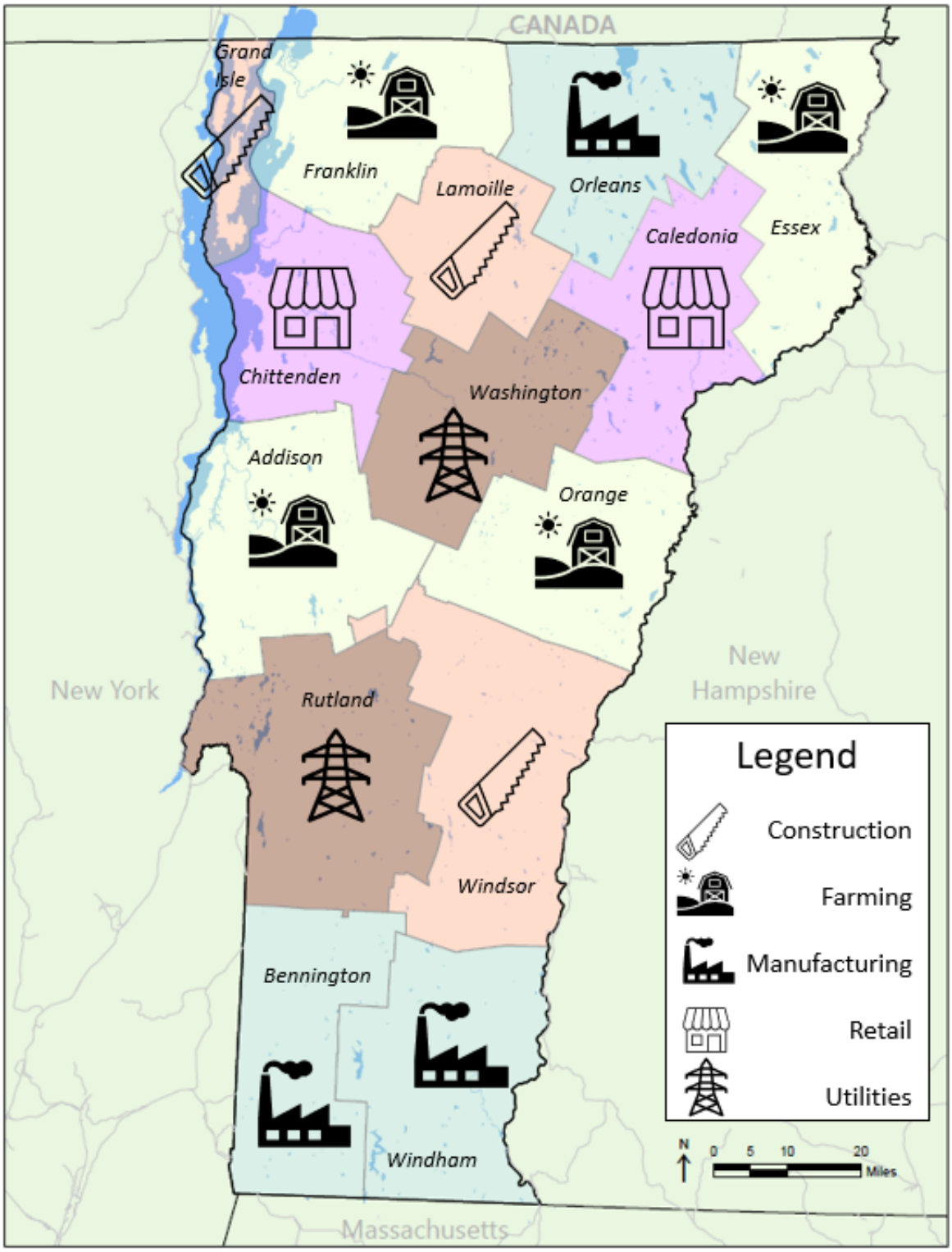
Source: US LODES WAC Data (2017); Analysis by Cambridge Systematics, 2020.

Another way to examine industry trends is through the concentration of employment in different industries using location quotient. This quantifies how concentrated a particular industry or cluster in a subdivision is relative to the geographic whole which can demonstrate which industries are particularly concentrated in some Vermont counties.

Table 3.5 shows the location quotient of each Vermont county in a selection of major industrial clusters by both the number of employers and the number of employees. Rutland County, which has extensive freight rail links, has the state's highest location quotient in the "Mining, Quarrying, and Oil and Gas Extraction" cluster. Freight rail is instrumental in the transport of both raw materials and processed minerals. For example, Omya, one of the state's largest employers, depends on VRS to haul marble from its quarry in Middlebury to its processing plant in Pittsford (Rutland County). In the Manufacturing cluster, Franklin County enjoys the highest location quotient in terms of employees in the state. The County benefits from the presence of the NECR which provides freight rail service and has access to intercity passenger rail through the *Vermonter*'s stop in St. Albans.

Figure 3.2 shows the top location quotient by employment in each County.

FIGURE 3.2 VERMONT COUNTIES – TOP INDUSTRIES BY EMPLOYMENT LOCATION QUOTIENT (2018)



Source: US BLS; Analysis by Cambridge Systematics, 2020.

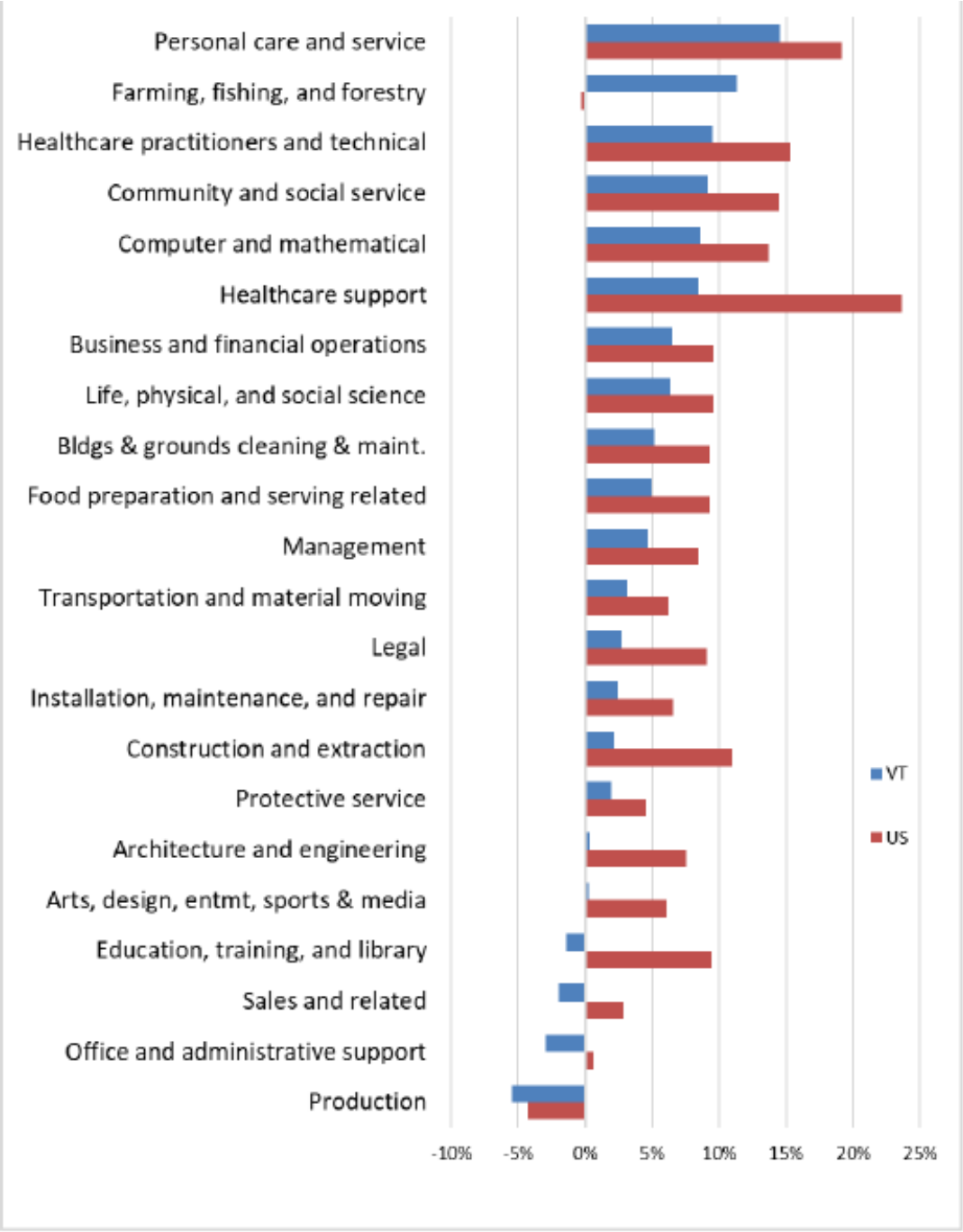
TABLE 3.5 VERMONT LOCATION QUOTIENT BY COUNTY AND INDUSTRY (2018)

COUNTY	AGRICULTURE, FORESTRY, FISHING, AND HUNTING (11)		MINING, QUARRYING, AND OIL AND GAS EXTRACTION (21)		UTILITIES (22)		CONSTRUCTION (23)		MANUFACTURING (31-33)		WHOLESALE TRADE (42)		RETAIL TRADE (44-45)		TRANSPORTATION AND WAREHOUSING (48-49)	
	LQ BY EST.	LQ BY EMP.	LQ BY EST.	LQ BY EMP.	LQ BY EST.	LQ BY EMP.	LQ BY EST.	LQ BY EMP.	LQ BY EST.	LQ BY EMP.	LQ BY EST.	LQ BY EMP.	LQ BY EST.	LQ BY EMP.	LQ BY EST.	LQ BY EMP.
ADDISON	5.45	5.15	1.07	0.57	1.13	ND	1.66	1.17	1.39	1.48	0.72	ND	1.03	1.20	0.91	0.59
BENNINGTON	0.85	0.59	-	-	1.04	ND	1.34	0.74	1.40	1.53	0.72	0.26	1.37	**1.38**	0.66	ND
CALEDONIA	1.96	ND	0.61	ND	2.14	0.94	1.56	1.07	**1.66**	1.36	0.67	0.49	1.34	1.37	1.02	0.65
CHITTENDEN	0.60	0.26	0.22	0.10	0.39	ND	1.13	1.03	1.04	1.08	1.00	0.83	1.06	1.11	0.78	ND
ESSEX	**7.64**	**15.61**	-	-	**3.13**	ND	1.29	0.77	1.48	1.49	0.56	ND	0.89	0.65	**1.84**	0.56
FRANKLIN	5.78	3.67	0.73	0.30	2.13	0.48	1.45	0.60	1.25	**1.68**	0.84	0.72	1.25	1.19	1.62	1.29
GRAND ISLE	3.06	ND	1.25	ND	2.19	ND	1.95	**1.88**	0.81	0.55	0.79	ND	0.89	1.33	1.61	**1.64**
LAMOILLE	1.46	ND	0.53	ND	1.39	ND	1.67	1.33	1.05	0.53	0.74	0.36	1.17	1.12	0.85	ND
ORANGE	4.05	4.07	1.47	0.39	0.65	ND	**2.00**	1.57	1.46	1.03	0.81	0.74	0.88	0.94	0.85	ND
ORLEANS	3.55	ND	0.66	ND	1.75	ND	1.82	1.17	1.35	1.39	0.63	ND	1.35	**1.38**	1.62	0.88
RUTLAND	1.28	0.39	**2.22**	**2.53**	1.38	**3.74**	1.52	1.10	1.28	1.26	0.86	0.68	**1.42**	1.25	0.81	0.69
WASHINGTON	0.53	0.45	0.71	0.40	1.87	1.66	1.21	0.79	1.34	0.78	0.93	0.66	1.16	1.10	0.65	0.43
WINDHAM	1.79	ND	0.32	ND	1.39	1.22	1.39	0.91	1.40	1.25	**1.80**	**1.15**	1.05	1.05	0.86	0.57
WINDSOR	1.75	0.82	1.04	0.53	2.05	0.98	1.53	1.09	1.34	0.92	0.72	0.76	1.02	1.04	0.75	0.54
UNKNOWN/ UNDEFINED	0.87	0.45	-	-	-	-	0.86	0.69	0.39	0.05	3.79	1.69	0.22	0.09	0.81	0.26

*US BLS QCEW (2018). Note: **Bold** data indicates the highest value within each NAICS category (LQ by establishment and LQ by employment)*

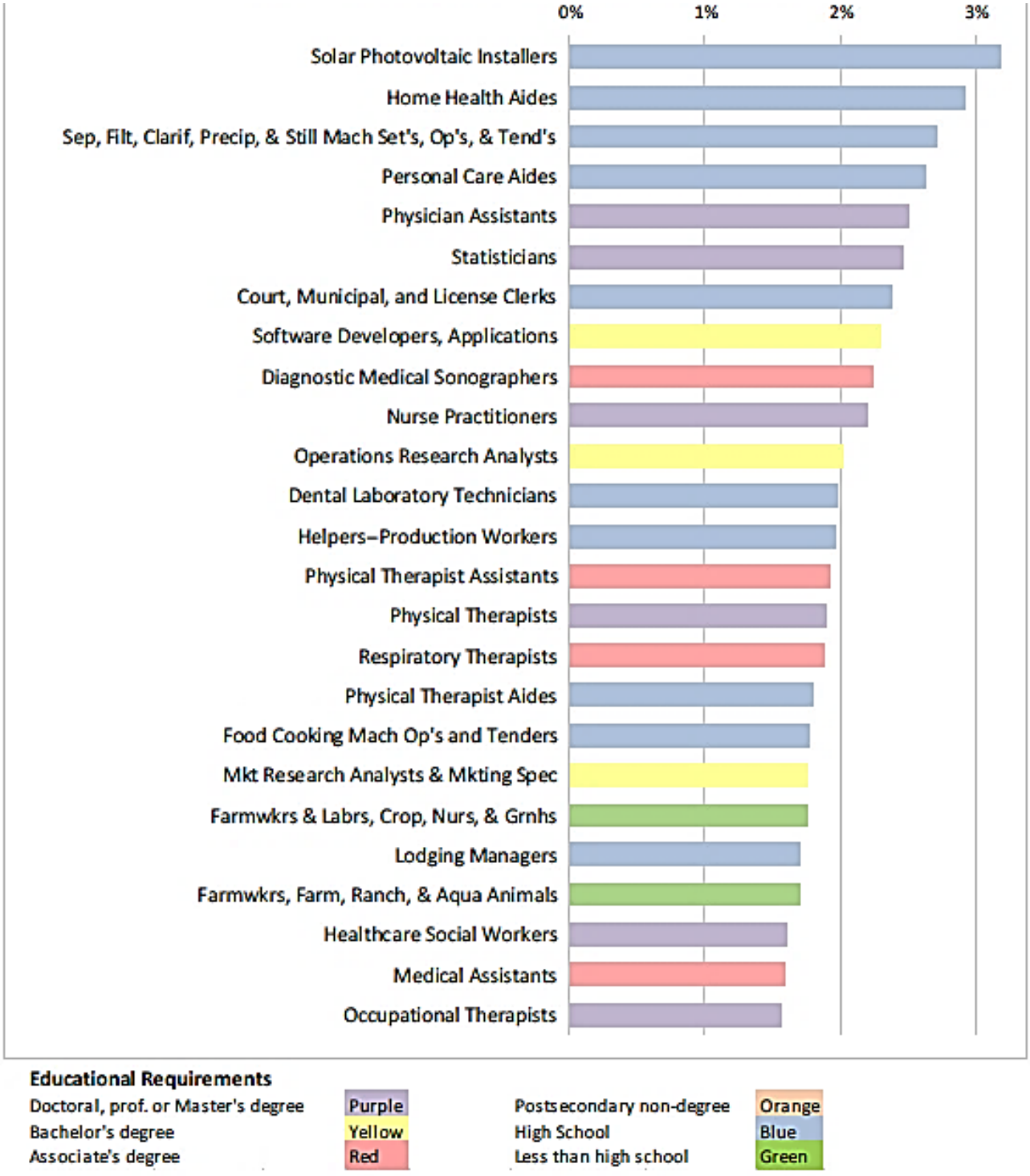
Looking into the future, the Vermont Department of Labor projects employment by major occupational groups out to 2026 (with 2016 base year). Those projections are shown in Figure 3.3 (by percent change) and Figure 3.4 (by annual average growth rate). Although much of the growth is projected in social services, education, and other non-freight reliant categories, the continued growth in farm, fishing, and forestry related jobs as well as transportation and construction/extraction will produce demand for freight rail service into the future.

FIGURE 3.3 PERCENT CHANGE IN EMPLOYMENT BY MAJOR OCCUPATIONAL GROUP (2016-2026), VERMONT (BLUE) AND UNITED STATES (RED)



Source: http://www.vtlmi.info/projlt.pdf

FIGURE 3.4 VERMONT TOP 25 OCCUPATIONS BY AVERAGE ANNUAL GROWTH RATE, 2018-2028



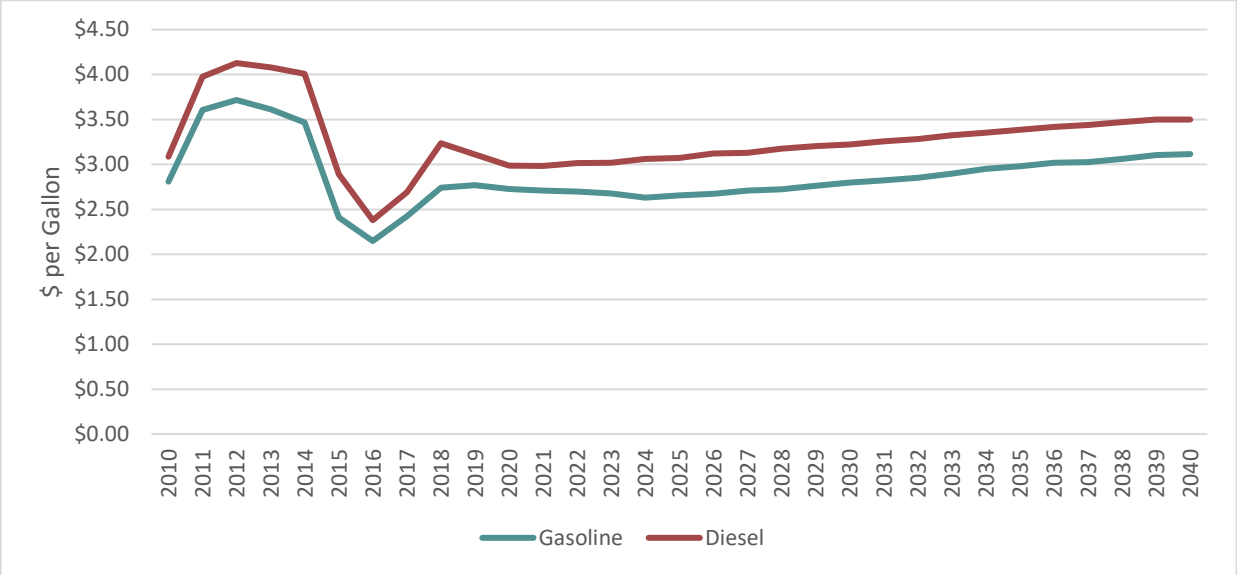
Source: http://www.vtlmi.info/projlt.pdf

3.3 Fuel Cost Trends

Figure 3.5 shows prices of gasoline and diesel in New England from 2010 to 2019 and projections for prices through 2040. Historic trends in the New England region generally mirror national trends with a peak in prices around 2012, a low in 2016, and rising prices to 2018 with a slight decline in 2019. However, overall costs compared to other regions has typically been higher. For example, the U.S. average cost per gallon of gasonline peaked at $3.62 in 2012 versus $3.71 in New England.

The price for gasoline is expected to grow by approximately 25 percent between 2015 and 2040, with diesel increasing 21 percent. For gasoline, short-term projections through 2024 indicate a slight decline in price. It should be noted that fuel prices are highly volatile, so forecasts are subject to error.

FIGURE 3.5 PRICE OF GASOLINE AND DIESEL FUEL (2019 DOLLARS PER GALLON) IN NEW ENGLAND (2010-2040)



Source: U.S. EIA.

Higher fuel prices provides favorable conditions for increasing usage of rail, as rail is more fuel efficient than truck or automobile transportation. Under typical conditions, trains can move one ton of freight 492 miles on one gallon of diesel fuel, whereas trucks can move one ton of freight about 120 miles on a gallon of diesel.[14] Intercity passenger trains can move one passenger approximately 58 miles per gasoline gallon-equivalent unit of fuel, compared to automobiles, which move a passenger 41.7 miles per gasoline gallon-equivalent.[15] Many factors, including adjustments to freight load factors, terrain and operating charactieristics, intercity rail ridership and car

[14] Rail fuel efficiency statistic sourced from: https://www.csx.com/index.cfm/about-us/the-csx-advantage/fuel-efficiency/; Truck fuel efficiency estimate was derived by multiplying fuel economy (estimated at 6 miles per gallon) by a load capacity assumption of 20 tons of freight per truck.

[15] https://afdc.energy.gov/data/10311

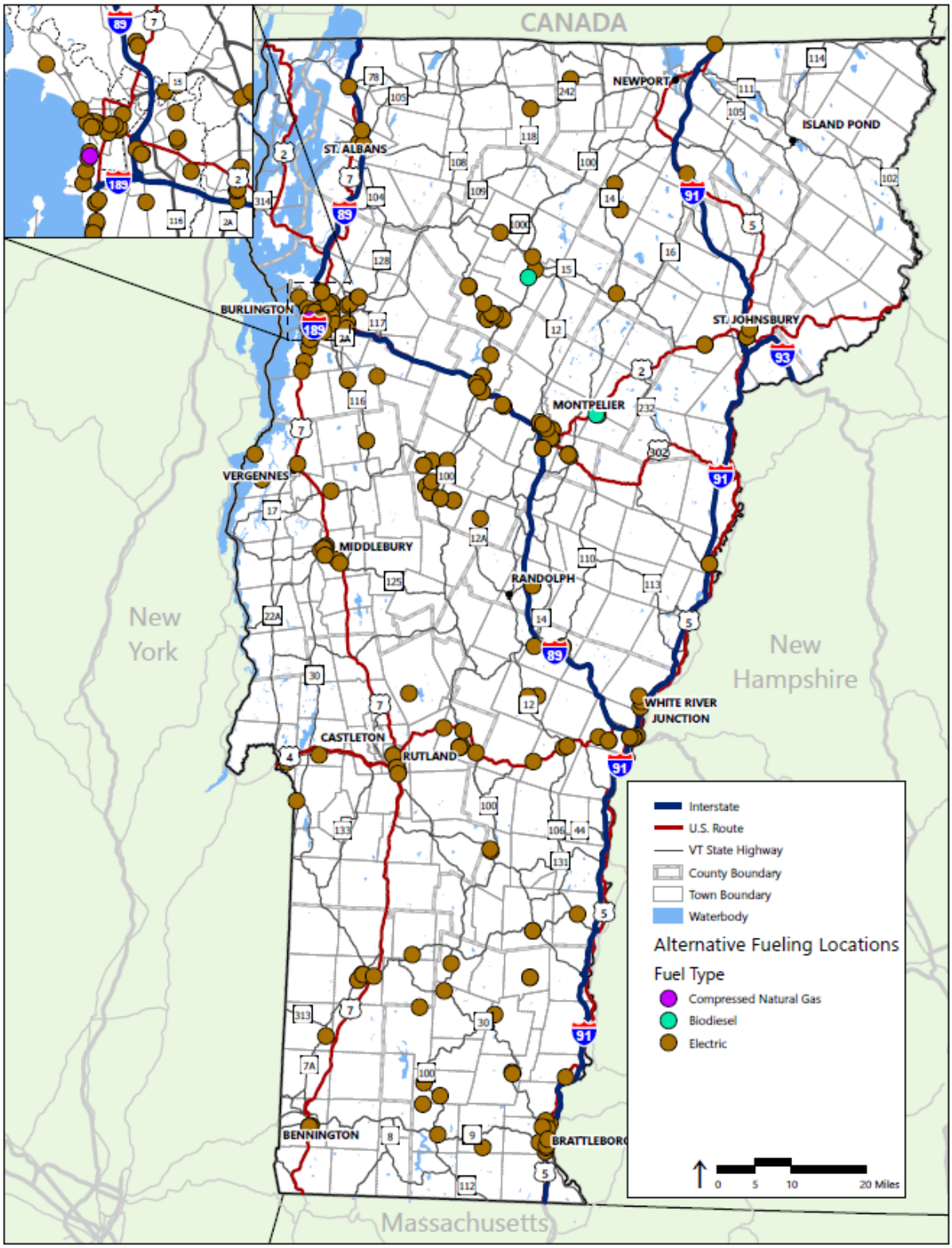
occupancy, among others, can influence these comparative statistics. However, these comparisons suggest that as fuel prices rise, rail becomes a relatively more cost-effective option for transporting people and goods.

However, the potential switch to rail due to rising fuel prices may in some part be offset by an expanding infrastructure of alternative fueling locations (and increasing number of vehicles).[16] Vermont has a network of more than 250 alternative fueling locations, the vast majority of which serve electric vehicles, some of which may be able to accommodate heavy duty vehicles, including trucks. These sites are shown in Figure 3.6.[17]

[16] https://afdc.energy.gov/states/vt

[17] More information about electric charging stations in Vermont can be found at Drive Electric Vermont, https://www.driveelectricvt.com/

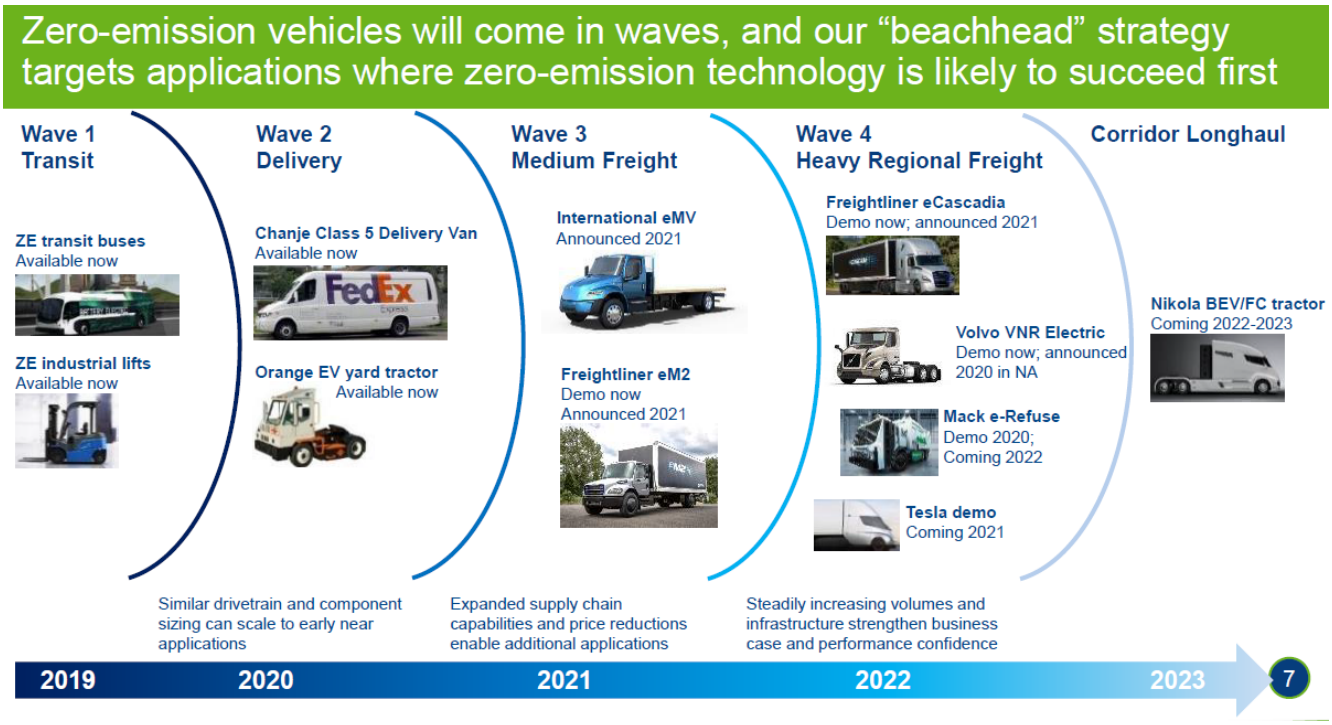
FIGURE 3.6 VERMONT ALTERNATIVE FUELING LOCATIONS



Source: https://afdc.energy.gov/states/vt; Analysis by Cambridge Systematics (2020).
Note: Many alternative fueling stations cannot accommodate large commercial vehicles.

In July 2020, Vermont joined 15 states and the District of Columbia in signing an agreement that calls for 100 percent of all new medium- and heavy-duty vehicle sales to be zero emission vehicles by 2050.[18] In addition, Vermont is actively involved in a number of coalitions including the Northeast Diesel Collaborative which combines public and private sector partners to significnatly reduce diesel emissions and improve public health in the northeastern US. Emerging zero-emission freight vehicles (see Figure 3.7) combined with a growing inventory of fueling locations and public policy and incentives that support transitioning to zero-emission vehicles could help Vermont and other states achieve emission goals.[19]

FIGURE 3.7 ZERO-EMISSION VEHICLE DEPLOYMENT TIMING



Source: Northeast Diesel Collaborative "Plugging In: Electric Trucks in the Northeast." Presented June 25, 2020.

3.4 Rail Congestion Trends

As in the 2015 Rail Plan, the rail system in Vermont experiences little or no congestion due to the relatively light density of traffic present on most of the network. Most rail lines in Vermont are unsignalized and rely on manual dispatch/track warrant control to direct train traffic. The Association of American Railroad's (AAR) National Rail Freight Infrastructure Capacity and Investment Study estimates that a rail line with single track, no signal/track warrant control dispatching, and mixed traffic would have a capacity to handle 16 trains per day. While admittedly the AAR's study ignores numerous factors that determine effective track capacity such as number, location, and size of sidings, grades, curves, nature of freight traffic and locomotive consists, etc., none of the rail lines in Vermont carry anywhere near 16 trains per day on a regular basis. Even with detours and reroutes in place during

[18] https://vermontbiz.com/news/2020/july/14/scott-signs-multi-state-agreement-electrify-trucks-and-buses

[19] https://afdc.energy.gov/laws/state_summary?state=VT

the Hoosac Tunnel collapse and during construction of the Middlebury Tunnel which impacted travel on the VTR, the remaining lines in Vermont did not approach this level of traffic.

Although some concerns have been raised about potential interaction between intercity passenger and freight rail service in areas without Positive Train Control (PTC), an Amtrak analysis of the *Vermonter* and *Ethan Allen Express* routes identified a number of mitigation measures such as warning signs for upcoming speed restrictions, additional speed restrictions as deemed necessary, and enhanced communication rules between crew member which will enhance safety without the need for PTC.[20] Other routes in Vermont are not expected to carry enough volume in the foreseeable future to require PTC.

3.5 Land Use Trends and Community Impacts

Compared to the rest of the United States, Vermont retains a rural character with a large amount of forested and undeveloped land. Most of the State is comprised of rural or small town/city settlement patterns with only Burlington being classified as an Urbanized Area with a population over 50,000.[21]

As noted in Section 3.2, the counties around Burlington are growing in population while all other counties in the State have seen a decrease over the past decade. This means Vermont is becoming more metropolitan and less rural, with more people concentrated in a smaller area. This has potential impacts for transportation, as higher population densities potentially increase the cost-effectiveness of transit and the abilty to walk and bike. Traditional village settlements separated by undeveloped rural land is fundamental to Vermont's "brand" and continued investment in historic villages and downtowns can help maintain these areas and promote additional growth.

Even Vermont's rural areas are competitive compared to national trends. The U.S. Department of Agriculture reports that one in four rural counties nationally suffer from low unemployment and persistent child poverty, and more than one in ten have low education and persistent poverty. None of Vermont's counties meet the criteria for any of these labels (as of 2017).[22]

However, as noted in the 2040 Long Range Transportation Plan (LRTP), "inefficient, low-density, rural-residential and strip commercial development exists at the periphery of many of Vermont's urban areas. This land use pattern is difficult to avoid due to the relatively inexpensive and easily built-upon suburban and rural open lands surrounding developed centers."[23] A 2018 study found Vermont is the third most forested state in the lower 48 states of the U.S., a factor which contributes to the State's reputation for recreational opportunities and rural areas. However, that same study also noted that parcelization, subdivision, and development of land is causing Vermont

[20] https://vermontbiz.com/news/2019/january/01/amtrak-keep-rolling-vermont-now

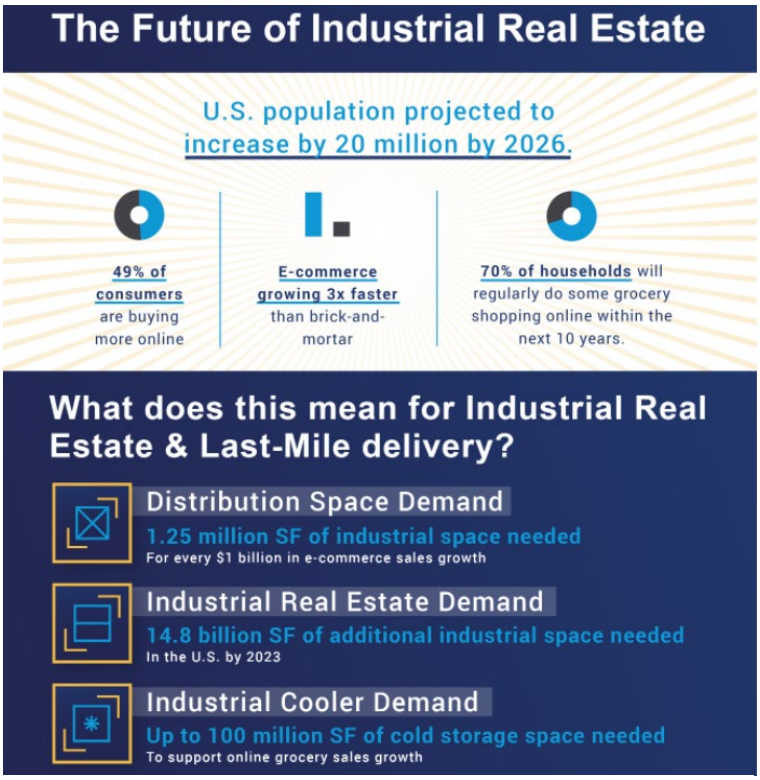
[21] https://www.census.gov/programs-surveys/geography/guidance/geo-areas/urban-rural/2010-urban-rural.html

[22] https://ljfo.vermont.gov/assets/Subjects/Commission-Resources/05a742b874/Population-Changes-and-Vermont-State-Revenue-FULL-REPORT.pdf

[23] https://vtrans.vermont.gov/sites/aot/files/planning/documents/planning/2040_LRTP_%20Final.pdf

to lose some of that forest cover.[24] As in most areas of the U.S., it is often cheaper to build new facilities or housing on unused parcels than it is to rebuild or infill in already developed areas. In addition, for areas losing population, reduced tax revenue may impact the ability to provide services or support infrastructure.

Other national and global trends also have an impact on land use in Vermont. As discussed further in Section 6.2, e-commerce creates a larger demand for industrial/warehousing land uses, especially near population centers in order to serve customers on a timely basis. On the other hand, the long-term impacts of COVID-19 on residential patterns, combined with continued expansion of broadband internet and access to goods through e-commerce may draw additional residents to Vermont's rural opportunities.



Source: https://www.freightwaves.com/news/daily-infographic-the-future-of-industrial-real-estate

Vermont has a stringent land use permitting process under Act 250 which applies to a number of construction activities including any commercial or industrial purpose on more than 10 acres. Advocates argue that this Act has been instrumental in protecting natural and cultural resources that are vital to the State, opponents suggest additional cost and time required to comply with the Act could dampen the ability of freight-reliant businesses to move to or expand in the State.

3.6 Passenger Demand and Growth (Section 2.2.3 of the Rail Plan)

This information will be provided as part of a separate technical memorandum focused on passenger ridership and growth projections.

[24] https://vnrc.org/news-stories/new-report-tracks-parcelization-trends-in-vt/

4.0 HIGHWAY

4.1 Highway Congestion Trends

As discussed in Existing Conditions Tech Memo, the capacity of Vermont's highway system is generally adequate to meet current demand with relatively low congestion outside of the Burlington area. Vermont residents spent an average of 8.4 hours per year in congestion, far below the national average at about 35 hours and low congestion means fewer impacts on truck trips as well as resident trips.[25]

Also noted in the Existing Conditions Tech Memo, Vermont is meeting their target for the national freight performance measure of Interstate truck travel time reliability (TTTR). As of 2018, the state is also meeting the two other travel time reliability measures in the FAST Act—Interstate travel time reliability and Non-interstate National Highway System (NHS) travel time reliability. These targets and achieved values are shown in Figure 4.1 below. Overall, this information indicates that highway congestion has limited negative impacts on travel reliability outside some localized issues in the Burlington region.

FIGURE 4.1 VERMONT TRAVEL TIME RELIABILITY PERFORMANCE MEASURES

Measure	Target	2017 Value
Interstate travel time reliability	≥ 90% of miles with LOTTR ≤ 1.50	99.6%
Non-interstate NHS travel time reliability	≥ 80% of miles with LOTTR ≤ 1.50	88.2%
Truck travel time reliability	Interstate Truck Travel Time Reliability (TTTR) Index ≤ 1.75	1.69

Source: Vermont 2040 Long Range Trannsportation Plan.

Note: LOTTR – Level of travel time reliability is calculated as the ratio of the longer travel times to a "normal" travel time, using data from FHWA's National Performance Management Research Dat Set.

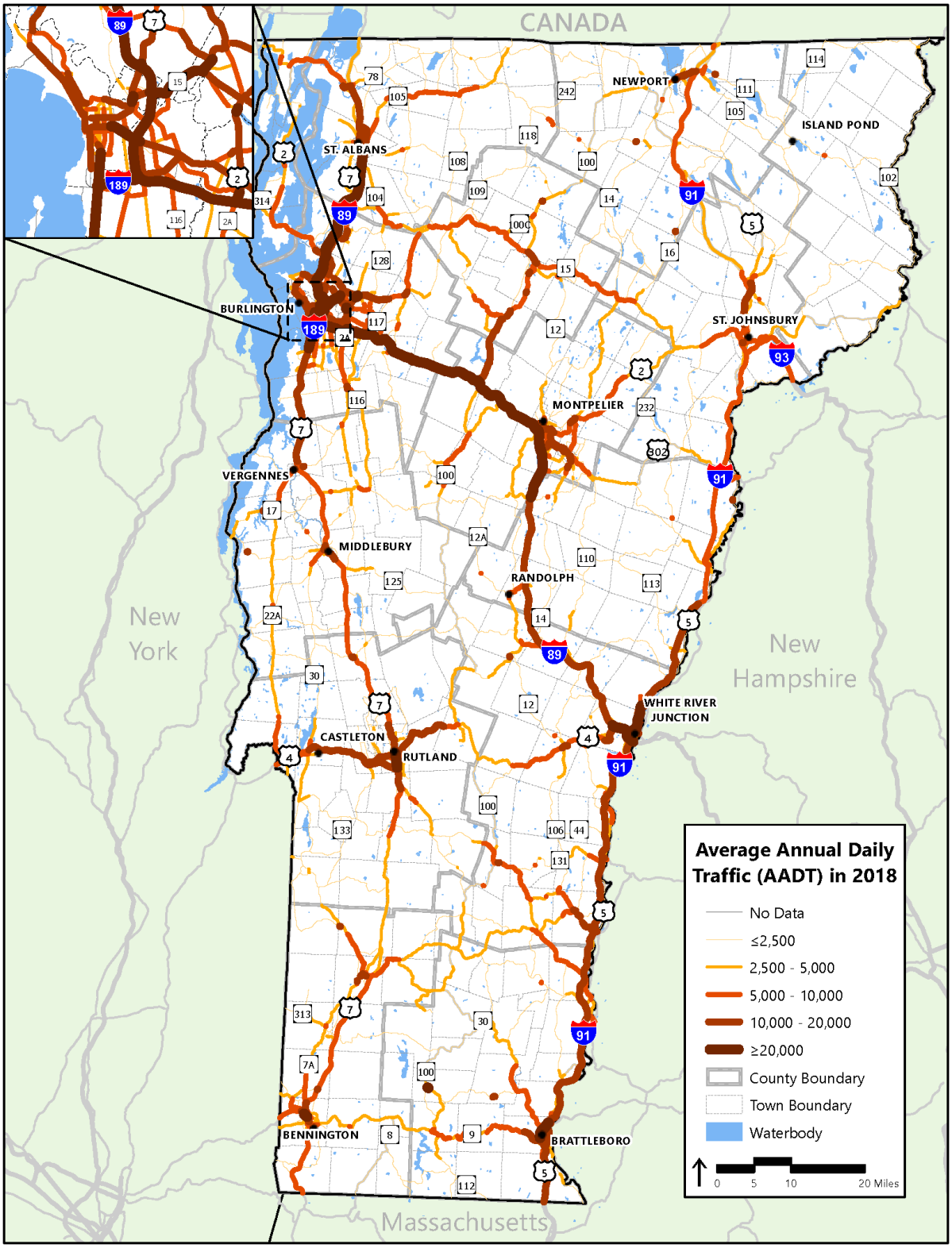
As of 2017, Vermont is also meeting most other highway-related national performance measures in the areas of safety, pavement, bridges with two exceptions: the number of highway fatalities and the number of non-interstate NHS pavements in poor condition.[26]

Figure 4.2 shows the total annual average daily traffic (AADT) in Vermont. The maximum value is approximately 56,000 vehicels per day on I-89 near U.S. 2 in South Burlington. This interchange and nearby roads including U.S. 7, I-189, I-89, and U.S. 2 between the I-89/U.S. 2 interchange north of Winooski and U.S.7/I-189 interchange south of Burlington are the busiest in the State. Outside of this region, most of the traffic volumes in Vermont are below 30,000 vehicles per day on the interstate system and below 10,000 vehicles per day on most other roads.

[25] https://www.infrastructurereportcard.org/wp-content/uploads/2016/10/FINAL_REPORT_ASCEVT_web.pdf

[26] The number of fatalities and serious injuries per 100 million vehicle miles traveled was not calculated.

FIGURE 4.2 VERMONT ANNUAL AVERAGE DAILY TRAFFIC (2018)



Source: HPMS (2018); Analysis by VHB, 2020.

Impact on Rail Travel

Because Vermont roadways are not as congested as those in some other states, the primary congestion benefits that Vermont rail passengers realize by train travel will tend to relate to the other segments of their trips. Many of the trips on the *Vermonter* and *Ethan Allen Express* originate or terminate on the crowded Northeast Corridor, to or from metro areas such as New York, Washington and Philadelphia. The congestion on roadways in these areas is much higher than in Vermont, so Vermont's passenger rail service provides access to and from these locations without adding to congestion.

4.2 Future Highway Volumes

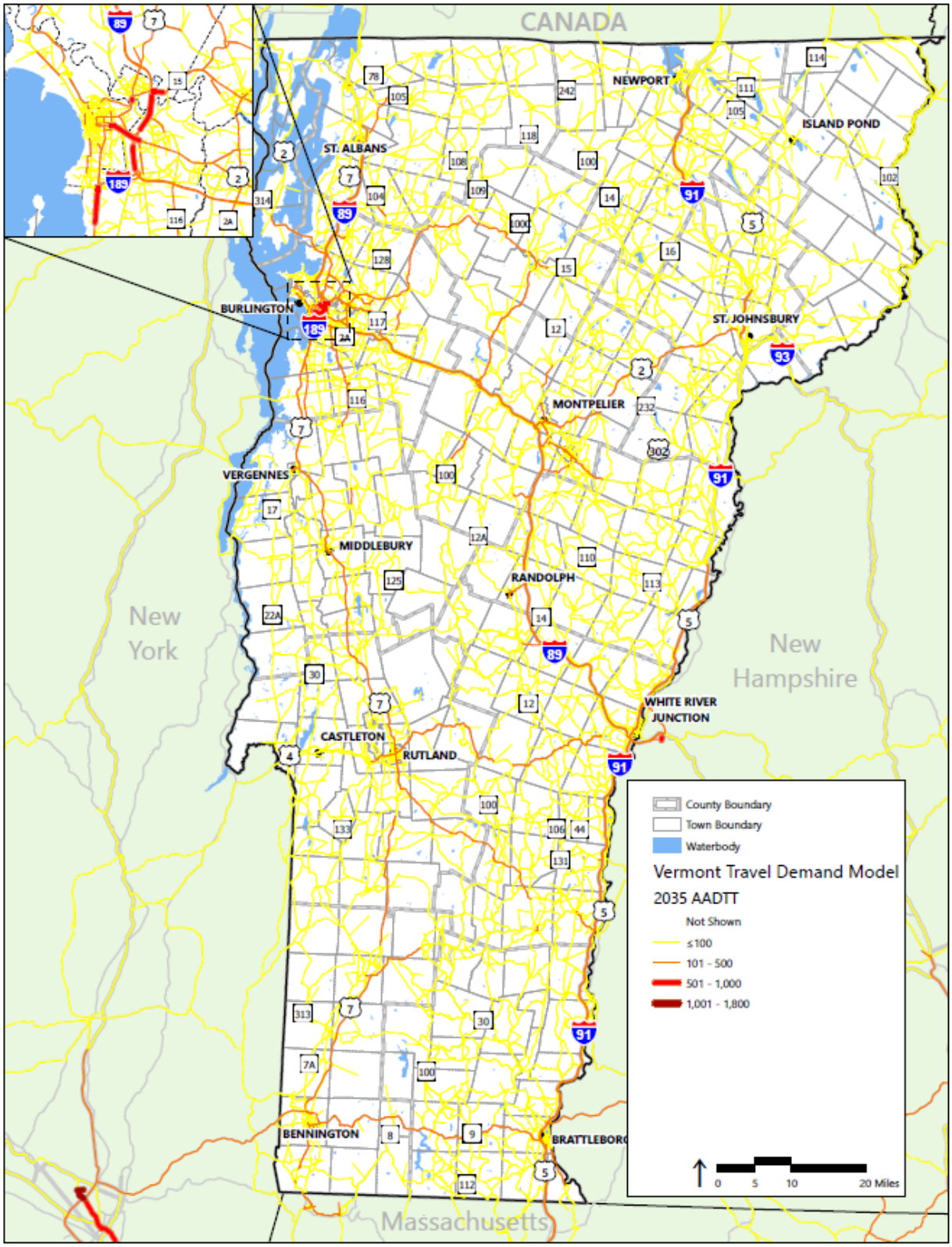
For future projections, the most relevant data available is from the Vermont Statewide Travel Demand Forecast. This forecast uses 2010 as a base year with growth factors adjusted based on actual 2015 data. However, this means that projections to 2035 are still based on 2010 volumes. The maximum AADT from the Statewide model for 2035 shows a peak of approximately 61,000 vehicles in the Burlington region. Figure 4.3 shows projected truck volumes in 2035. Maximum truck volumes are projected to be below those shown in 2018 data so this data is unreliable as a projection of future conditions.

As discussed in Section 2.1, the completion of a limited access highway from the Highgate Spring POE to Montreal is likely to increase truck traffic on I-89. In addition, Chittenden County Regional Planning Commission and VTrans are developing a comprehensive investment program for the 37 mile I-89 corridor in Chittenden County.[27] Interchange improvements and other spot changes may be used to improve traffic flow through this area with Exits 12B, 13, and 14 being initial targets for evaluation.[28]

[27] https://envision89.com/

[28] https://envision89.com/advisory-committee

FIGURE 4.3 VERMONT PROJECTED ANNUAL AVERAGE DAILY TRUCK TRAFFIC (2035)



Source: Vermont Travel Demand Model (2020).

5.0 AIR

5.1 Airport Congestion Trends

Vermont has ten state-owned airports and one municipal airport (Burlington International Airport) in addition to five privately owned airports. Burlington International Airport (BTV) and Rutland–Southern Vermont Regional Airport, the State's number one and number two largest airports in terms of passenger and freight/mail volume, respectively, do not suffer from the congestion and delays seen at the larger hub airports in the Northeast. BTV—the only major commercial airport in Vermont—is located in South Burlington, owned by the City of Burlington and operated by the Burlington Airport Commission. BTV had 686,852 passengers depart and 686,169 passenger arrivals in 2019. The 90- minute catchment area of BTV extends across the northern half of Vermont (excluding the Northeast Kingdom) and into southern Quebec and northern New York State. The BTV catchment area overlaps with the Montreal Trudeau International Airport (YUL) catchment area near the Canadian border.

The majority of passenger traffic to and from Burlington is between destination airports located in the Northeast Corridor, including New York (JFK/EWR), Philadelphia (PHL), and Reagan National Airport in Washington, DC (DCA). However, flights to Chicago (OHR), Detroit (DTW), Charlotte (CLT), Atlanta (ATL), and Denver (DEN) are also popular. Endeavour Air, a subsidiary of Delta carries the largest share of passengers (20 percent), followed by Republic Airways (serving Delta, United and American).[29]

Burlington International Airport received approximately 4.9 million pounds of freight and originated approximately 3.7 million pounds of freight in 2019. Approximately 83 percent of the inbound freight originated in Syracuse, NY and was carried by Federal Express (FedEx), followed by inbound shipments from Memphis and Portland, ME also carried by FedEx. In total, FedEx accounted for 99 percent of the total inbound tonnage. These three airports also dominated outbound shipments from Burlington. Smaller amounts of cargo also traveled between Burlington and Atlanta (Delta Airlines), Charlotte (PSA Airlines), Chicago (United Airlines), Newark (United Airlines), and Philadelphia (Piedmont Airlines). Freight on these routes moves in the belly of a passenger flight. Burlington International Airport has a U.S. Customs Port of Entry open from 8 A.M. to 8 P.M. daily which has the capability to process goods arriving directly from outside the United States, should demand for such air freight service increase in the future.[30]

Freight movement at BTV is lower than volumes in 2014, but still above Great Recession levels when it fell below seven million pounds. However, 2020 volumes are likely to be significantly lower due to the COVID-19 pandemic which severely limited flights between airports across the United States and around the world.

Road access to BTV is via US 2, an undivided highway that runs through the middle of South Burlington. Traffic volumes on this segment are approximately 41,000 vehicles per day and TTTR scores show some inconsistency in the corridor.

[29] US BTS T-100.

[30] https://www.cbp.gov/contact/ports/burlington-international-airport-vermont-0207

Rutland received approximately 235,000 pounds and originated approximately 600 pounds. Of this, more than 99 percent arrived via FedEx from Albany, NY with the remainder arriving from Newark on FedEx. Outbound cargo from Rutland went to Cincinnati, OH on USA Jet Airlines, Inc.[31] Road access is via U.S. 7, VT 103, and Airport Rd. with traffic volumes of approximately 10,000 vehicles per day.

Impact on Rail Travel

As mentioned above, much of the traffic at Vermont's largest airport, BTV, originates or terminates on the Northeast Corridor. These are highly congested airports, and are within a few hundred miles of Vermont. Improved travel times and on time performance throughout the Northeast region, and improved connections to popular destinations such as New York, Philadelphia, Washington, and Montreal, could promote more competition between rail and air modes for intra-regional trips, potentially alleviating congestion at the region's major airports and offering alternatives to travelers to and from the State of Vermont.

5.2 Future Air Cargo Trends

The COVID-19 pandemic has had a significant impact on air transportation worldwide with up to 50 percent less seats and approximately 2.5 million fewer passengers projected for 2020. This reduction in passenger traffic is likely to reduce the number of flights (and vice versa) which will lessen the options for air cargo which passenger airlines often carry freight in the belly of the aircraft.[32] Total air cargo shipments are down approixmately 28 percent year on year in April 2020 though some companies are increasing their cargo capacity by removing seats from passenger aircraft to allow for cargo-only flights.[33]

Vermont's airports have the capacity to cover an increase in air cargo traffic should demand in Vermont spike during or after the COVID-19 pandemic. The forthcoming Vermont Airport System Plan notes that the current (2018) combinations of aircraft capacity and frequencies already operating on schedules at BTV, RUT and MPV are sufficient to cover existing needs and forecasted future needs over the next 20 years. In addition, the Federal Aviation Administration is implementing its NEXTGEN initiative to modernize the U.S. Air Traffic System. As of 2018, BTV had already begun transitioning to NEXTGEN systems which will reduce cancellations, weather delays, taxi and take-off delays, and improve safety through accurate routing and improved communications. BTV has already begun transitioning to NEXTGEN systems.[34]

The larger concern for Vermont's air freight capabilities is the possibility of a reduction in service. Long-term changes due to COVID-19 are difficult to predict but passenger traffic is likely to remain below normal levels for the foresable future, reducing belly cargo capacity and demand. A reduction in coverage by companies like FedEx

[31] As noted in the Air Modal Profile, BTS data excludes nearly all outbound cargo at Rutland-Southern Vermont Regional Airport and all cargo at E.F. Knapp Airport in Montpelier due to reporting requirements for commercial operations with revenue below certain thresholds.

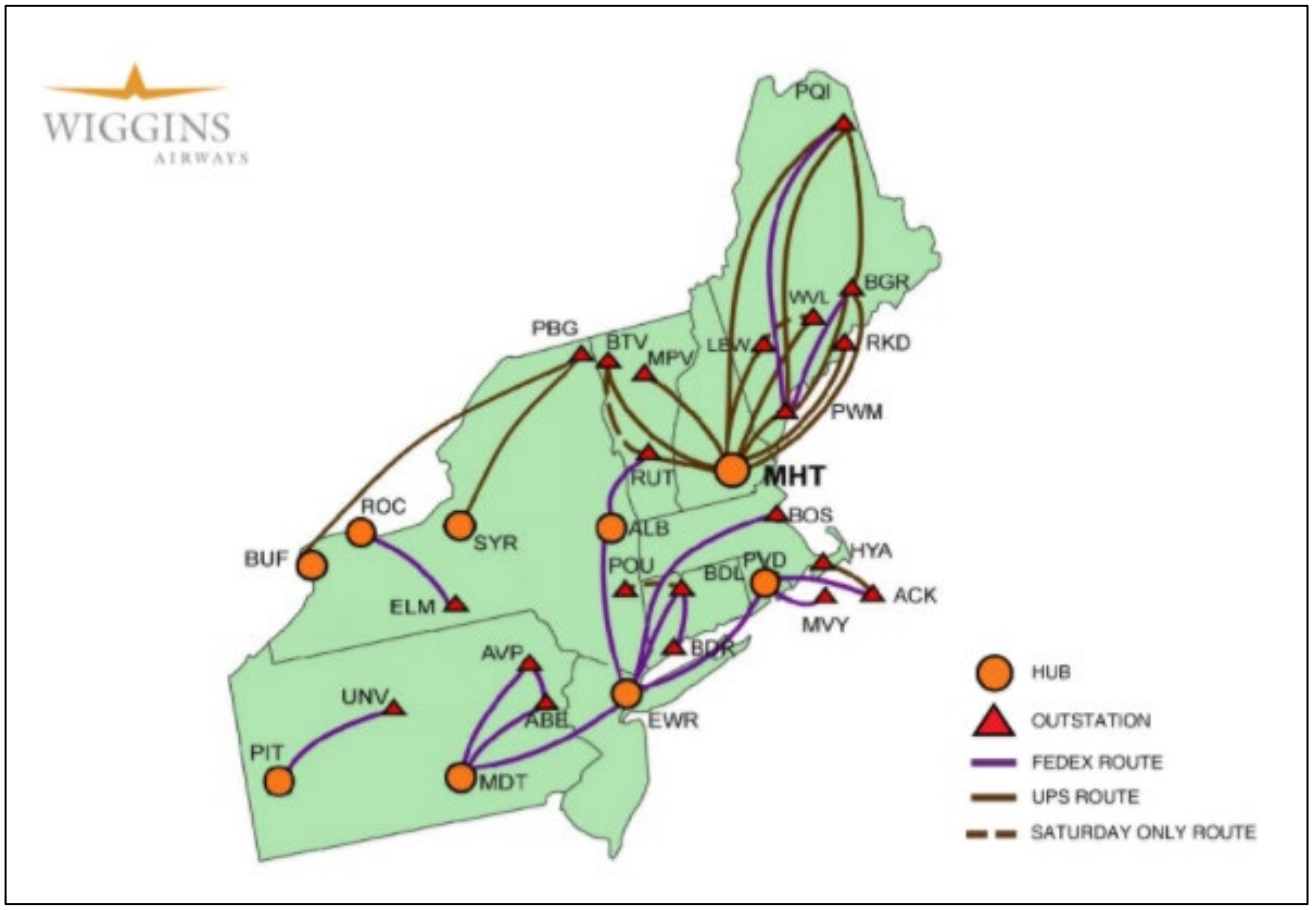
[32] https://www.icao.int/sustainability/Documents/COVID-19/ICAO_Coronavirus_Econ_Impact.pdf

[33] https://www.aircargonews.net/freighters-world/how-coronavirus-has-turned-the-airfreight-market-on-its-head/

[34] https://www.infrastructurereportcard.org/wp-content/uploads/2016/10/FINAL_REPORT_ASCEVT_web.pdf

or UPS (or their regional partner, Wiggins Airways,[35] see Figure 5.1) could hurt Vermont businesses and their ability to move time-critical goods.

FIGURE 5.1 WIGGINS AIRLINE ROUTE MAP



Source: https://wiggins-air.com/route-map/

[35] https://wiggins-air.com/

6.0 KEY FREIGHT TRENDS

This section highlights a number of global and national trends that impact freight movement across all modes. Their implications for Vermont are also explored.

6.1 Global Shipping and Tariffs

Global Shipping

Several trends are occurring nationally and worldwide that could impact the amount and type of freight handled at the world's ports and thus influence how goods travel to and arrive at inland destinations in Vermont.

Since the late 1990's, ocean carriers have been forming alliances with the intended goals of controlling capacity and stabilizing freight rates in the market. Carrier alliances allow better management of ship capacity, more effective coordination of future ship orders with forecast demand, lower operating costs through more effective collaboration with service providers, and greater reach, allowing alliance partners to service new ports and maximize the potential of new routes. Today, it is estimated that the three largest shipping alliances have a market share of approximately 80 percent of global container carrying capacity.[36] Whereas alliances can create value for carriers, they may cause negative impacts for ports. Many ports depend on one or two alliances, giving the alliances leverage over ports to reduce rates and invest in additional infrastructure.

Shippers are continuing to use larger ships as shipping lines reduce the unit cost of moving containers and other commodities. In particular, the ability to accommodate larger ships through the Panama Canal has resulted in a shift of traffic from West Coast ports to U.S. Gulf and East Coast Ports. Ports such as Houston, Savannah, New York/ New Jersey, and Charleston are competing heavily for discretionary cargo, much of which is traveling to or from inland markets. The ports through which discretionary cargo is imported or exported is typically determined by the end-to-end (including water and land moves) cost and travel time offered through each potential port.

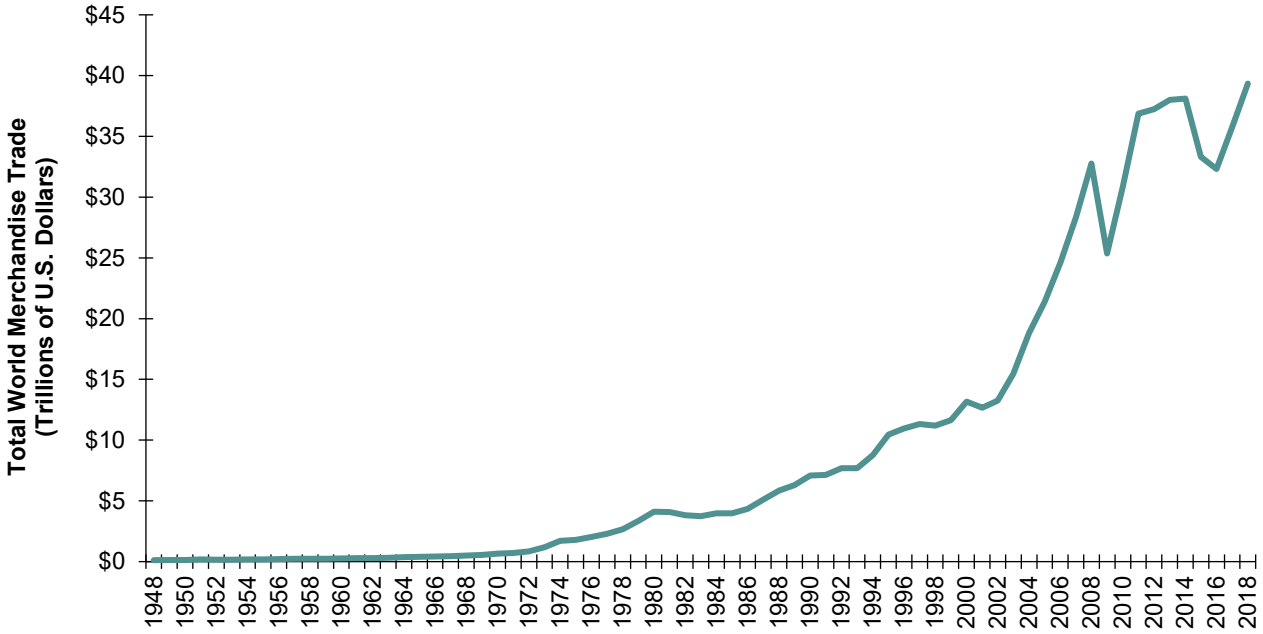
For example, a set of parts for a new manufacturing line could be shipped from Asia to a West Coast port such as Port Rupert (Canada), put on rail to Montreal, and then carried by truck to a destination in Vermont. Alternatively, the same shipment could move by water to New York/New Jersey and then by truck to Vermont. In this example, the water route to New York/New Jersey takes about one week longer than the trip via Port Rupert and Montreal, but is a lower cost to the shipper. During the COVID-19 pandemic and associated shortages of some medical equipment and consumer goods, West Coast ports appeared to capture a larger share of discretionary cargo, as shippers were willing to pay more for shorter transit times. For Vermont, maintaining reliable access to the highway and rail systems that connect to East Coast and inland ports (and by extension the West Coast) can allow shippers to respond to disruptions and continue operations, thus keeping shelves stocked for Vermont consumers.

[36] International Transportation Forum, *The Impact of Alliances in Container Shipping*, 2018.

Tariffs

There was rapid growth in goods traded globally in the last two decades, growing from $11.2 trillion in 1998 to $39.3 trillion in 2018, an average annual increase of 6.5 percent (Figure 6.1).[37] Significant decreases occurred around the global recession in 2008 and 2009 and during a period of high commodity prices around 2015. Contributing to the steep increase in global trade in the 1990s and early 2000s was the proliferation of Free-Trade Agreements (FTAs), which reduced barriers to trade between two or more countries. In the 1990s and 2000s, an average of nearly 30 FTAs per year were signed. However, the number of FTAs signed from 2011 to 2015 averaged about half of that, signaling increasing protectionism and trade restrictions.

FIGURE 6.1 TOTAL WORLD MERCHANDISE TRADE VALUE (1948-2018)



Source: World Trade Organization, https://data.wto.org/.

One example of protectionism is the implementation of tariffs, which are intended to boost a country's industry and shield it from foreign competition. In theory, these restrictions force U.S. companies to buy locally produced products instead of more expensive (or limited) foreign products. However, some companies, like automobile and airplane manufacturers, need imported raw materials and could pass on any increased costs to obtain those materials to consumers. Tariffs can have a significant impact on trade.

While Canada is Vermont's largest trading partner, eastern Asia accounted for between 25 and 30 percent of foreign trade. The U.S. has imposed tariffs on more than $250 billion worth of Chinese goods, with tariff rates between 10 percent and 25 percent, while China has imposed tariffs ranging from five percent to 25 percent on $110 billion worth of U.S. goods. Increasing tariffs increase the price of impacted goods on businesses and consumers in Vermont and elsehwere around the country. The increased prices lead to lower demand, which impacts consumers who use

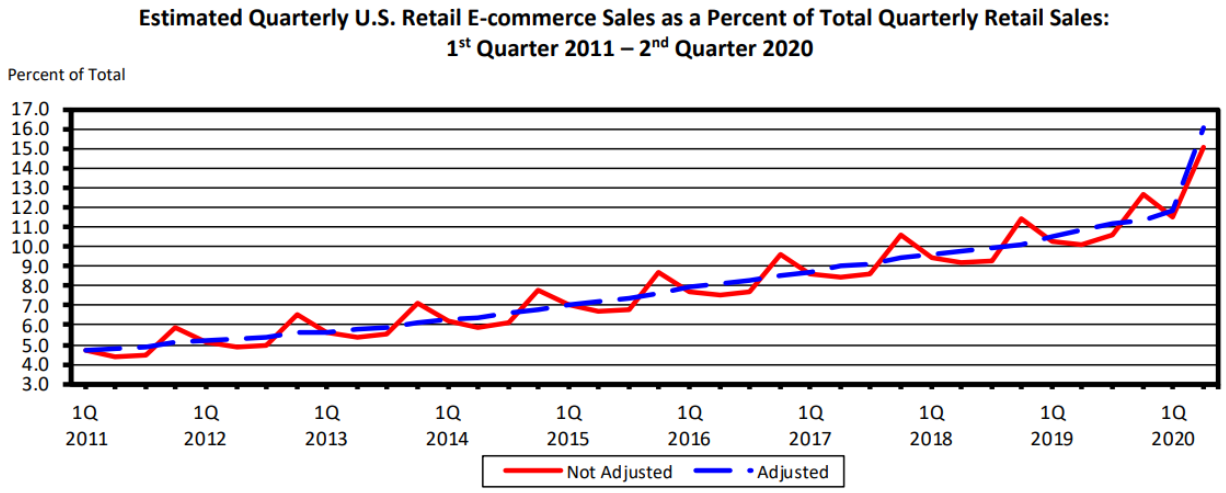
[37] World Trade Organization (WTO).

the products directly and businesses that use the products as input in their processes. There is some evidence that the tariffs could have lasting impacts as some companies begin to rewrite contracts to allow them to pass on price increases related to tariffs to customers.[38]

6.2 E-Commerce

The shift to online shopping is well underway in the U.S. E-commerce shipments are defined by the US Census Department as online orders for manufactured products where price and terms of sale are negotiated over the Internet, Extranet, Electronic Data Interchange network, e-mail, or other online system. E-commerce sales spiked in the first quarter of 2020, and are likely to have continued rapid growth through the second quarter. Figure 6.2 shows the growth in E-commerce sales as a percent of total retail sales by quarter from the first quarter of 2011 through the first quarter of 2020. E-commerce accounted for 16 percent of all retail sales in the US in the first quarter of 2020, compared to five percent in 2011. This rapid growth in e-commerce deliveries places stress on local roads using less-than-truckload and parcel service and is shifting warehousing towards more/smaller facilities close to population centers to meet delivery demands.

FIGURE 6.2 NATIONAL E-COMMERCE TRENDS, 2011-2020



Source: "Quarterly Retail E-Commerce Sales Report, Quarter 2, 2020", U.S. Census Bureau.

Vermonters' growing use of eCommerce can be seen through sales tax received. Following a 2018 Supreme Court decision to allow states to collect sales tax on online purchases, Vermont received $10.2 million from online retailers in 2018 and are on pace to collect even more in 2019.[39]

[38] Casselman, Ben, *The New York Times*, "Trade War Starts Changing Manufacturers in Hard-to-Reverse Ways," May 30, 2019, https://www.nytimes.com/2019/05/30/business/economy/trump-tariff-manufacturer.html.

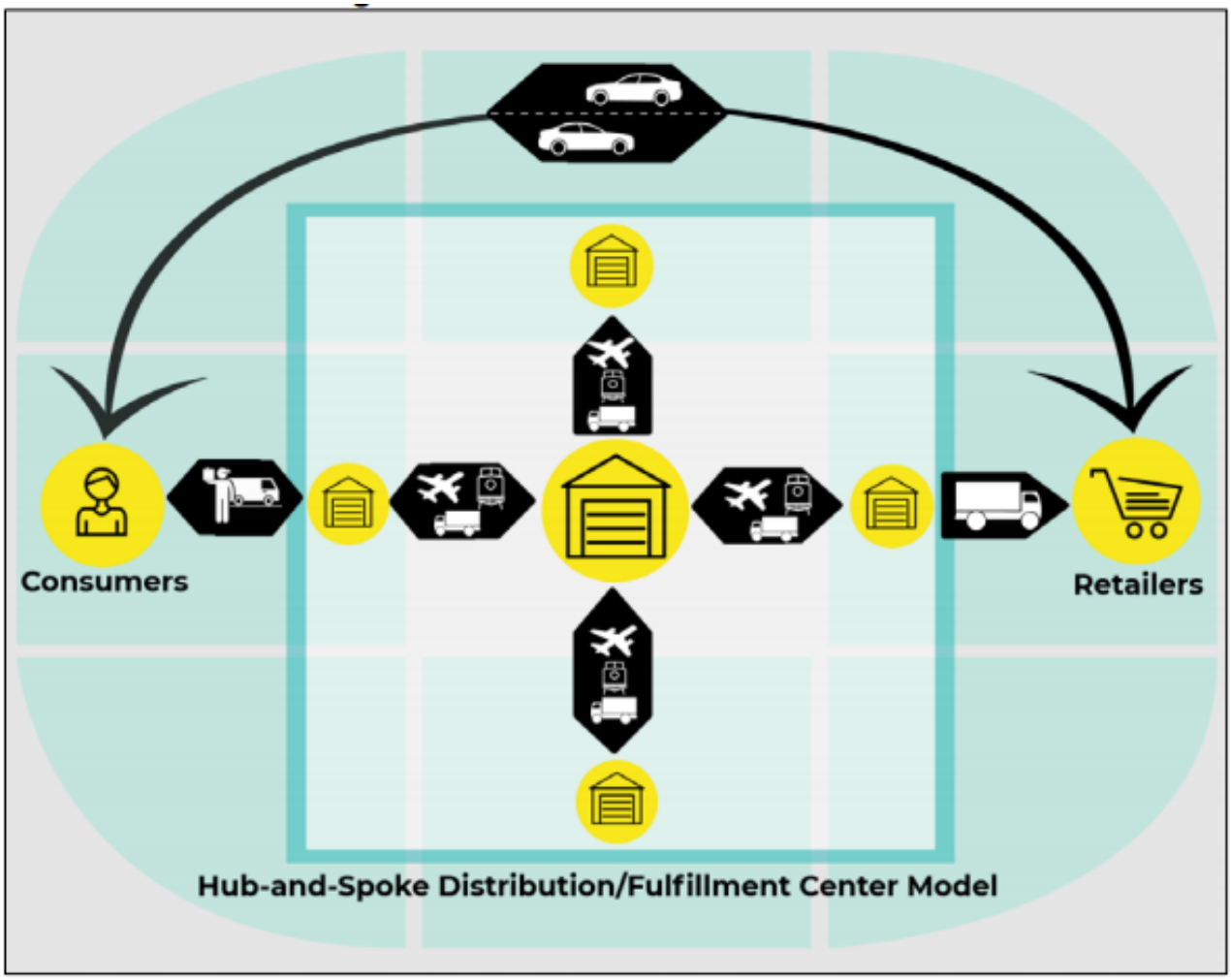
[39] https://www.wcax.com/content/news/Vermont-collects-double-the-online-sales-tax-expected-567469031.html

While Vermont residents certainly utilize eCommerce to obtain goods, the State is also using eCommerce to distribute goods made in Vermont. Amazon, one of the largest drivers of online shopping ranked Vermont 8th in terms of growth of small and medium-sized businesses selling products online in 2019.[40]

All of this growth places different demands on the State's freight network. In a traditional distribution network, goods are delivered from a large central warehouse to retail stores, and customers travel to the stores to pick up goods. The rise of e-commerce, and consumer demands for quick and/or time-definite delivery, has led to a tiered distribution system (an example is shown as Figure 6.3), where a central warehouse supplies retail stores and a network of e-commerce order fulfillment centers. The fulfillment centers are where consumers' orders are packaged and prepared for delivery. The orders are then delivered to the consumer's doorstep or to a retail store for customer pick-up. Fulfillment centers range in size from 5,000 square foot rooms inside a big box retail store to 1 million square foot facilities, depending upon the needs of the retailer, the range of products carrieed, and the size and characteristics of the market area served.

[40] https://vermontbiz.com/news/2019/may/01/amazon-ranks-vermont-8th-fastest-growing-small-and-medium-sized-businesses

FIGURE 6.3 TIERED WAREHOUSING AND FULFILLMENT CENTER NETWORK EXAMPLE



Source: https://truckingresearch.org/wp-content/uploads/2019/02/ATRI-Impacts-of-E-Commerce-on-Trucking-02-2019.pdf

The increased demand for home deliveries often means there are more delivery vehicles on the road, including trucks and cargo vans. Some parcels are delivered by automobile, using contracted gig-economy workers.

The delivery trips added to the network are replacing many passenger automobile trips to retail stores. The potential for e-commerce to facilitate reductions in net traffic and greenhouse gas emissions, however, is largely contingent upon carriers adopting alternative fuels, adapting their logistics chains to improve efficiency, and upon consumers to make choices, such as ordering more than one item at once and/or to select shipping options that allow for consolidation and more efficient handling and logistics.[41]

This has also increased the need for logistics facilities such as sortation centers and fulfillment centers to be near population centers to service the demand for goods and to meet consumer demands for faster delivery times.[42]

[41] https://www.bain.com/insights/how-to-cut-carbon-emissions-as-ecommerce-soars/

[42] https://globalcitylogistics.org/?page_id=414

This requirement is leading to more industrial real estate transactions and development in high-cost urban markets previously thought to be undesirable for industrial development. Many e-commerce retailers are also redeveloping or adapting vacant or underutilized large retail spaces into fulfillment centers. Some brick-and-mortar retailers have changed their store floorplans to incorporate space for fulfilling online orders for delivery or customer pickup.

Due to its relatively low and distributed population, Vermont has not yet experienced the building boom in this area as have surrounding states. For example, Amazon which dominates this market currently, does not have a fulfillment center in Vermont, though there are locations in Nashua, NH and Windsor, CT and a new fulfillment center outside of Albany, NY due to open in 2020.[43] At present, it appears most e-commerce shipments are delivered by parcel carriers such as U.S. Postal Service, UPS, and FedEx. As e-commerce demand continues to grow, development or expansion of sortation centers for these carriers, or development of fulfillment centers for e-commerce retailers, may soon come to Vermont. Understanding the evolving shipment and delivery time demands of the consumer can help land use and officials to anticipate needs and/or help economic development officials to proactively market desirable sites.

The rise of e-commerce orders has also created new opportunities for less-than-truckload (LTL) carriers who move shipments that are larger than parcel size. While UPS, FedEx, and other parcel carriers discourage customers from using their small-package networks for large and/or heavy items, LTL carriers have increased their business delivering large home furnishings, appliances, and other bulky items to consumers.

Growth in LTL shipping comes chiefly at the expense of truckload shipping as LTL is both more flexible in terms of serving customers and a more desirable job for drivers who do not have to endure long trips with nights away from home. Because the total demand for goods isn't falling, and the requirement for faster time to market is likely to grow, then more LTL shipping entails more individual truck deliveries occurring more often. This adds to the pressure on highway and local road capacity, and on the capacity of loading docks and street parking to absorb greater numbers of trucks.

[43] https://www.cnbc.com/2020/01/19/map-of-amazon-warehouses.html

FIGURE 6.4 AN LTL CARRIER MAKING A DELIVERY IN AN URBAN NEIGHBORHOOD

6.3 Additive Manufacturing

Additive manufacturing (AM), colloquially known as 3D printing, uses computers, modeling software, and specialized printers using liquid, powder, or sheet material to "print" three-dimensional objects. Consumer electronics, medical devices such as hearing aids, aircraft components, footwear and toys are examples of product types; but concrete panels can also be manufactured in this process.

AM has the potential to disrupt the traditional supply chain by removing the need to have specific parts or products made in one location (often overseas) and shipped to another for assembly or retail distribution. Instead, the design of that part can be digitally transmitted and printed at a location closer to where the part will be used... AM requires the transportation of the raw materials that the 3D printers use to produce goods. Large quantities of these materials could be transported in bulk shipments, which are typically less expensive to move than finished products. The shortening of supply chains on both the inbound and outbound sides could have a significant impact across all transportation sectors, with a particular impact on trucking. The potential reductions in importing and exporting products that could be produced by AM could affect up to to 25 percent of the trucking industry, particularly first/last mile connections to port and air cargo facilities.[44]

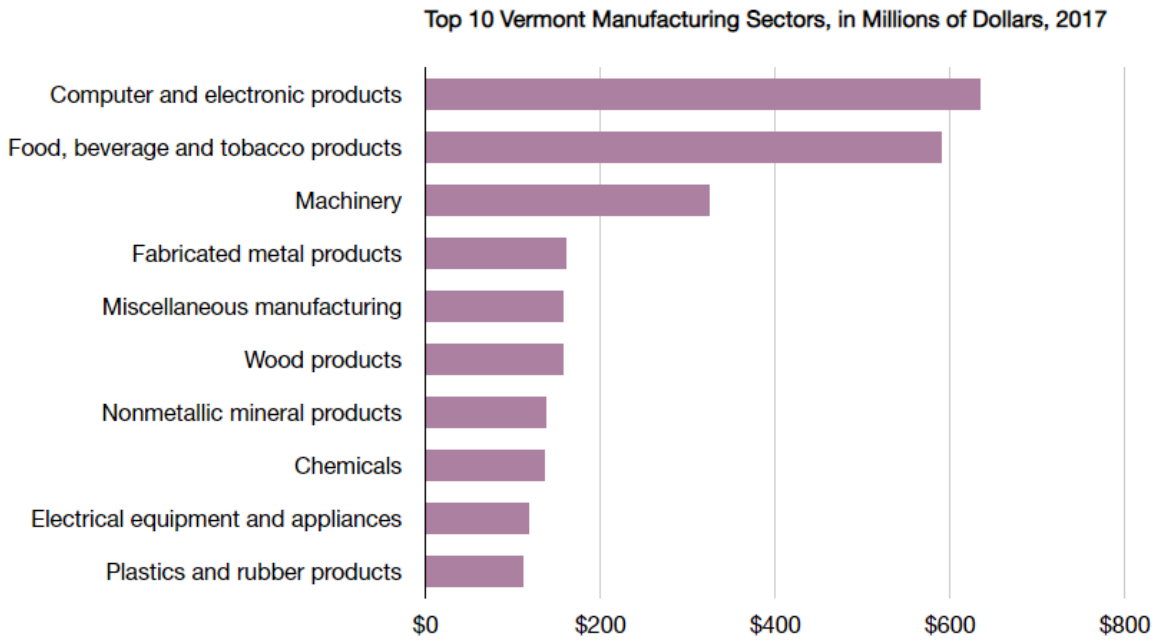
Vermont companies are exploring this approach. For example, the Department of Defense Office of Economic Adjustment provided Vermont with a grant designed to to develop an advanced additive manufacturing capability

[44] https://cait.rutgers.edu/wp-content/uploads/2018/05/cait-utc-nc19-final.pdf

to the defense related precision metal working businesses locate in Vermont.[45] In addition, the Vermont Additive Manufacturing Consurtium was founded in July 2019 based at the Vermont Techncial College in Randolph Center as a public-private partnership between industry, higher education and support and resource entities with an initial focus on precision metals manufacturing.[46]

Manufacturing employed nearly 10 percent of Vermont's workforce in 2018 with the top sub-sectors shown in Figure 6.5 below. Many of these categories are potential adopters of additive manufacturing approaches. Figure 6.6 shows manufacturing sectors by growth potential where aerospace parts, semiconductors, and many machinery pieces may be potential 3D printing targets.

FIGURE 6.5 VERMONT'S TOP 10 MAJOR MANUFACTURING SECTORS (2018)

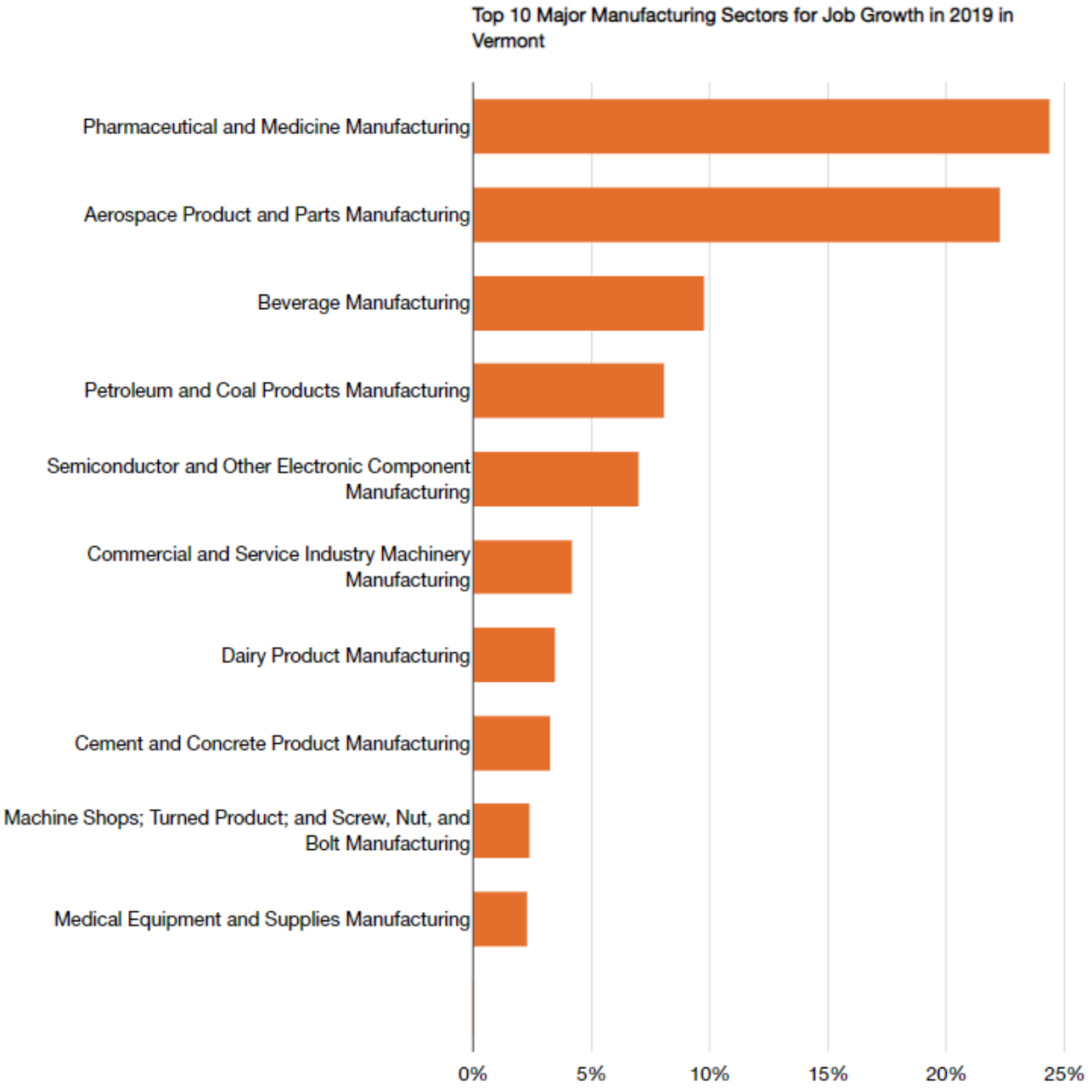


Source: *https://www.nam.org/state-manufacturing-data/2020-vermont-manufacturing-facts/*

[45] https://accd.vermont.gov/economic-development/office-economic-adjustment-oea/state-vermont-grant-additive-manufacturing

[46] https://www.vmec.org/wp-content/uploads/2019/10/VAMC-Overview_Sept2019.pdf

FIGURE 6.6 VERMONT'S TOP 10 MAJOR MANUFACTURING SECTORS FOR JOB GROWTH (2019)



Source: *https://www.nam.org/state-manufacturing-data/2020-vermont-manufacturing-facts/*

6.4 Broadband Connectivity

Underlying some of these trends is the ability for people and businesses to have access to fast, reliable internet service. The ongoing COVID-19 pandemic may increase this need as more employees work remotely, children need access to distance learning, and social distancing keeps people from traveling to stores to buy groceries and goods.

From 2010 to 2020, Americans with access to broadband internet (defined as speeds of at least 25 Mbps download, 3 Mbps upload) increased from an estimated 74.5 percent to 93.5 percent. During this same period, access to broadband in Vermont has grown tremendously, from 17 percent in 2010 to 89 percent in 2020. This 412 percent increase in broadband access represented the second-highest percentage growth in the past decade, after Montana. However, Vermont currently ranks 36th out of all states and the District of Columbia in terms of percent of households with broadband access.[47]

Figure 6.7 below shows broadband availability by road segment in Vermont as of 2019. Out of 308,082 building locations, 238,183 (77.3 percent) are serviceable at 25/3 Mbps or better by fiber to the premises or cable. Broadband is most accessible in the state's most urbanized areas, such as Greater Burlington, Barre-Montpelier, Rutland, and the Connecticut River Valley. The mostly rural northeastern part of the state has less broadband coverage and access than other parts of the States.

Only 32 percent of Essex County buildings are served by speeds greater than 25/3 Mpbs and only 68 percent are served by speeds of 4/1 Mpbs or better, both the lowest marks among Vermont counties by a considerable margin. Essex County is Vermont's least populous county and is also the county with the lowest household income, according to the 2018 American Community Survey. Caledonia, Lamoille, and Orleans counties, also in the Northeastern part of the state, are all clustered around 55 percent of buildings with 25/3 access, the only other counties below the 60 percent threshold. Over 90 percent of buildings in Chittenden County, Rutland County, and Windsor County are accessible to broadband at speeds over 25/3 Mpbs. Bennington County in Southern Vermont is the only other county above the 80 percent threshold.

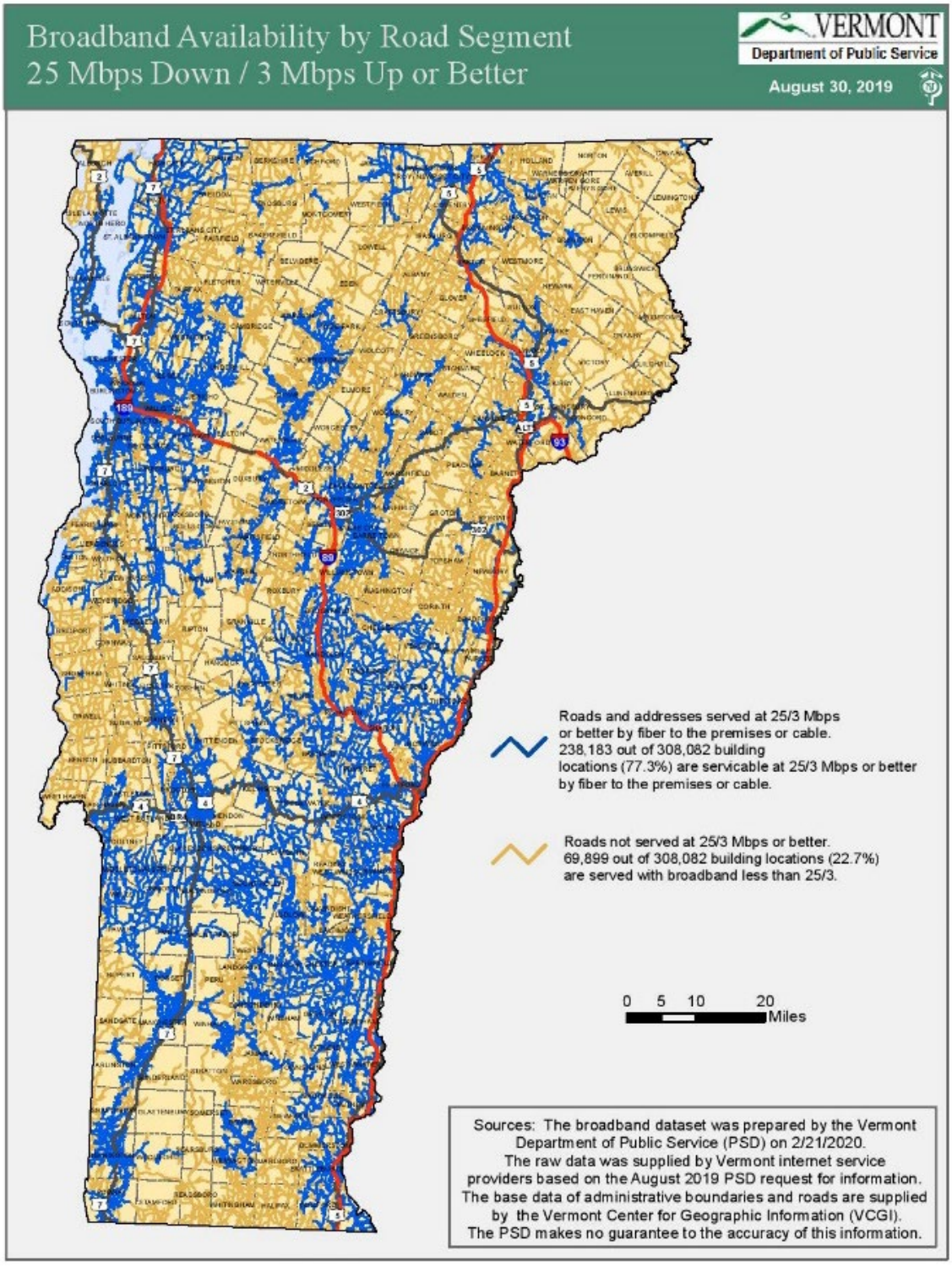
According to the Vermont Department of Public Service, there are 14 towns with no access to 25/3 Mbps internet, the largest of which is the Town of Orwell in Addison County, with a population of 1,321 according to the 2018 American Community Survey. Conversely, many of the state's largest cities and towns enjoy complete coverage (100 percent of all buildings served) of 25/3 Mpbs internet, including Rutland, Barre, St. Albans, Springfield, and Winooski, while 99.9 percent of Burlington buildings are accessible to 25/3 Mpbs.

To address this and other communications infrastructure issues, nine Communications Union Districts (CUD) have been established across the State of Vermont. A CUD is an organization of two or more towns that join together as a municipal entity to build communication infrastructure together. Figure 6.8 below shows the municipalities that have joined CUDs.

[47] All data from https://broadbandnow.com/research/broadband-2020

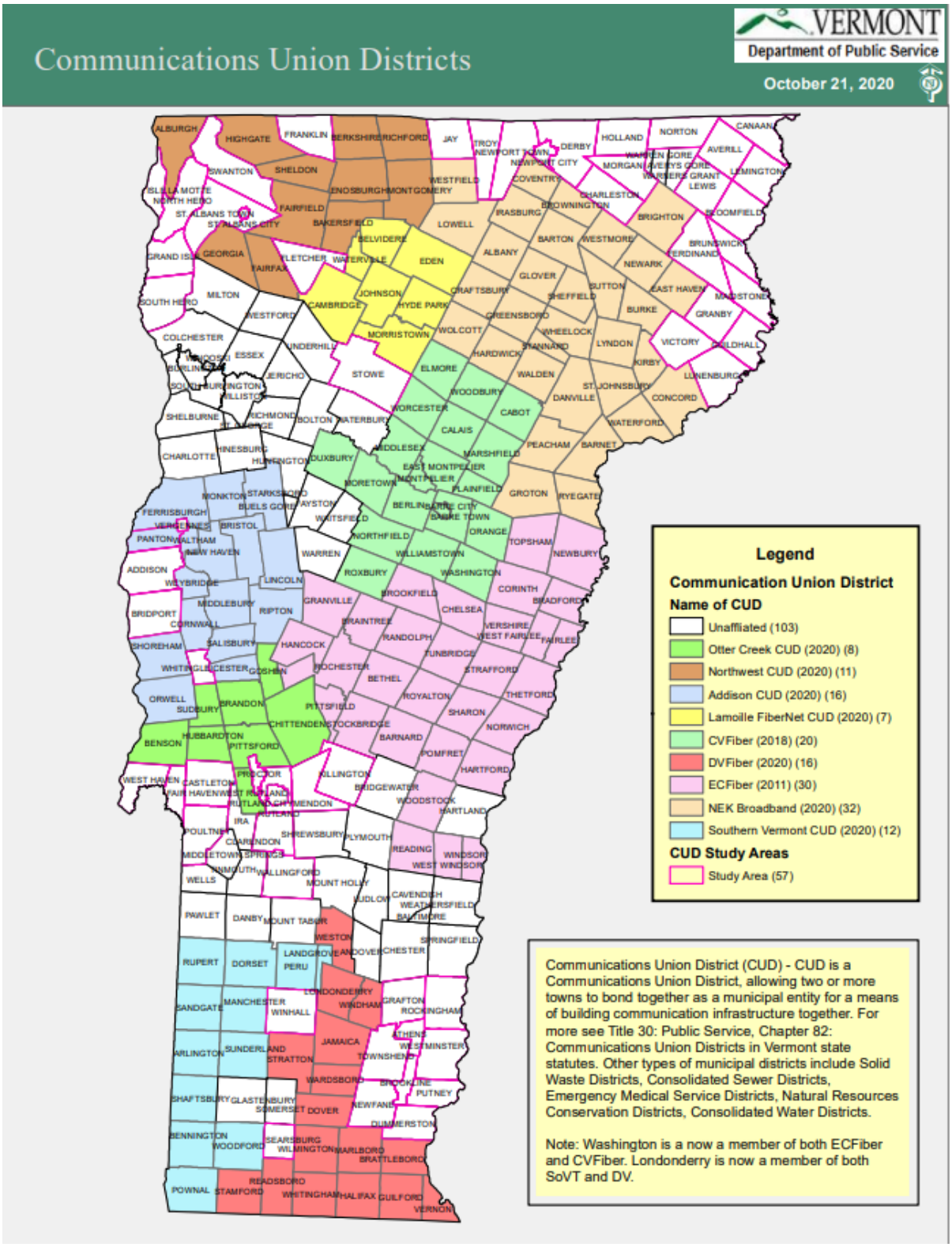
In an increasingly online world, access to fast, reliable internet is critical for both businesses and residents throughout the State.

FIGURE 6.7 VERMONT BROADBAND AVAILABILITY BY ROAD SEGMENT



Source: https://publicservice.vermont.gov/content/broadband-availability

FIGURE 6.8 VERMONT BROADBAND AVAILABILITY BY ROAD SEGMENT



Source: Vermont Department of Public Service, 2020 (https://publicservice.vermont.gov/content/vermont-communications-union-districts)

6.5 Workforce

Many jobs in the transportation and goods movement industries are considered "middle skill" jobs—more than a high school diploma, but less than a four-year degree. The skillsets may be technical, such as operating a computerized freight routing system; operational, such as driving a forklift; or, administrative, such as scheduling shipments and communicating with freight operators. Many of these middle skill jobs rely on experience and knowledge that is most effectively gained in the work environment or in apprenticeship programs that simulate the work environment.[48]

For example, a worker in a warehouse may need to operate a system for sorting and routing freight into appropriate delivery chains. However, because the system's functionality relies on having freight to manage, it is most effective for the worker to gain the necessary experience by shadowing a more experienced worker as they operate the system. Through this on-the-job exposure, the worker gains the necessary capabilities and skillsets to operate the system as an employee. Alternatively, the worker may take classes at a community college or workforce development center after standard work hours using a version of the system that a local employer or trade association has set up at the learning center for the purpose of building a workforce with the necessary experience or skillsets.

Less technical positions in freight operations also require certification in order to demonstrate that a worker has the appropriate skillsets to meet critical roles within the industry, and candidates are in demand. Commercial Driver Licenses (CDLs) are requirements for operating motor vehicles in the freight industry, and different subcertifications exist for different types of vehicles and different types of materials being transported. Operating forklifts, which stay on-site at their freight facilities, similarly require drivers to be credentialed on these vehicles as Certified Forklift Drivers.[49] The motor carrier and railroad industries have been reporting labor shortages for many years. Truck drivers are chronically in short-supply, causing some industries in Vermont to explore "sharing" drivers to help alleviate shortages.[50] Limited growth in earning potential, long and often irregular working hours, time away from home, and other factors have impeded companies' efforts to recruit and retain truck drivers and railroad conductors and engineers. The median age of the workforce in these positions is quite high, suggesting retirements are and will continue to contribute to the attrition. These issues extend to sectors that support these industries, including commercial towing, mechanics, and maintenance workers.

Like many sectors in the economy, the trade and logistics fields are experiencing significant change driven by widespread adoption of technology. Automated systems for scheduling and monitoring shipments, advanced robotics in freight operations, and new transportation technologies (including autonomous trucks) are creating demand for expanded and new certifications. Existing trade and logistics programs are diversifying and specializing their credentials with advanced supply chain management certificates in data analytics and freight optimization,

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[48] PricewaterhouseCoopers, 2012, "Transportation and Logistics 2030, Volume 5: Winning the talent race," <https://www.pwc.com/gx/en/transportation-logistics/pdf/pwc-tl-2030-volume-5.pdf>

[49] Los Angeles County Economic Development Corporation. "Goods on the Move! Trade and Logistics in Southern California," May 2017, <https://laedc.org/wp-content/uploads/2017/06/TL_20170515_Final.pdf>.

[50] https://www.covermeinsurance.com/vermont-fueling-and-paving-industries-considering-sharing-seasonal-drivers-in-face-of-driver-shortage/

while new certificates, such as drone operator certificate programs are being established to build a workforce for future technologies that are still in the early phases of adoption within the industry.[51]

While these technological changes will increase the need for technical skillsets, they also highlight the need for soft-skill development that will continue to rely on on-the-job training. In a high-tech environment, communication of technical data between different specialized groups of workers will become an increasingly critical component of operational efficiency. The specific communication procedures will be determined by the work environment in which the communications are used. As a result, workers with technical credentials will continue to need on-the-job training to understand how to apply their technical skillsets to the workplace most effectively. For non-traditional workers from underrepresented groups, emerging certifications in workforce readiness, which represent competency in professionalism and other soft skills, will represent an important credential for workers to signal their ability to enter these specialized trade and logistics environments and contribute to the success of the operations.[52]

Workforce Programs

There are a number of workforce-related programs in Vermont that focus on freight-related occupations. Examples of training and continuing education programs for careers in manufacturing and/or logistics include several degree programs and Office of Continuing Education & Workforce Development programs at Vermont Tech[53] and the Vermont Manufacturing Extension Center.[54] VTrans offers up to $1,500 to woman, minority, or disadvantaged persons to obtain a CDL, and many motor carriers are offering attractive signing bonuses and other incentives to help fill available positions. The Vermont Student Assistance Corportation also provides "non-degree" grants that can be used towards CDL training, and the Department of Labor's Worforce Innovation and Opportunity Act programs can also provide assistance.[55]

The Vermont Department of Labor Workforce Development Division operates 12 regional offices (Career Resource Centers) which provide broader help for job-seekers across a number of industry areas. A formal apprenticeship program is also available with freight-related industries like advanced manufacturing and construction identified as promising career areas.[56]

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[51] For example, see: Miami-Dade College Eig-Watson School of Aviation, "Programs and Courses," http://www.mdc.edu/aviation/programs.aspx

[52] https://businessfacilities.com/2019/04/workforce-training-talent-acquisition/

[53] https://www.vtc.edu/ ; https://cewd.vtc.edu/cewd/manufacturing/

[54] https://vmec.org/about/

[55] https://vtrans.vermont.gov/civil-rights/employment/edhc/cdl

[56] https://labor.vermont.gov/apprenticeship

APPENDIX A. COMMODITY FLOW DATA PROCESSING

This appendix describes the steps used to process and combine data from the Surface Transportation Board's (STB) Confidential Waybill Sample (2018) and the Federal Highway Administration (FHWA) Freight Analysis Framework v4 (FAF4), and to derive an estimate of freight flows passing through Vermont by truck.

A.1 Process Description: Substituting STB Waybill Data for FAF4 Estimated Rail Flows

The FAF4 database uses 2012 base year commodity flow survey data and projects future year freight volumes. The team acquired permission to use carload waybill data from the Surface Transportation Board, which offered a more recent (2018) base year of observed data. The team replaced the 2018 projected FAF4 rail flow information with 2018 rail flows from the STB Waybill data.

Because the STB Waybill data does not include forecasts, growth rates from FAF4 for Vermont rail traffic for each commodity group were extracted from FAF4 and applied to the flows in the STB Waybill data by commodity group. The team perfomed this task by calculating rail growth rates by:

- Origin-destination pair (at the state level);
- Commodity group (at the Standard Classification of Transported Goods 2-digit [SCTG2] level); and
- Mode (in FAF4, rail flows represent carload rail traffic, while intermodal rail flows are typically classified as "multiple modes and mail").

These calculated growth rates were then applied to the origin-destination-commodity-mode "lanes" in the base year STB Waybill flow data, and thus, future volumes were then calculated using those growth rates. There was a small number of origin-destination-commodity-mode lanes for which there was no corresponding record in FAF. For those records, the average growth rate for the commodity-mode (across all origin-destination pairs) was applied.

The Waybill includes data on weight (in tons) but not the value of goods moved. Value is estimated in FAF4. The value per ton of goods for each SCTG2 commodity group by rail and by multiple modes and mail were calculated from the FAF4 estimate, and then applied to the tonnage reported in the Waybill data in order to generate an estimated value of goods moved by rail in Vermont.

A.2 Process Description: Through Truck Flow Estimation

This section summarizes the basic methodology used for developing through truck trips for the state of Vermont. While the detailed approach may be different for different states, and the level of intricacy of state travel demand

models can vary greatly state-to-state[57], the basic structure of the methodology to develop through trips for any state should be similar.

First, a trip table is developed for different commodity types. The origin and destination of this table is by State and FIPs code. SCTG2 codes are attached to each of these commodity types as shown in Table A.1 below.

[57]Because Vermont and its metropolitan area are in attainment of air quality standards, substantial investment in development of detailed travel demand modeling tools has not been necessary. There is, therefore, some tolerance for error and imprecision in the results of this analysis.

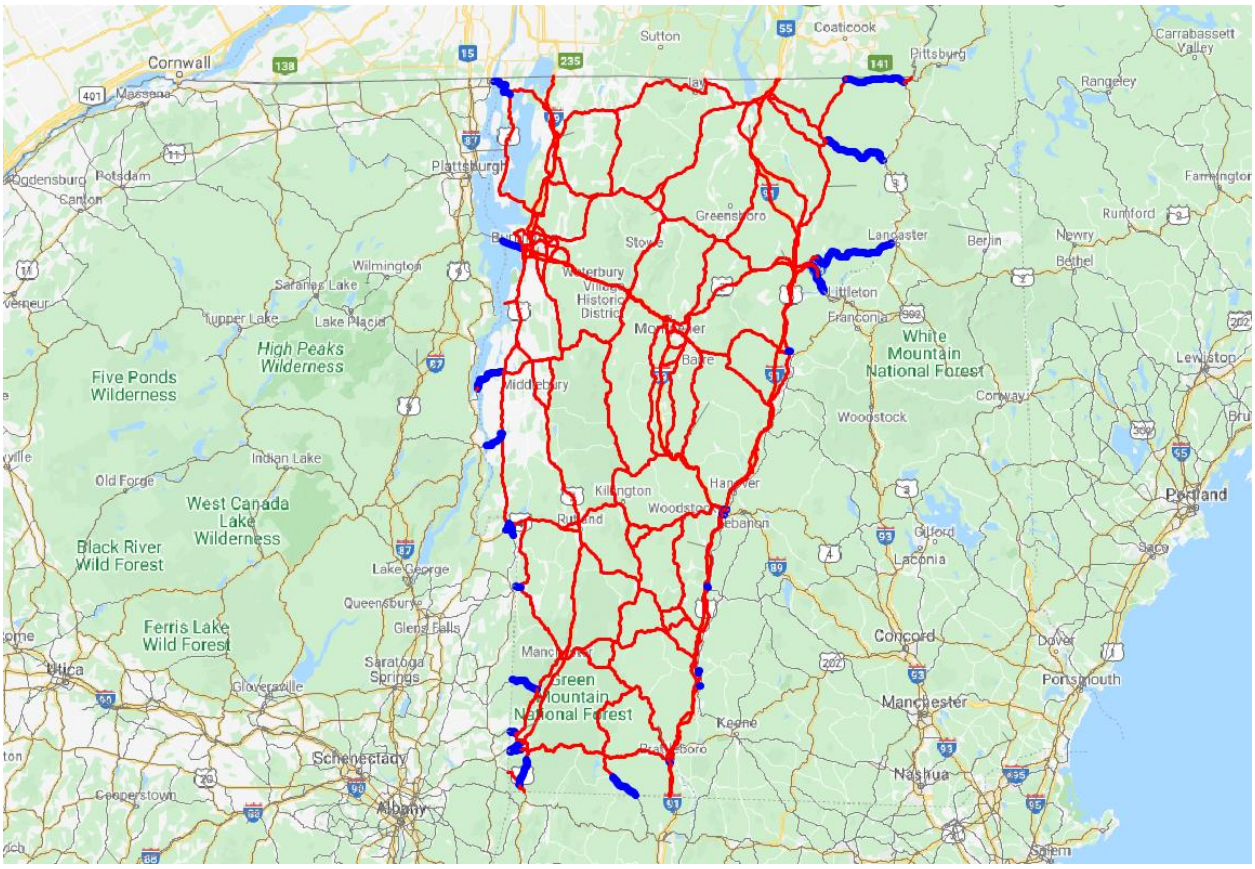
TABLE A.1 LIST OF SCTG2 COMMODITY CODES

Commodity Name	SCTG2_Code		Commodity Name	SCTG2_Code
Live animals/fish	1		Fertilizers	22
Cereal grains	2		Chemical prods.	23
Other ag prods.	3		Plastics/rubber	24
Animal feed	4		Logs	25
Meat/seafood	5		Wood prods.	26
Milled grain prods.	6		Newsprint/paper	27
Other foodstuffs	7		Paper articles	28
Alcoholic beverages	8		Printed prods.	29
Tobacco prods.	9		Textiles/leather	30
Building stone	10		Nonmetal min. prods.	31
Natural sands	11		Base metals	32
Gravel	12		Articles-base metal	33
Nonmetallic minerals	13		Machinery	34
Metallic ores	14		Electronics	35
Coal	15		Motorized vehicles	36
Crude petroleum	16		Transport equip.	37
Gasoline	17		Precision instruments	38
Fuel oils	18		Furniture	39
Coal-n.e.c.	19		Misc. mfg. prods.	40
Basic chemicals	20		Waste/scrap	41
Pharmaceuticals	21		Mixed freight	43

The flow data is presented by total annual kilo-tons. These numbers are then multiplied by 1000 to derive tons and divided by 295 to develop daily tonnage. Finally, it is divided by average ton per truck (15 tons per truck is a blended average load factor) to yield daily trucks.

Next, the daily truck trip table is assigned to the FAF4 highway network, which includes major highways and many other roadways across the United States. This step results in a network loaded with the volume of trucks represented in the commodity flow database. To estimate trips passing through the State of Vermont, select link assignments are performed, using some selected highway links along the border of Vermont. Figure A.1 shows the FAF4 network (gray) and the selected links highlighted in blue. There are 27 such links, which require 27 select link assignments.

FIGURE A.1 LOCATIONS OF SELECT LINKS ALONG THE BORDER OF VERMONT (BLUE)



The result of each select link assignment is a subset of trip table by different commodity types showing trip flows traveling through that link. There are 27 such trip tables (using 27 select link assignments) which are combined together. Since these links are on the border of Vermont, the resulting combined table show trips coming from outside of Vermont and going inside Vermont and beyond. Trips going inside Vermont are external-internal (E-I) and going beyond Vermont are external-external (E-E) trips.

The next step is to isolate external-to-internal (E-I) and internal-to-external (I-E) trips from the combined select link trip table. Trips going inside Vermont are tagged based on FIPS codes for Vermont's 14 counties. Any trip that has an origin that does not match Vermont county FIPS codes, but has a destination that matches a Vermont FIPS code, is classified as an E-I trip. Trips with a Vermont county origin but non-Vermont destination are considered I-E trips. The other trips in the trip table are considered as E-E trips. These E-E trips are then exported to a .dbf or excel file for subsequent analysis to characterize through trips by origin-destination pair, commodity group, or other attributes as desired.

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