UNDERSTANDING FREIGHT BEHAVIOR IN THE PACIFIC NORTHWEST: AN EVALUATION AND APPLICATION OF EROAD DATA TO FREIGHT DEMAND AND FORECAST MODELING

FINAL PROJECT REPORT

by

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16. Abstract

The overall objective of this work was to utilize a previously unused private data source to analyze freight movements in the Pacific Northwest. This objective was achieved through the use of private data acquired as part of an ongoing study with EROAD. EROAD is a company that develops and implements technology to modernize traditional paper-based systems within the trucking industry. As part of this modernization, EROAD collects data that can be used for modeling and forecasting freight movements. However, EROAD data have yet to be used for such an application.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

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LIST OF ABBREVIATIONS

AMS: Agricultural Marketing Service (USDA)

ATR: Automatic traffic recording

CFS: Commodity Flow Survey

CVISN: Commercial Vehicle Information System

ELD: Electronic logging device

FAF: Freight Analysis Framework

FHWA: Federal Highway Administration

FSA: Farm Service Agency

GPS: Geographic Positioning System

GVW: Gross vehicle weight

ITD: Idaho Transportation Department

ITS: Intelligent transportation systems

NASS: National Agricultural Statistics Service

NEC: Not elsewhere classified

PacTrans: Pacific Northwest Transportation Consortium

STB: Surface Transportation Board

USACE: United States Army Corps of Engineers

USDA: United States Department of Agriculture

WCSC: Waterborne Commerce Statistics Center

WIM: Weigh in motion

WSDOT: Washington State Department of Transportation

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CHAPTER 1. INTRODUCTION

The passage of the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 initiated an increasing interest in understanding freight movements within statewide planning efforts, particularly the evaluation of current and future freight transportation capacity necessary to ensure freight mobility. Since the passage of ISTEA, freight movements have been on the rise. Domestically, freight moved by truck in 2015 accounted for 66 percent of goods moved in terms of tonnage and 73 percent of goods moved in terms of value (Worth et al., 2016). In addition, from 2000 to 2010 ton-miles of commodities moved by truck from 2010 to 2015 were expected to have a 3 percent average annual growth rate, up 2 percent from the average annual growth rate of 1 percent. This continued growth creates challenges in allocating limited state funds to investments and improvement of the transportation system. Therefore, fully understanding freight demand is critical to transportation agencies for planning and forecasting accurately, effectively, and accordingly.

Although the task of understanding freight demand is acutely dependent on the quality of data, there is an intrinsic shortcoming in regard to the availability of quality freight data. As a result, the application of freight demand models can be rather limited. In most cases, transportation agencies, such as state departments of transportation and private enterprises, are pressed to use data that are published by federal agencies (e.g., the Freight Analysis Framework), purchased through a private data source related to freight (e.g., American Transportation Research Institute), or collected through surveys of freight operators and/or commercial motor vehicle drivers. Because of this, the processes of collecting efficient freight movement data can be expensive and very labor-intensive.

Hence, the overall objective of this work was to utilize a previously unused private data source to analyze freight movements in the Pacific Northwest, specifically through the State of Idaho as a case study. This objective was achieved through the use of private data acquired as part of an ongoing study with EROAD.[1] EROAD is a company that develops and implements technology to modernize traditional paper-based systems within the trucking industry. As part of this modernization, EROAD collects data that could be used for modeling and forecasting freight movements. However, EROAD data have yet to be used for such an application.

1.1. Background

A variety of data sources, both public and private, have been used for the study of freight movements. Of the public variety, Commodity Flow Survey (CFS) and the Freight Analysis Framework (FAF) are the most commonly used sources of data for analyzing domestic freight movements (Hernández and Anderson, 2016; RS&H Inc., 2016). These public data sources have been a primary focus of federally funded research (Bierling et al., 2011; Cambridge Systematics Inc. et al., 2008; Chase et al., 2013; Hancock, 2008; Quiroga et al., 2011). Unfortunately, these data are updated every few years, leaving gaps in regard to the growth or decline of freight movements. These data are compiled by state and federal agencies before being released to the public; therefore, freight estimates are commonly "noise-infused" to ensure confidentiality. Because of this, comparing freight demand estimates to alternative freight data or older CFS data is difficult. If such information is needed, state agencies must specify the exact specifications for the data to be purchased. In addition, these data are often aggregated at the state or FAF region, making intrastate freight movements difficult to determine without a more detailed analysis. This aggregation level imposes distinct restrictions in terms of freight behavior models. Therefore, a

[1] http://www.eroad.com/us/company/

much more disaggregated picture is required to better address regional and national freight planning needs (Pendyala and Bhat, 2012; Shin and Aultman-Hall, 2007).

In terms of private data, the most commonly used source is TRANSEARCH (Ahanotu et al., 2003; Baker and Planner, n.d.; Cambridge Systematics et al., 2012; Lim et al., 2014; Seedah et al., 2014; Sorratini and Smith, 2000; Transportation, 2009; Zhang et al., 2003). However, as is the case with public data, private data have their own limitations. Most often, these are a result of data that focus on a single mode of transport or commodity. More importantly, there are concerns regarding the reliability of the data. These often stem from the proprietary nature of the collection methods, compiling techniques, and underlying assumptions used for estimation, all being unknown to the analyst (Seedah et al., 2014; Walton et al., 2015).

Although the number of efforts that have utilized public and private data have been vast, these data sources often fall short in quality (Hazen et al., 2014) and the type of data provided. Therefore, it is necessary to explore new data avenues for modeling and forecasting freight movements. The objective of this study was to explore a new and innovatively collected data source for freight movement analysis through a current partnership with EROAD. A primary outcome anticipated from this work was a new, reliable data source that would provide transportation planners with a greater understanding of freight movement behavior in the Pacific Northwest, in addition to an analysis framework to apply such data.

CHAPTER 2. FREIGHT DATA INVENTORY

As mentioned earlier, the focus of this project was to study EROAD data in the context of its usefulness for conducting research on freight and commodity flows through the State of Idaho as a case study. The project also sought to provide a detailed evaluation and determine the possible applications of such data to better understand supply chains supporting the state's freight economy. To do so, it was imperative to first understand what types of data currently exist and document those. The following listed data are publicly available for most states, particularly those from federal agencies, and can be utilized to understand the different characteristics and nuances of freight activity throughout a state. Each data source, while possessing limitations to some degree individually (detailed origin-destination, route, commodity, or other data details), can provide a clearer picture of what is being transported over the nation's roadway system when used and evaluated collectively. For a more detailed reporting of the information found in this chapter, readers are referred to the Idaho Department of Transportation Research Project entitled "Idaho Statewide Freight Data & Commodity Supply-Chain Analysis" (Jessup and Hernandez, 2020).

2.1. Existing Data Sources

The following sections introduce and describe in detail the nationally available data sources listed below and discuss them in the context of our case study, the State of Idaho (Jessup and Hernandez, 2020):

- Freight Analysis Framework (FAF)
- United States Department of Agriculture (USDA)
- Idaho Transportation Department (ITD) automatic traffic recording (ATR) and weigh-in-motion (WIM) data

- Commercial Vehicle Information System (CVISN)
- Surface Transportation Board Rail Waybill (public rail movements)
- United States Army Corps of Engineers (USACE), Waterborne Commerce Data (barge movements).

2.1.1. Freight Analysis Framework

The Bureau of Transportation Statistics, in partnership with the Federal Highway Administration (FHWA), produces the Freight Analysis Framework (FAF). The FAF integrates data collected from several different sources to create a comprehensive pattern of freight movements between states and major metropolitan areas, considering all modes of transportation. The FAF utilizes information from various sources, including the 2012 Commodity Flow Survey and international trade data from the Census Bureau on different industry sectors (e.g., agriculture, resource extraction, construction, utilities, service, etc.). The baseline and most current edition available are FAF version 4 (FAF4), which provides a database of shipment tonnage and value by region or by state of origin and destination, commodity type, and mode[2]. Detailed information regarding freight movements originating and ending within a particular state can be obtained, including both the value (in millions of dollars) and volume (in tons) by commodity type. The following figures (figures 2.1 through 2.4) illustrate shipments leaving and arriving into Idaho from other states. Each figure provides the commodity distribution and the state in which shipments originated or ended by both volume and value. This type of information is useful for identifying both economic and geographical connections across different states and the types of industries generating freight activity.

[2] Data can be downloaded from: https://ops.fhwa.dot.gov/freight/freight_analysis/faf/

It is evident from the FAF data that a large majority of freight shipments into and out of Idaho are concentrated in neighboring states, particularly Utah and Montana. One important observation from comparing the FAF maps below is how much freight is contained (both generated and destined) within Idaho in comparison to that which leaves the state or originates in other states. This is attributed to the large agricultural and forest products industries located in the state and the freight characteristics associated with moving products from production to processing within the state borders. However, the maps also illustrate that businesses in Idaho depend upon freight movements coming into the state from as far away as Georgia and Texas (by tons) and Florida and Virginia (by value). Those states connected to Idaho via I-80/I-84 (Wyoming, Nebraska, Iowa, Illinois) are important for freight arriving into the state, as illustrated by the red intensity in both value and tonnage in the maps in figures 2.1 and 2.2. That corridor and those particular states are less important for freight leaving the state.

Differentiating between volume and value for inbound freight shipments can also help reveal unique characteristics. The connectivity and importance of Utah and Montana are the same for both value and tonnage for inbound freight volumes. This reveals a broader array of freight coming from those states, including both high value and low value bulk items. Also, freight shipments arriving from Wyoming, Nebraska, and Iowa are more volume intensive and lower value than those arriving from Illinois and California, which are more value based. It is also evident that agricultural and natural resource-based commodities dominate the largest volume of inbound freight shipments, given the distribution of commodities in the tonnage commodity bar chart, whereas those shipments with the highest value are mixed freight, foodstuffs, motor vehicles, and electronics. The primary commodities for outbound freight shipments by tonnage from Idaho are very similar to those commodities arriving into the state, including agricultural products, cereal grains, wood products, and coal. The largest category for outbound shipments by value is other foodstuffs (processed dairy products and processed potatoes). There is also a slightly different geographical connection for Idaho freight destinations; whereas Nebraska and Wyoming generate large volumes of inbound Idaho freight by both tonnage and value, those states are considerably less dominant for outbound shipments. Outbound freight shipments from Idaho are more concentrated in Colorado, Missouri, Illinois, and Texas for eastern shipments and the other Pacific Northwest states (Washington, Montana, Oregon) and California for westbound movements.

One benefit of the FAF is the fact that it is publicly available and does provide relatively detailed freight movements from state to state across different freight modes. It also helps characterize the underlying business and industrial makeup of the state by providing detailed commodity information on inbound and outbound shipments by both tonnage and value. One drawback is that the information is often quite dated, given that much of the information populating the FAF originates from either the commodity flow survey or the U.S. Census. As a result, it may not capture the dynamic nature of changes in freight activity on a more seasonal and real-time basis, and by the time the most recent version has been released, information on secondary freight activity, such as intermediate stops or empty truck trips, may be out of date. There is also no information regarding freight routing or trip-chain details (RS&H, 2016).

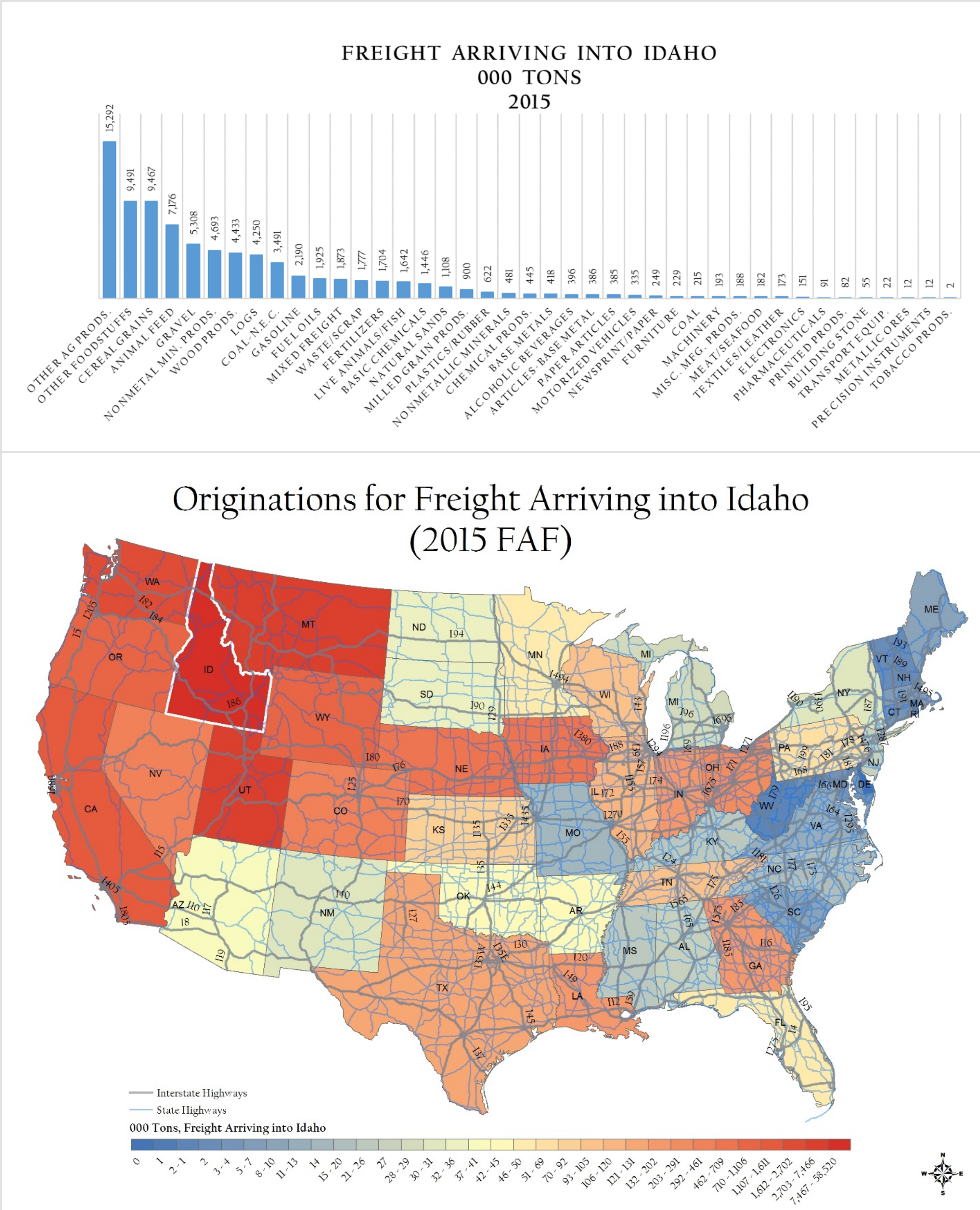


Figure 2.1 Freight arriving into Idaho, by originating state and commodity, tons, 2015

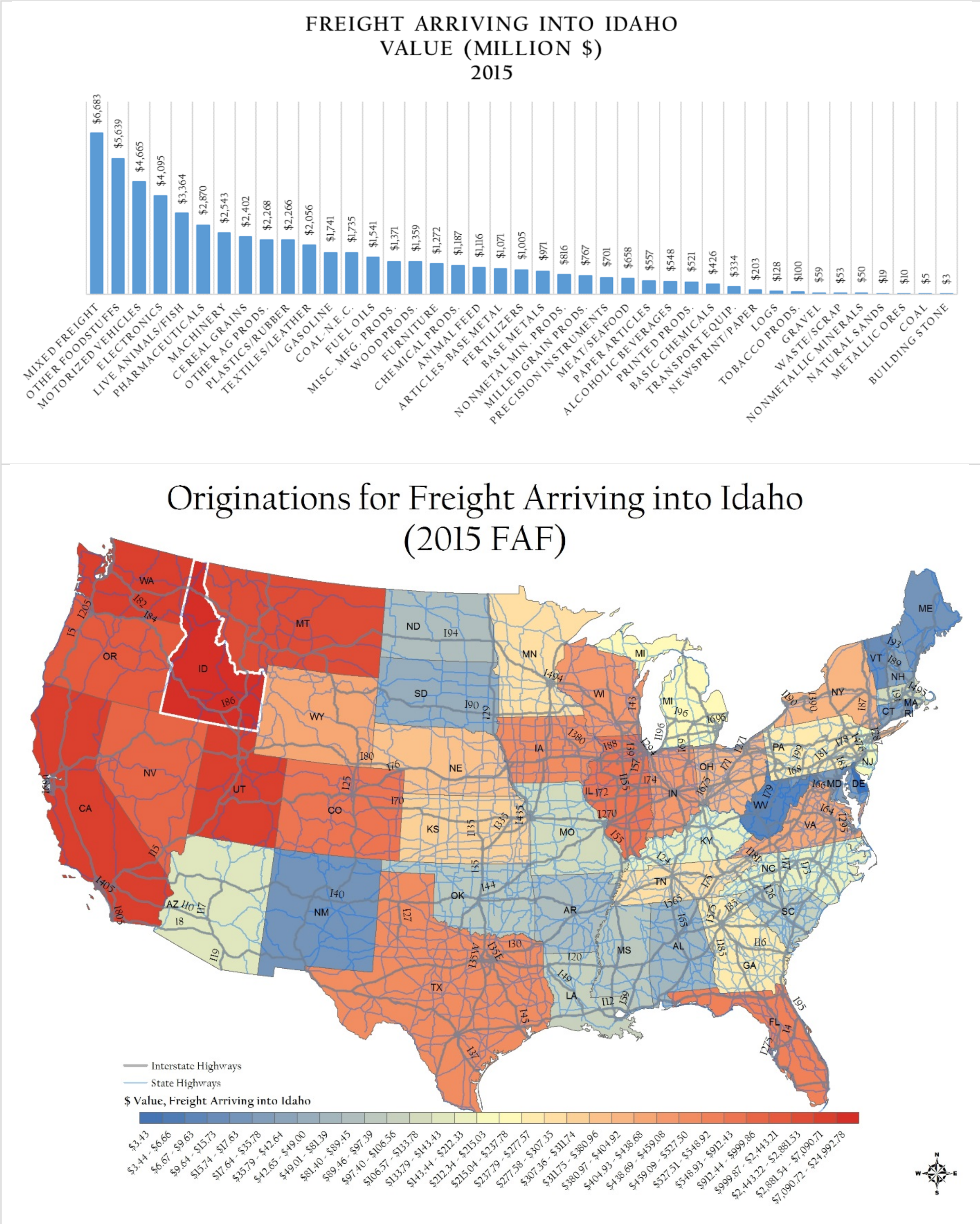


Figure 2.2 Freight arriving into Idaho, by originating state and commodity, value, 2015

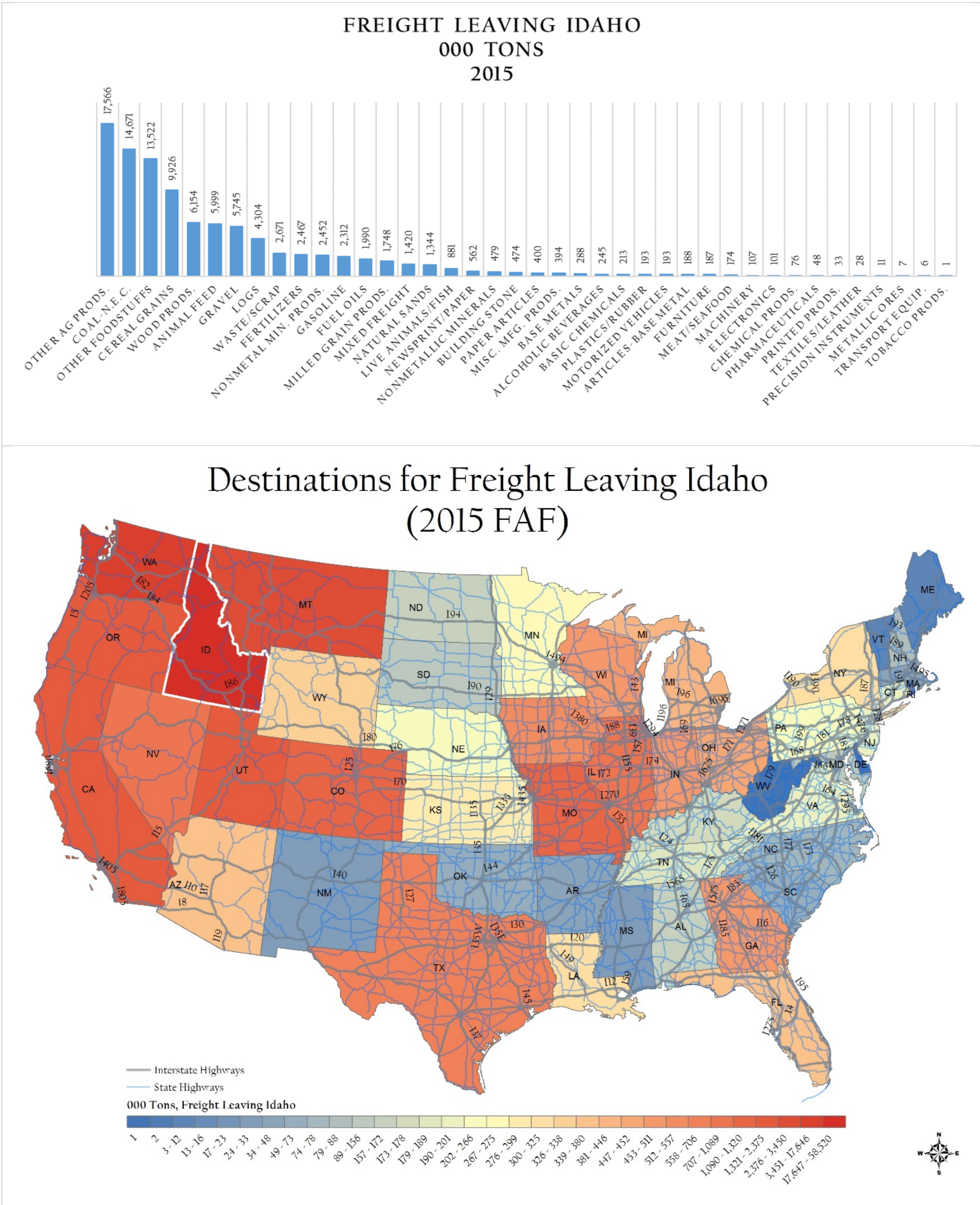


Figure 2.3 Freight leaving Idaho, by destination state and commodity, tons, 2015

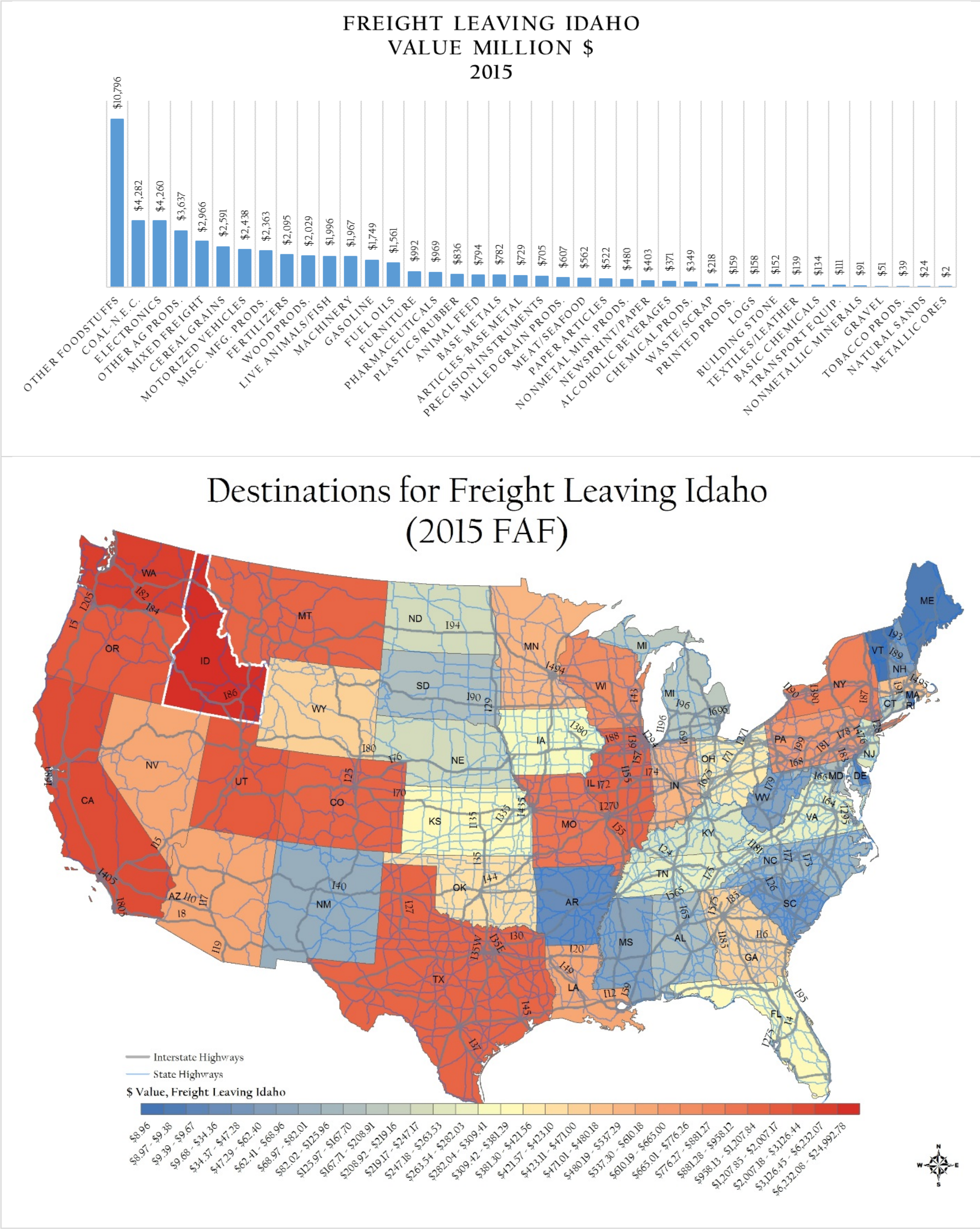


Figure 2.4 Freight leaving Idaho, by destination state and commodity, value, 2015

2.1.2. United States Department of Agriculture

The United States Department of Agriculture (USDA) can also be a valuable source for supplementing individual state freight and commodity flow information, particularly given the level of agricultural and natural resource-based industries that are concentrated within Idaho and the significant contribution these industries make toward the state's economy. The USDA provides county-level production data for all crops and agricultural commodities on an annual basis, which can be mapped to identify specific geographies within the state that generate different types of agriculture production and freight shipment activities. Examples of these USDA data are shown in figure 2.5, detailing hay, potato, wheat, and dairy production for the state. These agricultural products represent a large proportion of Idaho agricultural production and therefore constitute a significant component of the state's freight activity in moving products from field to processing/distribution centers (heavy, lower valued freight) and final markets (higher valued, processed goods). In each map in figure 2.5, the intensity of production is easily identified, and the southern half of the state has the heaviest agricultural production. Hay production, while spanning most counties from the southwestern to southeastern borders, is primarily concentrated between Twin Falls and the Oregon border to the west. This is the same area of concentration for dairy cows and milk production in the state because a large proportion of hay production supports the large dairies. Potato production is more heavily concentrated in the southeastern corner, between Twin Falls and Rexburg, which, while not displayed on the map, is also where many cold storage and potato processing plants are located. Grain production is concentrated in both the southern and northern portions of the state; primarily wheat and barley production, as illustrated in figure 2.5. Grain elevator locations are also displayed on this map, which show the destinations from the farms with the most grain shipments. In the north, near Lewiston and Grangeville, grain is often shipped via truck to the Snake River ports in Lewiston to utilize cost-effective barge shipment to export terminals on the Lower Columbia River near Portland, Oregon. In the south, grain shipped from elevators primarily utilizes rail in order to access Pacific Northwest grain export ports in Seattle and Tacoma, Washington, and Portland, Oregon.

The USDA has national data on the volume capacity and locations of grain elevators. The USDA Agricultural Marketing Service (AMS) also provides reports and data sets related to grain transportation, port deliveries, and non-grain products. However, many data are presented for the Pacific Northwest region, which aggregates data from Idaho, Oregon, and Washington (USDA AMS, 2017).

Many different agencies within USDA also have information on the locations of other agricultural and processing facilities that can aid in determining the origins of freight movements and major agricultural commodities produced in the state. These include the following:

- National Agricultural Statistics Service (NASS), which maintains a contact list of commercial and public warehouses from 48 states that store refrigerated products for 30 days or more and a database of the attributes of different agricultural products such as acreage, yield, production, prices, and more. (USDA NASS, 2017a, 2017b).
- Farm Service Agency (FSA), which compiles a list of warehouses in the U.S., including grain elevators in Idaho (USDA FSA, 2012).

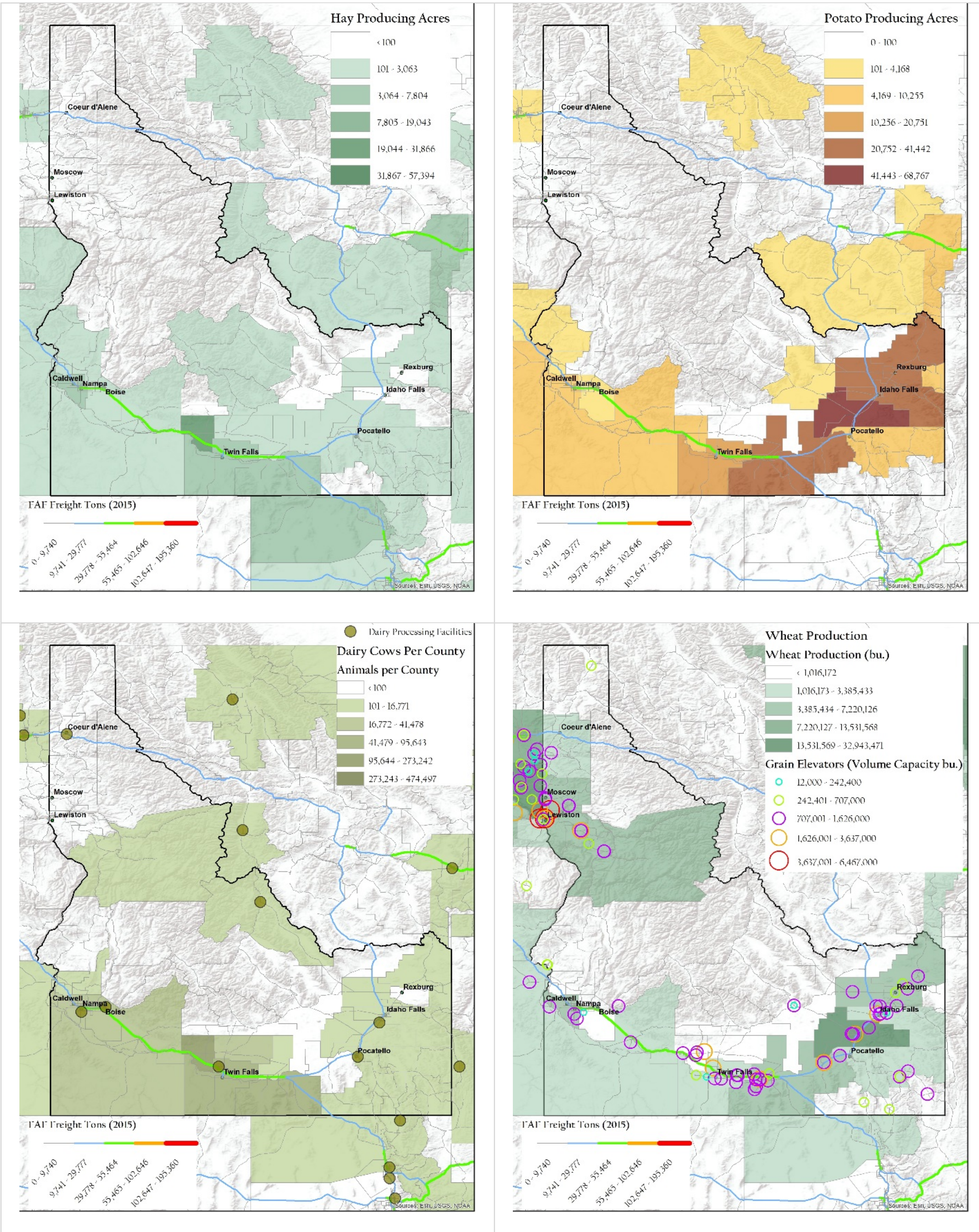


Figure 2.5 Idaho agricultural production, by county: hay, potatoes, dairy and wheat, 2016

2.1.3. Idaho Automatic Traffic Recorders / Weigh-in-Motion Data

The State of Idaho also compiles data collected from automatic traffic recording (ATR) devices and weigh-in-motion (WIM) sensors located in highways throughout the state. The places where traffic recording devices are located are continuously collecting traffic counts and provide very useful information related to changes in traffic activity over time, at specific locations and across different vehicle classifications. This information is used for a variety of purposes, including satisfying reporting requirements associated with the Highway Pavement Management System (HPMS) to FHWA. The obvious limitations associated with these data are the lack of information related to shipment origin, destination, commodity, or route traveled. However, by evaluating the data collectively across all locations throughout the state or for specific corridors, significant insights can be obtained regarding freight characteristics.

Figures 2.6 through 2.9 illustrate some useful information related to freight movements throughout the State of Idaho based on ATR data at all sites within the state for 2016. There are three different vehicle classifications for freight vehicles, including straight trucks (straight truck), tractor with one trailer (tractor trailer), and tractor with two trailers (truck two trailers). Two different bar charts are displayed in figure 2.6 showing the average truck counts by day of week and month per year, which illustrate some interesting trends. Straight trucks exhibit significant variation between weekend and weekday activity but very little variation in volumes across different weekdays. This is likely because straight trucks are utilized for delivery, which is influenced by regular working hours on weekdays that are consistent throughout the week. Tractor trailers and tractors with two trailers exhibit similar but less pronounced patterns. The tractors with two trailers have the most weekday variation, particularly between Monday and Tuesday and between Thursday and Friday. There are also differences in seasonal patterns across months, by vehicle type. The straight trucks exhibit the least month to month or seasonal variation; they generally maintain consistent volumes per month throughout the year. The patterns of both the truck with trailer and truck with two trailers peak during the summer and fall months, with the truck and two trailer vehicles having the most pronounced peak between July and October. This is most likely because of the seasonal nature of agricultural production and the utilization of these vehicle types in moving agricultural products.

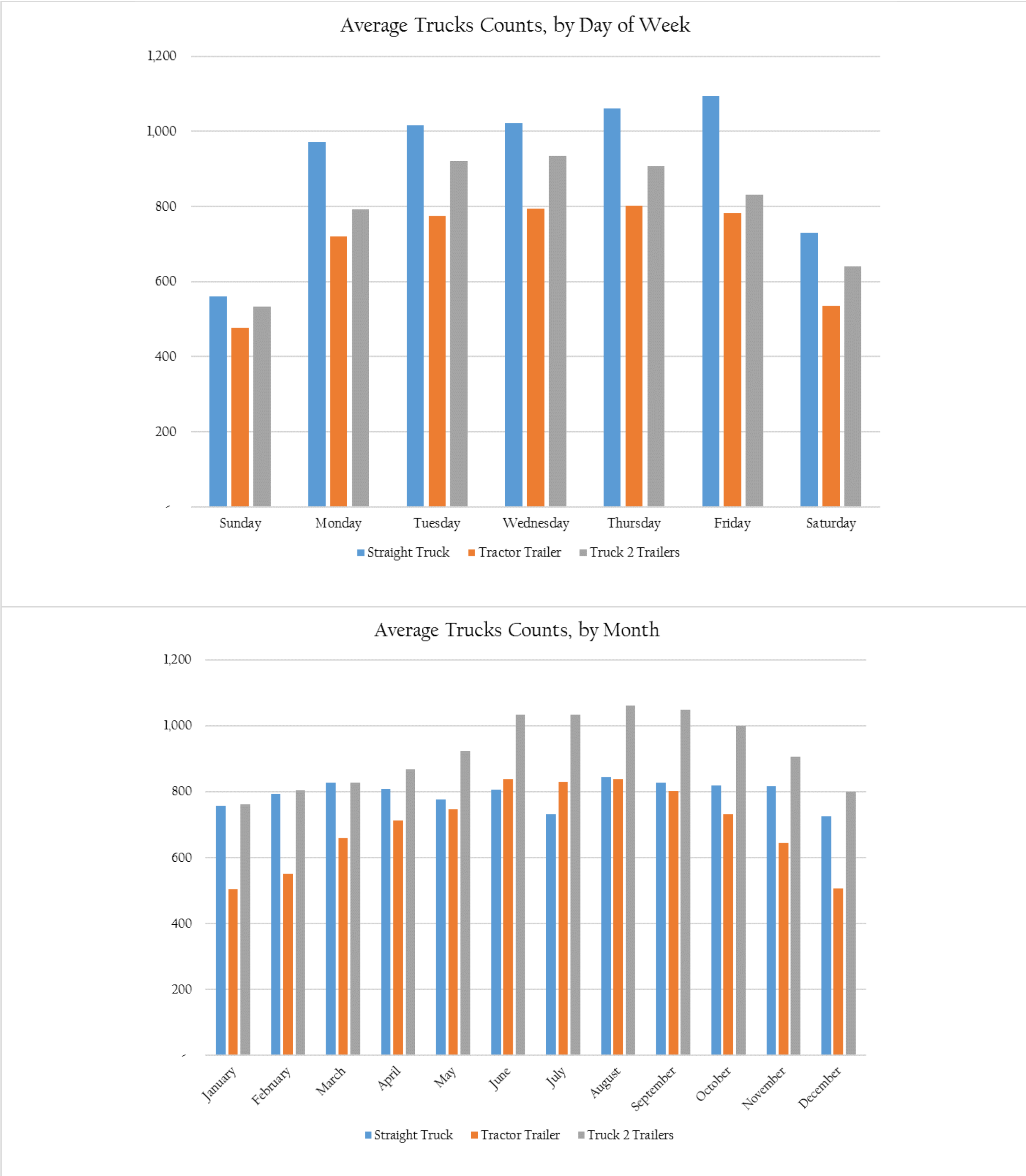


Figure 2.6 Average truck counts at all ATR locations, by day of week and month, 2016

Other figures below identify the geographical concentrations of average truck counts by vehicle type (figure 2.7), the degree of weekday variation by vehicle type for the state (figure

2.8), and the monthly variation by vehicle type (figure 2.9). It is apparent that the highest concentrations of straight truck traffic are around urban regions, but not for the longer distance tractor trailer and tractor with two trailers. The larger vehicle types are evenly distributed across the southern and northern Interstate system, with less in between. The values exhibited in figures 2.8 and 2.9 represent a percentage, calculated as the range (difference between the highest and lowest average day) divided by the overall weekly average for day of week variation. This allows comparisons in variability across the three different vehicle types and geographies, for those vehicles and areas with the greatest weekday or monthly variation. The variation by truck type in conjunction with density of truck traffic is a result of the products and commodities being moved. For example, straight trucks are primarily concentrated around urban areas, and weekday variation is greatest in these areas, but these vehicles still exhibit significant weekday variation in rural areas even though the truck counts there are relatively low. Tractor trailers and trucks with two trailers are predominately concentrated along the Interstates and, except near urban areas, show very little weekday or monthly variation around the Interstates in comparison to the rural and agricultural regions. This is because of the seasonal nature of agricultural production.

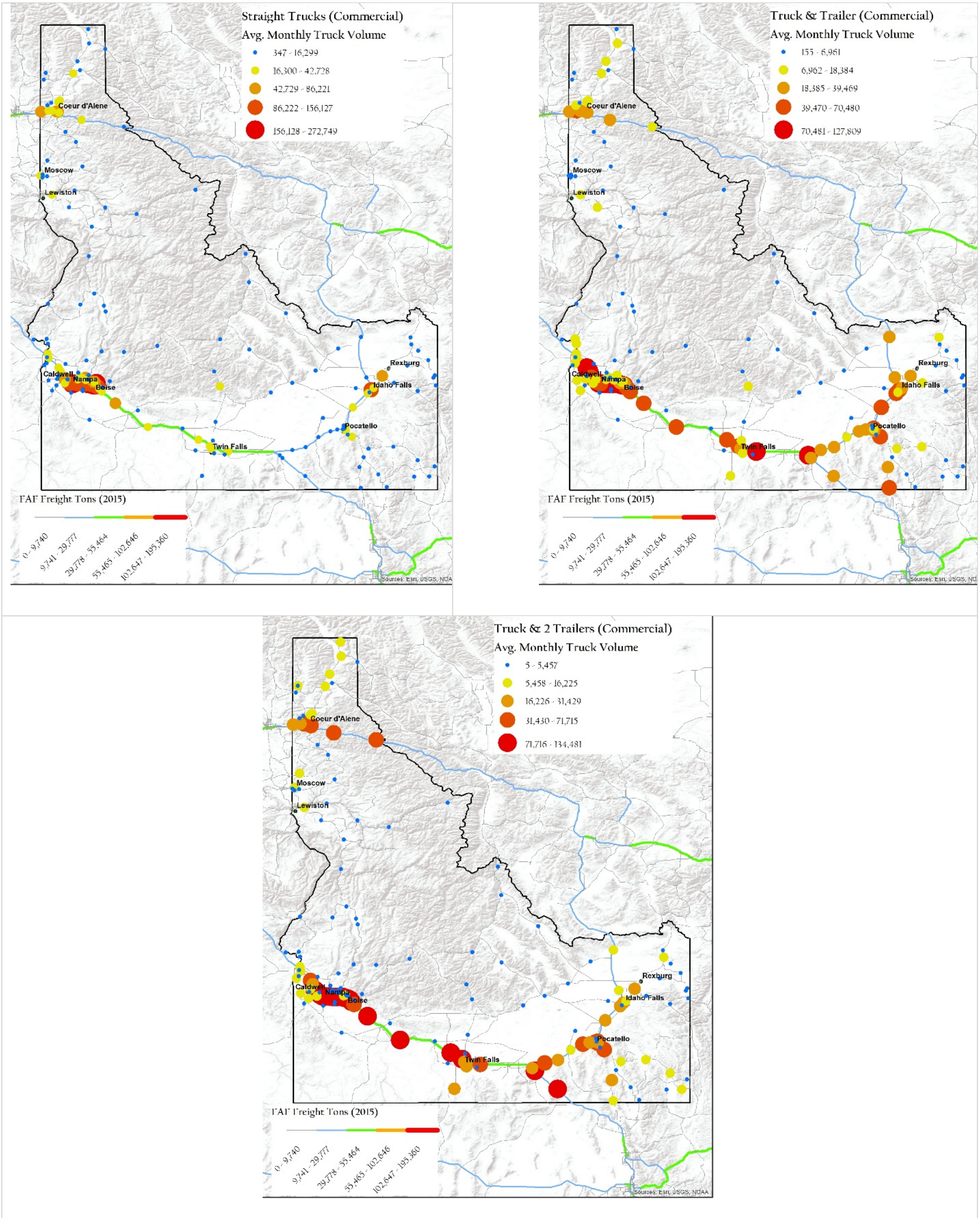


Figure 2.7 Average truck counts at all ATR locations, by day of week and month, 20

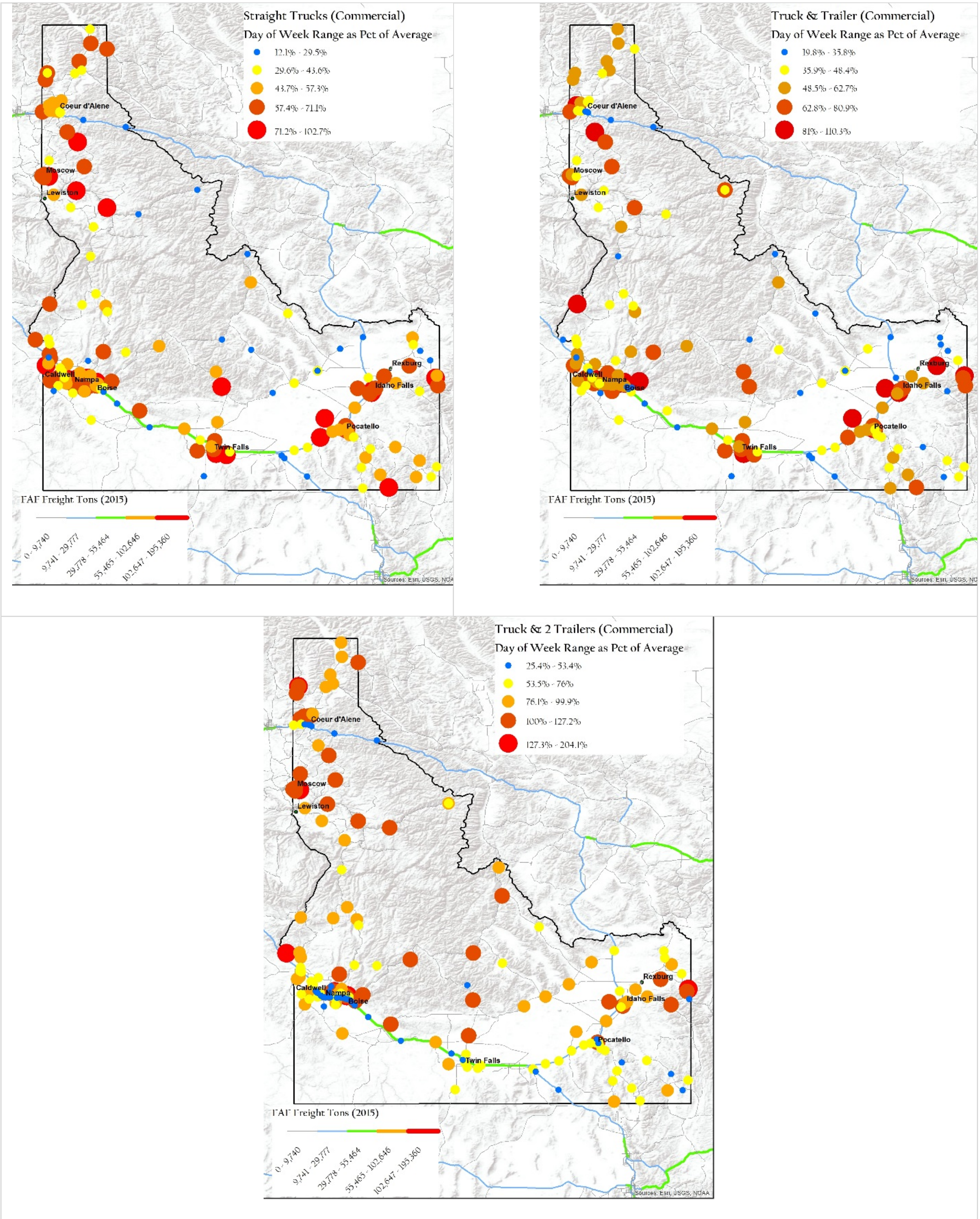


Figure 2.8 Day of week variation at all ATR locations, by truck type, 2016

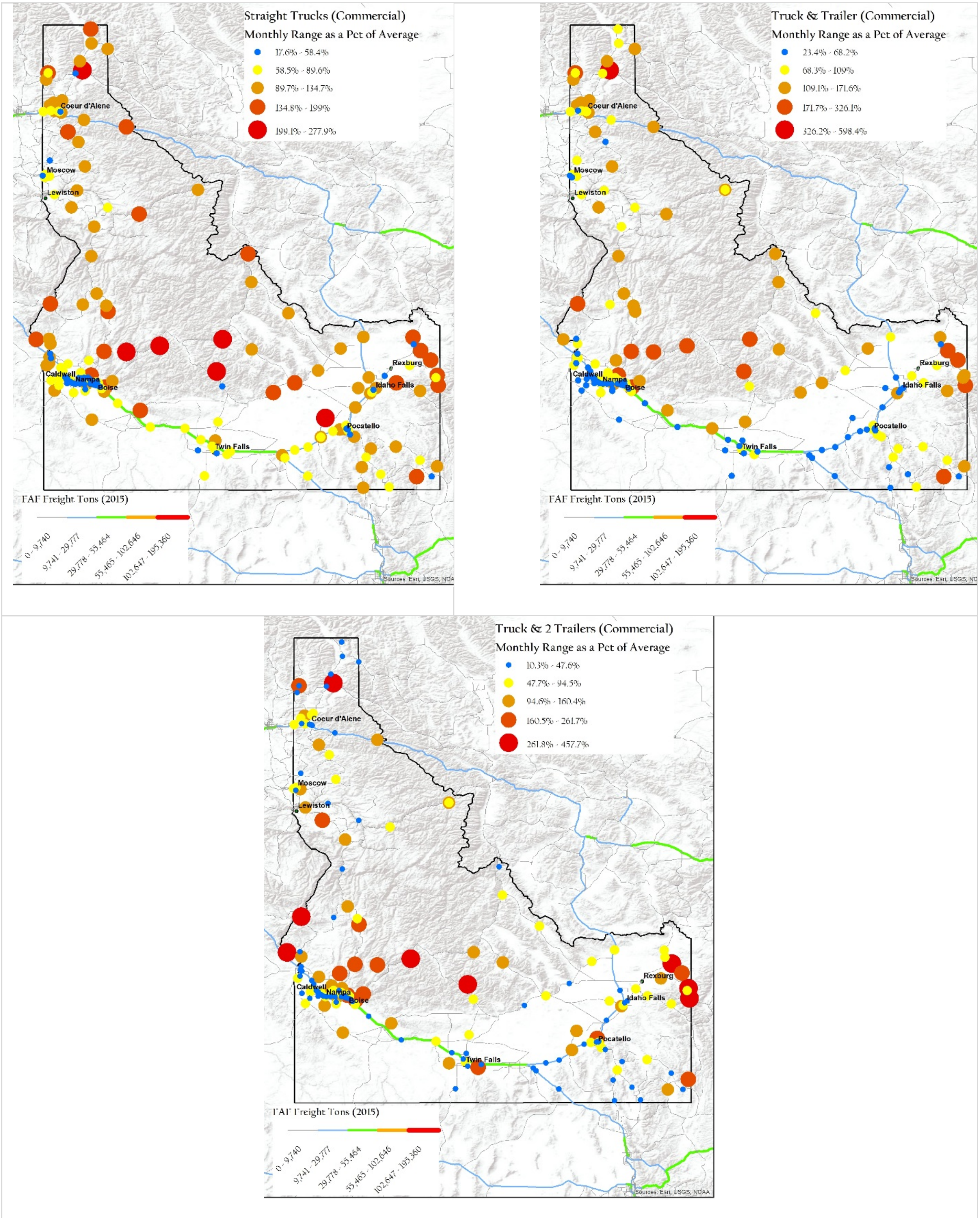


Figure 2.9 Month variation at all ATR locations, by truck type, 2016

The advantages of automatic traffic counters are as follows:

- Data can be collected without traffic disruption.
- Truck counts can be obtained from different locations in the state with low labor requirements.
- Traffic frequencies by vehicle type for specific locations can be obtained.

The disadvantages include the following:

- There is potential for equipment failure.
- No information is provided about the origins and destinations of trips, types of commodity shipped, routes, etc.
- Data collection is limited to highway segments that have traffic counters.

Nevertheless, this data source allows the identification of truck corridors, which may be beneficial for identifying potential locations of roadside surveys (Jessup et al., 2004).

2.1.4. Commercial Vehicle Information Systems Network

Most states have a commercial vehicle enforcement division that is part of the state patrol or a parallel entity focused on enforcing regulations around commercial vehicles operating within and through the state. Some of these states (such as Idaho, Washington, and Oregon) also implement the Commercial Vehicle Information Systems and Networks program (CVISN), which is an integrated network of information systems and communications networks at the local, state, and national levels (DOT ITS, 2017). The Idaho CVISN program includes port of entry booths in two locations where trucks can register when they first enter the state, East Boise and Lewiston (see red markers in figure 2.10). The monitoring system aims to detect, weigh, classify, and aid the enforcement of commercial vehicles (Idaho Enterprise Open Data Portal, 2017). The core function of CVISN is to implement electronic screening at the inspection site where enrolled vehicles are identified and screened on the basis of safety history, credentials (e.g., registration and fuel tax payment), and weight and are allowed to enter if they meet the state's criteria for bypassing inspection sites (DOT FMCSA, 2012). This data source enables collection of data on vehicle types that pass through the ports of entry, but no information can be obtained on origin and destination, shipping routes, type of commodity shipped, etc.

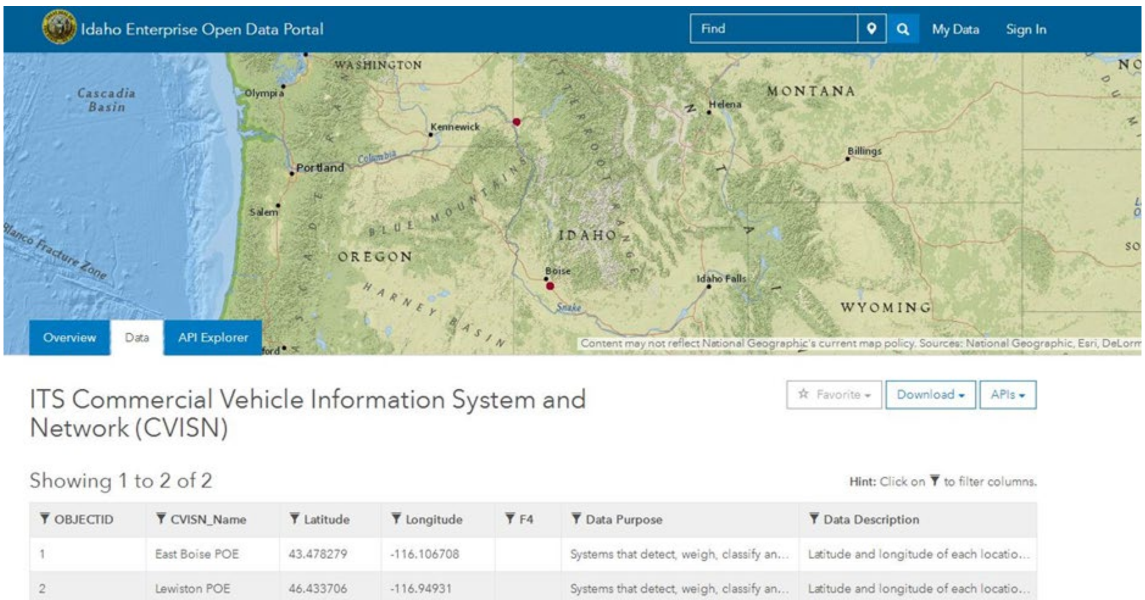


Figure 2.10 ITS, CVISN locations in the State of Idaho, 2017

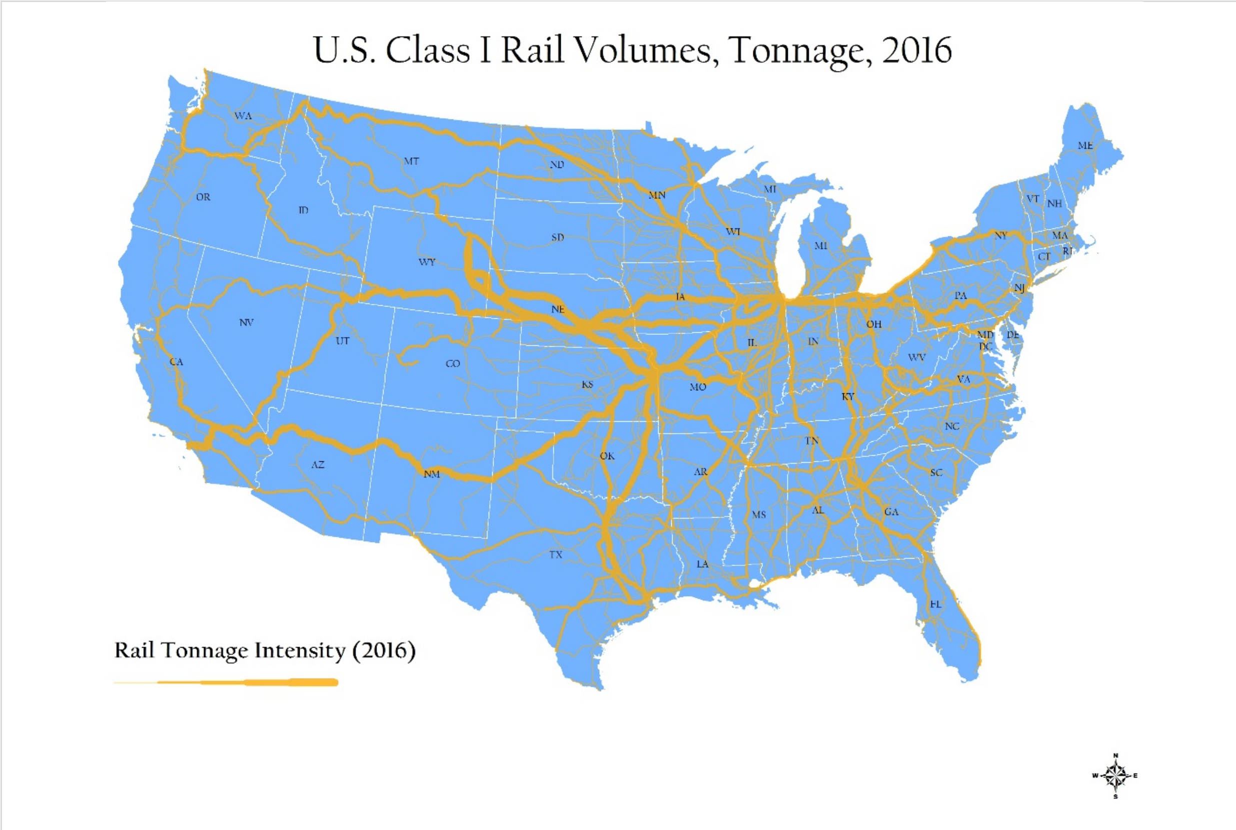
2.1.5. Surface Transportation Board Rail Waybill

The Surface Transportation Board (STB) maintains a database that contains national coverage of rail shipment information, the source of which is an annual stratified sample of waybills for railroads that carry 4,500 or more cars per year. Data are submitted by freight railroads to the STB. Data are available in two forms: the Carload Waybill Sample, a confidential database, and the Public Use Waybill Sample, a publicly available, aggregated database (STB, 2017). While the Carload Waybill Sample is restricted, access can be granted in instances when it is the only source of data and/or when obtaining data from other sources would be expensive or otherwise burdensome. The Public Use Waybill Sample is created from the confidential Carload Waybill Sample file.

The advantages of the Carload Rail Waybill sample are accessible data on the following:

- origin and destination
- type of commodity
- car count
- weight
- revenue
- length of haul
- participating railroads
- interchange locations.

The main disadvantage is that access to the Carload Waybill Sample is restricted because of sensitive information about shipping and revenues. Access can be requested from STB, but the requesting party must follow certain requirements and protocols. However, an aggregated, publicly available version containing non-confidential information is available.



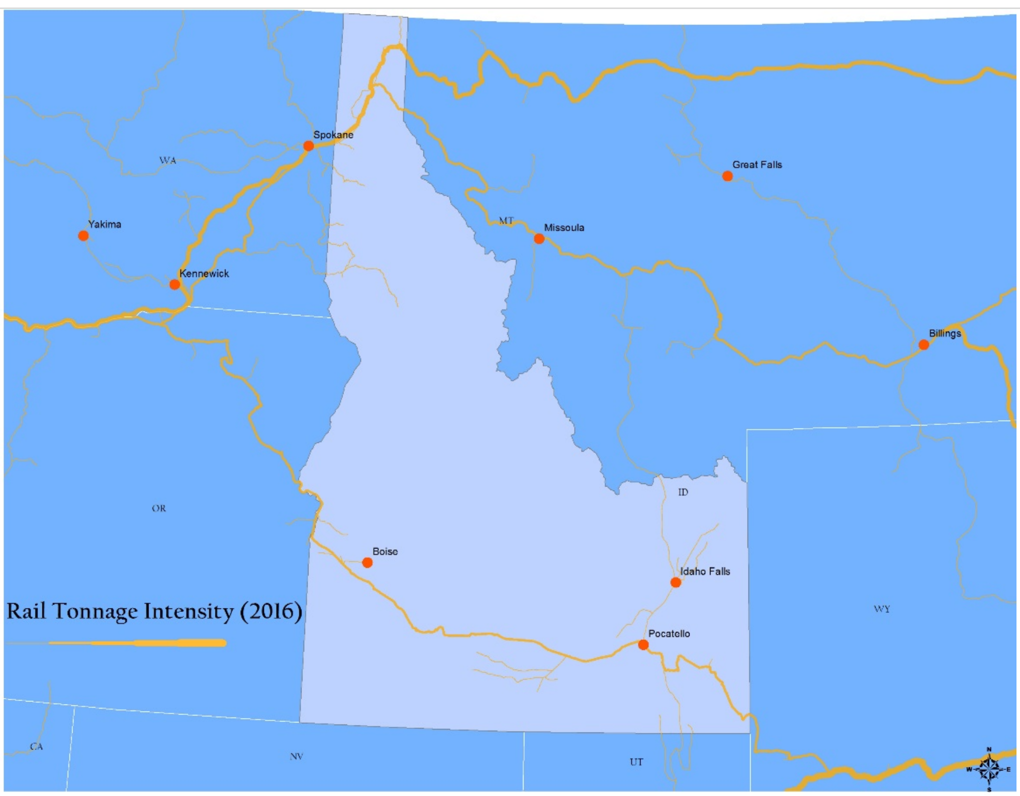


Figure 2.11 Class I rail volumes, 2016

2.1.6. U.S. Army Corps of Engineers, Waterborne Commerce Data

Water shipments by barges can be obtained from the U.S. Army Corps of Engineers (USACE) Waterborne Commerce Statistics Center (WCSC). The WCSC collects and provides data to the public on cargo and vessel trips that occur in the navigational channels of the U.S.. Under federal law, vessel operating companies must report domestic waterborne commercial movements to the USACE. The vessel types include dry cargo ships and tankers, barges (loaded and empty), fishing vessels, towboats, tugboats, crew boats and supply boats to offshore locations, newly constructed vessels from the shipyard to delivery point, and vessels remaining idle during the reporting period (WCSC, 2014). Vessel characteristics, documentation, and ownership data can be accessed (with limitations) through the US Coast Guard Vessel Database (WCSC, 2017a). Public domain databases contain state-to-state and region-to-region commodity movements in tonnage by type of commodity, origin, and destination. Data are updated annually and span from 2001 to 2016 (WCSC, 2017b, 2017c).

Data are presented for 14 major commodity types:

- coal, lignite and coal coke
- crude petroleum
- petroleum products
- chemical fertilizers
- chemicals excluding fertilizers lumber, logs, wood chips and pulp
- sand, gravel, shells, clay, salt and slag
- iron ore, iron, and steel waste and scrap
- non-ferrous ores and scrap
- primary non-metal products; primary metal products
- food and food products
- manufactured goods
- unknown and not elsewhere classified (NEC) products.

Figures 2.12 and 2.13 show the state-to-state movements of a commodity by tonnage, specifically where Idaho is the origin state and destination state, respectively. Data are available for only three commodity types originating from Idaho and two commodity types going to Idaho.

The main drawback of using the WCSC data is the inability to obtain information about specific commodities. For example, significant volumes of unknown and NEC products are shipped from Idaho, so a breakdown of the specific commodities that fall into this category would be helpful.

For region-to-region commodity movements, there are 15 regions; Alaska, Hawaii and the Pacific Territory, the Caribbean, Canada, the Rest of the World (foreign ports), Trans-shipment Areas (ports and offshore anchorages), and Other (open water such as fishing areas, oil rigs). The rest of the regions are classified by major rivers (e.g., Upper Mississippi, Lower Mississippi, Columbia/Snake/Willamette), lakes (e.g., Great Lakes), and coastal states (e.g., Gulf Coast-East and West, Atlantic Coast-North, South, Middle, Washington/Oregon). Looking at regional data, however, water shipments from/to Idaho are aggregated within Washington and Oregon.

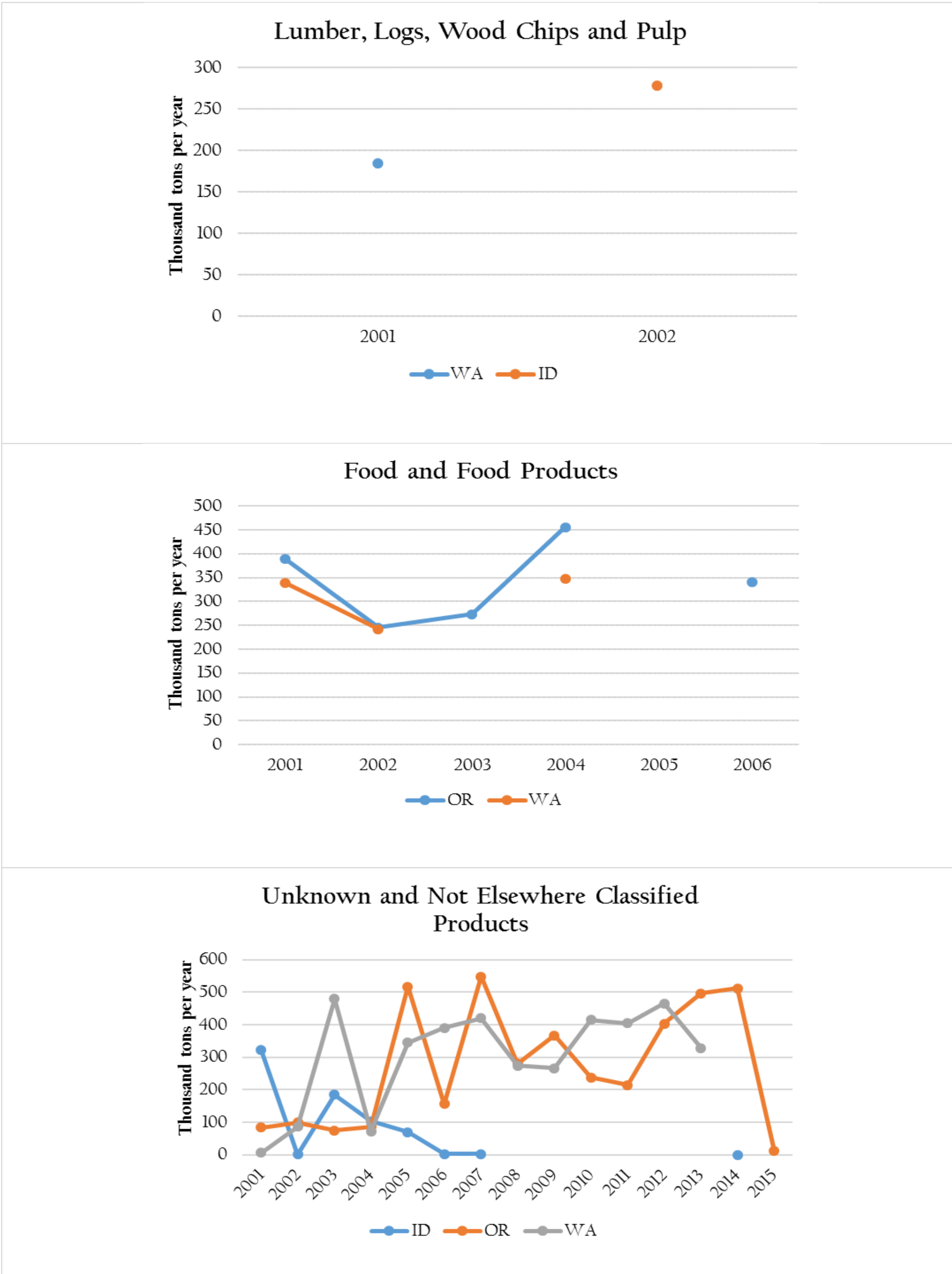


Figure 2.12 Waterborne commodity movements from Idaho to other states, by tonnage.

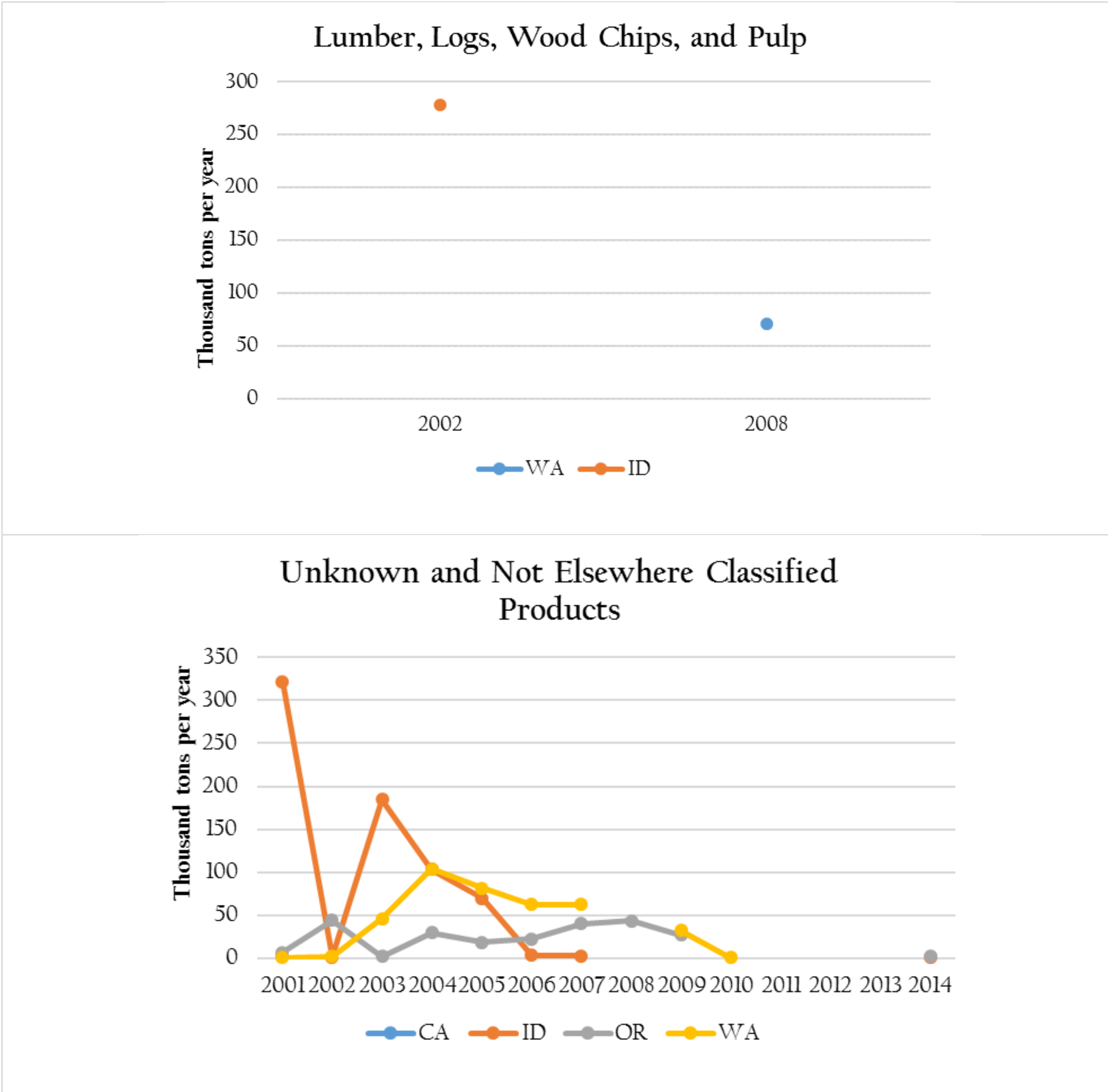


Figure 2.13 Waterborne commodity movements from other states to Idaho, by tonnage.

2.1.7. Summary of Available Freight Data

This section summarizes the strengths and drawbacks of the different sources of publicly available data on freight movements by truck, rail, or water. FAF4 provides detailed data of state-to-state freight movements by different modes, particularly origins and destinations of trips and types of commodities shipped. However, freight data are often dated because they are based on the U.S. Census or commodity flow surveys that are not updated annually. Furthermore, data on freight movements within the state, secondary freight activities, or trip-chain details are not captured in the FAF4 database. The FAF4 data do provide useful data on intra-state freight movements, as highlighted above for freight movements into and out of Idaho.

Table 2.1 Types of data available from public sources

	FAF4	**USDA**	**Traffic Counters**	**Port of Entry**	**Rail Waybill**	**USACE WCSC**
Origin of vehicle trips	○	●	●	●	○	○
Destination of vehicle trips	○	●	●	●	○	○
Vehicle classification	○	●	○	○	●	○
Type of commodity carried	○	●	●	●	○	○
State-to-state freight data	○	●	●	●	○	○
In-state freight data	●	●	○	●	●	●
Intermediate stops	●	●	●	●	●	●
Locations of grain elevators and warehouses	●	○	●	●	●	●
Attributes of agricultural products (acreage, volume of production)	●	○	●	●	●	●
Vehicle/rail car count data	●	●	○	●	○	●
Vehicle/rail car weight data	●	●	●	○	○	●
Revenue of carloads (rail only)	●	●	●	●	○	●
Length of haul (rail only)	●	●	●	●	○	●
Participating railroads (rail only)	●	●	●	●	○	●
Interchange locations (rail only)	●	●	●	●	○	●

Notes: FAF4 - Freight Analysis Framework Version 4; USDA – U.S. Department of Agriculture databases; Traffic counters – includes Automatic Traffic Recorder and Weigh-in-Motion; USACE WCSC - U.S. Army Corps of Engineers Waterborne Commerce Statistics Center. ○ means data are available; ●means data are not collected by the source.

Table 2.1 presents a side-by-side comparison of the types of data that are available from the different sources described previously. This illustrates that while no individual data source can provide all freight-related data in the state, each can be used in tandem with other data sources.

The *USDA* does not provide detailed freight movement information like other existing data sources, but it is a valuable source of agricultural and natural resource-based industries that can be mapped to identify the locations in the state where productions of these industries and related freight movements are concentrated.

Data from *traffic recorders and weigh-in-motion* devices help to identify geographic concentrations of truck traffic in the state. Information can be further classified by vehicle type and different time periods. However, this source does not provide information on the origins and destinations of trips, types of commodity shipped, routes, etc. Also, data are limited to highway segments where traffic counter devices are used.

Through the CVISN program, data on the classifications and weights of vehicles that enter the *Port of Entry* can be obtained. Other details such as origins and destinations and types of commodity shipped are not collected at the port of entry.

The *Rail Waybill* sample provides data on rail car counts and weights, types of commodity, revenue of carloads, length of haul, and participating railroads, but data are restricted for public access because of confidentiality issues. The Waybill sample for public use aggregates data to show state-to-state rail movements by commodity classification.

The public domain databases of the *USACE WCSC* provide information for state-to-state and region-to-region waterborne commodity movements. Data are presented in tonnages by type of commodity, origin and destination. Commodities are grouped into general classifications to protect the confidentiality of individual companies providing the data. This becomes an obstacle when movements of specific commodities must be evaluated.

2.2. Avenues for Supplementing Freight Data

Primary data collection can be an alternative or supplement to the secondary data described above that are currently available. Primary data collection approaches include use of GPS vehicle route data that can be obtained from private sources, surveys or questionnaires (such as establishment, shipper/trucker, and roadside surveys), and video streaming and image capture. This section describes each approach, including implementation, investment and maintenance requirements, data quality, geographic coverage, commodity identification, and seasonality (Allen et al., 2012; Jessup et al., 2004).

2.2.1. GPS Vehicle Transponder Data

Through a technology provider, a freight company can attach electronic logging/tracking devices or Global Positioning System (GPS) receivers on trucks to manage their vehicle fleet. Using GPS equipment is a high-tech means to gather data on vehicle route information, vehicle speed, trip distance, travel time, start/stop/idle time periods, and truck type frequencies on given corridors. Examples of technology providers are INRIX and EROAD.

INRIX collects data on vehicle counts and real-time traffic speed. The three data sources are automotive manufacturers, mobile phones, and truck fleets equipped with GPS receivers. An INRIX trip record with waypoints includes travel route data related to the start, end, and waypoints of a particular type of vehicle within a user-defined region. These data are useful for looking at trip patterns with routing and detailed speed and travel time profiles, assessing system changes over time, and linking demographic information with associated trips.

EROAD provides an in-vehicle electronic logging device (ELD) that can be used by drivers and fleet managers to monitor the drivers' hours of service. Drivers can log daily and weekly reports, as well as reports of on-duty status, rests, and resets. All data are transmitted to a secure web portal from which managers receive real-time notifications and access driver records. More information about this technology provider can be found at the following website: http://www.eroad.com/.

The drawbacks of using GPS receivers for data collection are high equipment costs, equipment malfunctions and other technical difficulties, and lack of information on trip purpose, commodity shipped, and trip chaining. Also, not all freight companies within the area of study may utilize GPS receivers on any or all of their trucks, thereby limiting the data collected. These concerns can be minimized by increasing the density of vehicle numbers with GPS receivers or by narrowing the focus of the study (e.g., to a specific corridor or trip generator of interest). However, widespread utilization of GPS equipment to collect data on freight movements may be cost prohibitive relative to the value of data obtained. Table 2.2 presents the advantages and disadvantages of using GPS receivers.

Table 2.2 Advantages and disadvantages of GPS data

	Advantages	**Disadvantages**
Implementation	No traffic disruption.	Requires private shipper participation.
Investment and maintenance		Very high equipment investment cost. Equipment malfunction and technical difficulties are common.
Statistical reliability/sampling frame		Limited sample of vehicles participating in the study. Very limited sample of all freight movements in urban setting.
Data attributes	Relatively accurate route and trip activity data.	Very limited information regarding trip purpose, commodity hauled, and trip chaining.
Geographic coverage		Limited to sample size.
Commodity		Does not capture types of commodities hauled.
Seasonality		Does not capture seasonality of shipments.

Source: Jessup et al. (2004).

2.2.2. Freight Surveys / Questionnaires

An establishment survey is conducted at the place of business. The survey can collect data on the total number of truck trips to/from the surveyed establishments within a specified reporting period (day/week/month), trip purpose, value of shipments, and supply chain information (Allen et al., 2012; DOT FHWA, 2008). Some respondents, however, may not be able to provide sufficient information about other attributes, such as origin of the vehicle, commodity being shipped by each vehicle, trip destination, etc. (Allen et al., 2012). Data are collected through an interview survey, online survey, mail survey, or a combination.

Interview Surveys. An interview survey can be accomplished through face-to-face or telephone interview. In some cases, the truck owner is not the best agent to ask for information about the daily use of the trucks. Hence, the first challenge with this methodology is finding a respondent who is willing to participate and able to provide the necessary information, which may lead to potential information bias. Once the contact person has been identified, the next steps are to obtain participation and to schedule the interview. The respondent may be sent a copy of the survey before the interview so that he or she can become familiar with the questions and have sufficient time to prepare.

Because of personal contact, interview surveys typically have higher response rates than mail surveys. In this methodology, having the interviewer present makes it easier for respondents to clarify any details in the questionnaire. This format also allows the interviewer to delve into more details for particular responses and to ask to follow up with the subject if needed. Interview surveys are easy to implement and can be used to supplement information obtained through other data collection techniques.

Trucks are utilized for a variety of different shipment types, routes, commodities, and origin-destination combinations. Identifying specific trip details about all shipment types is quite difficult in a telephone interview but may be less difficult in a face-to-face interview because the respondent can show the interviewer printed reports and other supporting data.

Carrying out face-to-face interviews can be very costly, depending on the sample size. On the other hand, telephone interviews can cover a large sample size at less cost than face-to-face interviews (e.g., because there are no travel costs). The drawbacks of a telephone survey include the difficulty of obtaining accurate contact information and problems with follow-up calls (e.g., incorrect phone numbers).

For either a face-to-face survey or a phone survey, there are time constraints because interviews can only occur during regular business hours, and they can be cut short or interrupted when the respondent is busy. Therefore, data collection through this method can be time consuming and costly. Furthermore, data may be biased to those vehicles licensed within a given urban or metropolitan area. Table 2.3 presents the advantages and disadvantages of this methodology.

Table 2.3 Advantages and disadvantages of face-to-face or phone surveys

	Advantages	Disadvantages
Implementation	Easy to implement. No disruption of traffic. Quicker turn-around than mail survey. Higher response rate than mail survey. Allows for more in-depth discussion of particular responses. Easy to follow up with contacts. Face-to-face survey makes it easier for respondents to share reports and other supporting data to the interviewer. Phone survey can cover a larger geographical area because the interviewer does not need to travel to the respondent's place of business.	Difficult to find appropriate and accurate contact information. Can be time consuming and expensive. Need to do call-backs. Higher personnel requirements than mail surveys.
Investment and maintenance	Low investment requirement.	Must be replicated periodically to maintain current relevance.
Statistical reliability/sampling frame	Generally good information for those that respond. Survey design may include targeted truck movement types.	Low response rate may create biased data. Difficulty finding appropriate respondents also contributes to bias or non-response.
Data attributes	Very good data details for completed responses.	
Geographic coverage	Generally limited to those vehicles within the area.	Poor coverage of urban truck movements from trucks licensed in other states and areas.
Commodity	Survey design may include specific commodities.	
Seasonality	Survey design may include seasonality of trips.	

Source: Jessup et al. (2004).

Online Surveys. Establishment and shipper surveys may also be conducted via web-based, online avenues through survey questionnaires that have been developed by survey centers, educational institutions, or third-party technology services companies such as SurveyMonkey, Checkbox Survey, SurveyGizmo, Zoho Survey, Typeform, and others. These data collection techniques are common for obtaining information quickly and at relatively low cost and can reach a broad audience.

Like mail surveys, online surveys can also result in relatively low response rates. The primary method for sending out these types of surveys is via email (often blocked by spam filters) and/or by social media platforms such as Facebook, LinkedIn, and Twitter. The types of information that can be obtained may be limited to relatively easy surveys related to individual experiences. Response rates for complicated information related to business operations, shipment origin/destination, and routing are often low because of the medium (see table 2.4 for advantages and disadvantages).

Table 2.4 Advantages and disadvantages of online surveys

	Advantages	Disadvantages
Implementation	Easy to implement, low cost. No disruption of traffic.	Difficult to identify and deliver the survey link to individuals knowledgeable of data desired. Challenge getting trip details for all shipment types that the shipper or trip generator may possess.
Investment and maintenance	Low investment requirement. Minimal personnel requirement.	Must be replicated periodically to maintain current relevance. Response rates drop on repeated replications.
Statistical reliability/sampling frame	Challenges controlling for known population/sample size. Generally good information for those that respond. Survey design may include targeted business types.	Low response rate may create biased data. Difficulty finding appropriate respondents also contributes to bias or non-response.
Data attributes	Good data details for completed responses.	Limited ability to clarify meaning to specific questions or answers.
Geographic coverage	Can cover large geography at low cost.	Poor control of coverage of freight movements, given that some large freight companies do not have much online presence.
Commodity	Survey design may include specific commodities.	Difficult to obtain detailed information on commodity types that are shipped.
Seasonality	Survey design may include seasonality of trips.	Difficult to obtain detailed information on commodity types that are shipped.

Source: Jessup et al. (2004).

Mail Surveys. Mail surveys are one of the most common methods of collecting data from shippers or licensed truck owners. This methodology is very easy to implement and has low investment and maintenance costs. Personnel requirements are minimal, and the data collected are generally of sufficient and accurate quality and detail, particularly from completed responses.

However, mail surveys typically have lower response rates, which may bias the information collected. Like the interview survey, there is difficulty in identifying and ensuring that the appropriate person in the organization will be the one receiving the survey and providing responses. Also, mail surveys do not provide opportunities to clarify and discuss particular questions or answers, and non-responses to specific questions are difficult to interpret. Survey coverage may also be quite low because freight movements by vehicles outside the geographical area are not included in the mail survey. However, given the ease and low cost of implementation, this approach may be useful to capture freight movements that are not accessible through other means. The advantages and disadvantages of using mail surveys are shown in table 2.5.

Table 2.5 Advantages and disadvantages of mail surveys

	Advantages	Disadvantages
Implementation	Easy to implement. No disruption of traffic.	Difficult to obtain trip details for all shipment types that the shipper or trip generator may possess.
Investment and maintenance	Low investment requirement. Minimal personnel requirement.	Must be replicated periodically to maintain current relevance.
Statistical reliability/sampling frame	Generally good information for those that respond. Survey design may include targeted truck movement types.	Low response rate may create biased data. Difficulty finding appropriate respondents also contributes to bias or non-response.
Data attributes	Very good data details for completed responses.	Limited ability to clarify meaning to specific questions or answers.
Geographic coverage	Generally limited to those vehicles within the area.	Poor coverage of urban truck movements from trucks licensed in other states and areas.
Commodity	Survey design may include specific commodities.	Difficult to obtain detailed information on commodity types that are shipped.
Seasonality	Survey design may include seasonality of trips.	Difficult to obtain detailed information on commodity types that are shipped.

Source: Jessup et al. (2004).

Combined Mail and Telephone Surveys. Combining a mail survey and interview, particularly by phone, can significantly improve response rates over that from implementing either individually. However, this combination can cause the cost of implementation to significantly increase. Making telephone contact before the mail survey, and as a follow-up, provides the opportunity to increase response rates and enhance qualitative information about freight movements. Information about other relevant trip generators may also be available. Although the two data collection methods are combined, the majority of the data are collected via the mail survey.

Both mail and interview surveys are limited to the list of registered vehicles or firms within the area of study; therefore, there remains poor coverage of movements by trucks that are licensed in other areas. The advantages and disadvantages of the combined mail and telephone survey are presented in table 2-6.

Table 2.6 Advantages and disadvantages of a telephone-mail survey

	Advantages	**Disadvantages**
Implementation	Easy to implement. No disruption of traffic. Quicker turn-around than mail survey alone.	Difficult to find appropriate and correct phone numbers. Can only call during regular business hours. Follow-up calls may be time consuming and costly. More costly than telephone survey or mail survey alone.
Investment and maintenance	Moderate investment requirement in personnel.	Must be replicated periodically to maintain current relevance. Higher personnel requirements than a mail survey.
Statistical reliability/sampling frame	Generally good information for those that respond. Survey design may include targeted truck movement types.	Low response rate may create biased data. Difficulty finding appropriate respondents also contributes to bias or non-response.
Data attributes	Compared to mail survey only, there is improved ability to explain questions and clarify intent, leading to better data details.	
Geographic coverage	Generally limited to those vehicles within the area.	Poor coverage of urban truck movements from trucks licensed in other states and areas.
Commodity	Survey design may include specific commodities.	
Seasonality	Survey design may include seasonality of trips.	

Source: Jessup et al. (2004).

2.2.3. Shipper / Trucker Surveys

A shipper/trucker survey or freight operator survey is used to collect data about the pattern of the operator's truck activities within the area of study. Other data that can be obtained through this survey method are information about the entire vehicle fleet (as opposed to a single vehicle), loading/unloading activities, trip purpose, etc. (Allen et al., 2012). The data gathering activities are commonly implemented through interview surveys (face-to-face or telephone), mail surveys, or a combination of both. The advantages and disadvantages of each of these methods are described above and summarized in tables 2.3 through 2.6.

2.2.4. Roadside Surveys

Roadside surveys are implemented by conducting direct personal interviews of truck drivers at accessible locations, such as weigh stations on Interstate highways and freeways or toll and bridge crossings. Previous studies have demonstrated many advantages of utilizing roadside interviews, particularly in terms of obtaining a high response rate and complete information related to origin, destination, route, loaded weight, empty weight, commodity transported, truck owner, and other characteristics. The driver is also the most knowledgeable of the current shipment characteristics, which helps in the identification of the primary contact person, addressing a disadvantage for many interview surveys. This methodology has good sampling control, broad geographic coverage, and easy implementation requirements. Because the sample is collected is from a known traffic population in a given time period, the statistical reliability of road surveys is also quite high, and it allows analysts to extrapolate all information collected to the entire vehicle population. Also, the interaction between respondents and survey personnel enables clarification of specific questions on the spot, hence minimizing any misunderstanding and errors in data entry. The survey can also capture the seasonality of moving commodities, such as agricultural products, by collecting data at different periods throughout the year.

There are also some disadvantages in using roadside surveys. For instance, implementation requires sizable labor services. Survey personnel need to be properly trained, and communication and coordination are needed among the survey crew, law enforcement agency (helping to pull over vehicles), department of transportation personnel, and facility operators.

Implementation may also disrupt traffic in high volume corridors. This methodology is constrained to truck traffic that is passing through designated survey locations. Another constraint is time. Survey personnel need to be clear with their questions while at the same time being cognizant of the time to accomplish the survey so as not to disrupt the driver's schedule and because follow-ups are not possible after the interview. Survey personnel may also be exposed to safety risks and adverse weather conditions. Table 2.7 shows the advantages and disadvantages of road surveys.

Table 2.7 Advantages and disadvantages of roadside surveys

	Advantages	Disadvantages
Implementation	Relatively easy to implement. Short interview (2 to 6 minutes).	Time constraint. Relatively high labor requirements, especially for large geographic areas. Potential disruption of traffic. No follow-ups. Significant risk to survey personnel.
Investment and maintenance	If managed properly, investment costs are relatively low.	Must be replicated periodically to maintain current relevance. Higher personnel requirements than interview survey.
Statistical reliability/sampling frame	Best sample control because sample is from known traffic population over a known time period. Highest response rate.	Limited locations where survey is implemented may bias sampling.
Data attributes	Excellent ability to obtain all desired data given one-on-one interaction with drivers. Complete information on origin, destination, route, commodity, etc.	None.
Geographic coverage	Provides coverage of truck activity other than at survey locations but truck must first pass through survey site. Includes vehicles passing through from outside the geographical area.	Only captures traffic that passes through interview sites.
Commodity	Provides information on the type of commodity being transported.	None.

	Advantages	Disadvantages
Seasonality	Captures the seasonality of moving commodities, such as agricultural products.	Relatively high labor requirement since data need to be collected at different periods throughout the year.

Source: Jessup et al. (2004).

2.2.5. Vehicle Video / Image Capture

Vehicle recognition through video surveillance or image capture is another high-tech means of collecting freight movement data, particularly counts and classifications of vehicles passing through selected routes at a specific time of day and day of the week. The main advantage of this method is the collection of good information on traffic flows without disrupting traffic. However, it does not provide data on origins and destinations, trip purposes, routes, and types of commodity transported. The high initial equipment cost and maintenance costs, as well as potential technical problems due to adverse weather and time of day, are additional limitations of this methodology. However, data collected from video surveillance can be effective when complemented by information collected from other sources and data sets. The advantages and disadvantages of this methodology are presented in table 2.8.

Table 2.8 Advantages and disadvantages of vehicle video/image capture

	Advantages	Disadvantages
Implementation	No traffic disruption.	Potential for equipment failure or technical difficulties. Adverse weather and time of day can impact visibility and data collection.
Investment and maintenance		High equipment cost and requirements. Relatively high maintenance and replacement cost for video equipment.
Statistical reliability/sampling frame	Captures all trucks passing a video site during all visible time periods.	Provides limited information.
Data attributes	Provides general descriptive information on traffic flows, e.g., counts and classifications of vehicles at a specified time period.	No information about origin and destination, trip purpose, route, etc.
Geographic coverage		Limited to locations with video capability within and around urban areas.
Commodity		Does not provide information on the types of goods being transported.
Seasonality		Cannot capture the seasonality of moving commodities, such as agricultural products.

Source: Jessup et al. (2004).

Table 2.9 provides a summary of the types of data that can be collected using the different survey approaches. Table 2.10 shows the common methods used to implement the survey approaches.

Table 2.9 Types of data collected via different survey approaches

Type of data	Survey Approaches				
	Establishment Survey	Shipper/ Trucker Survey	Roadside Survey	Technology Provider Survey	Vehicle Video/ Image Capture
Vehicle trip generation at establishments*	○	●	●	●	●
Goods/service flows at establishments*	○	●	●	●	●
Ordering/stockholding at establishments*	○	●	●	●	●
Vehicle trip purpose*	○	○	○	●	●
Goods carried by each vehicle*	●	⊗	○	●	●
Detailed vehicle trip patterns*	●	⊗	⊗	○	●
Vehicle routing*	●	⊗	⊗	○	●
Vehicle fuel/speed/fleet data*	●	○	⃠	⃠	●
Origin of vehicle trips*	⃠	⃠	○	○	●
Destination of vehicle trips**	⃠	⃠	○	○	●
Loading/unloading activities*	⃠	⊗	●	●	●
Loading/unloading dwell time*	⃠	⊗	●	⊗	●
Supply chain system of organizations*	○	⊗	●	●	●
Traffic flow and mix*	●	●	●	●	○
Vehicle classification**	●	○	○	●	○
Seasonality of shipments**	⊗	⊗	○	●	●

*Adopted from Allen et al. (2012); **Added from Jessup et al. (2004)

Notes: ○ means data are commonly collected with this survey approach; ⃠ means data are sometimes collected with this survey approach; ⊗ means data could be collected with this survey approach but it is not common; and ● means data cannot be collected with this survey approach.

Table 2.10 Common avenues for implementing survey approaches

Implementation Method	Survey Approaches				
	Establishment Survey	Shipper/ Trucker Survey	Roadside Survey	Technology Provider Survey	Vehicle Video/ Image Capture
Face-to-face interview (scheduled)	○	○	●	●	●
Face-to-face interview (intercept)	○	⊗	○	●	●
Online Survey	○	○	●	●	●
Telephone survey	○	○	●	●	●
Mail survey	○	○	●	●	●
GPS receiver	●	●	●	○	●
CCTV	●	●	●	●	○

Sources: Allen et al. (2012); Jessup et al. (2004).
Notes: ○ means data are commonly collected with this survey approach; ⦸ means data are sometimes collected with this survey approach; ⊗ means data could be collected with this survey approach but it is not common; and ● means data cannot be collected with this survey approach.

2.3. Freight Data Inventory Summary

This report summarizes the different types of data currently available to the Idaho Transportation Department to help develop a freight data collection plan. Examples of these different types of data are provided, in addition to the strengths and weaknesses associated with each data source. In addition, this report provides a summary of the different approaches and avenues for supplementing existing freight data. Each one of these approaches also presents different challenges in capturing specific aspects of the freight supply chain, costs of obtaining the information, and ease of replication into the future. These issues are discussed, and the advantages / disadvantages of each approach are offered.

The freight data collection plan identifies a strategy for utilizing existing data from various public and private sources and supplementing those data by performing one or a combination of the alternative data collection approaches described in this document. Each alternative approach should be evaluated in terms of its implementation, collection, and applicability to inform specific freight-related activities. The advantages and disadvantages of each approach and implementation method need to be taken into account, such as those related to response rates, potential costs, and data details.

CHAPTER 3. EROAD DATA AND IDAHO CASE STUDY

In most cases, the data available for transportation planners are inefficient for freight demand modeling. The available data generally consist of historical vehicle traffic counts on various highway segments and are typically divided by vehicle type. However, this type of data does not provide vital freight information, such as commodities being transported and their origin/destination, to efficiently model freight demand. Using the results of a freight establishment survey, this study sought to illustrate how EROAD data can provide additional information in a more disaggregate form in comparison to more readily available data, as explained in Chapter 2. More detailed information on the freight establishment survey can be found in Jessup and Hernandez (2020).

3.1. Methodology and Data Collected

To better understand the utility of using EROAD data, two data collection techniques were employed to capture different aspects of freight and commodity flow activities within and throughout the State of Idaho; specifically, freight establishment surveys and EROAD freight telematic data. Using the results from an establishment survey conducted by Jessup and Hernandez (2020), several key industry/commodity types were identified. These key industry types included agriculture and food processing, forest products, computer/electronics manufacturing, healthcare services, mining/minerals, transportation equipment, and warehousing/distribution centers (see figure 3.1).

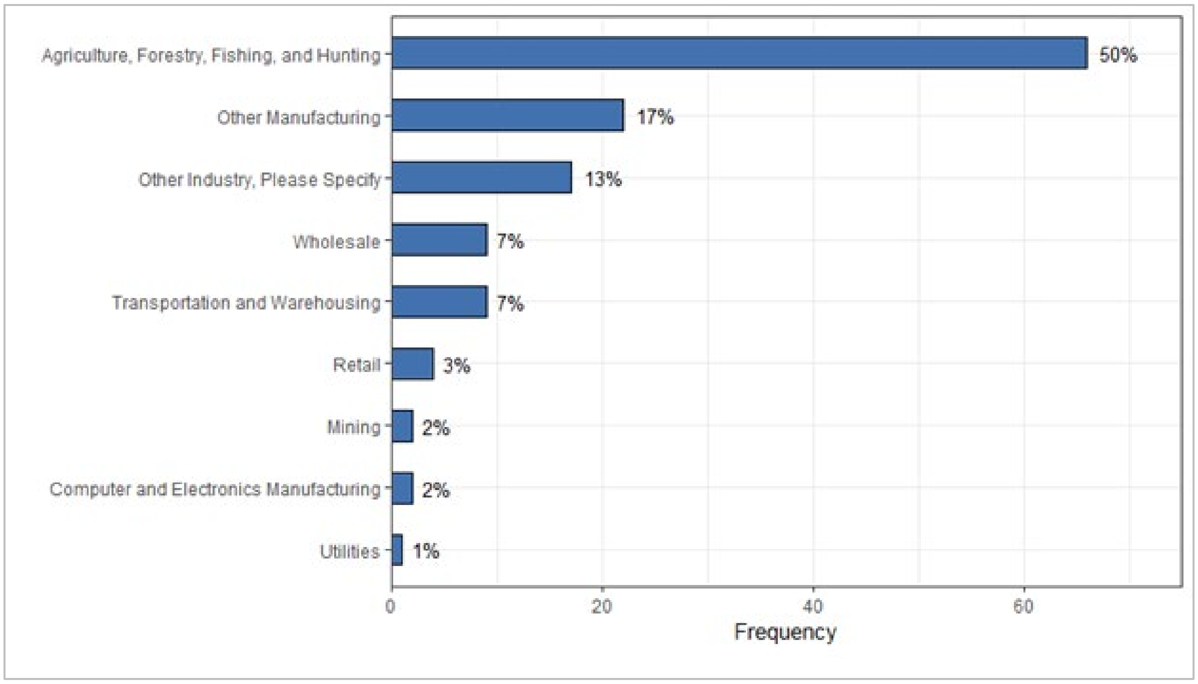


Figure 3.1 Distribution of survey respondents by industry type (Jessup and Hernandez, 2020)

Utilizing the results of the establishment survey and additional data collected from the identified existing sources presented in Chapter 2, several geospatial maps were acquired, developed, and merged to create a set of facility locations that were used to study EROAD coverage and potential. The following section describes in more detail the EROAD data used for this project and provides an overview of their potential for modeling.

3.2. EROAD Truck Trip Data

EROAD provides an in-vehicle electronic logging device (ELD) that can be used by drivers and fleet managers to monitor the drivers' hours of service. These devices also use GPS equipment in a hi-tech manner to gather data on vehicle route information, vehicle speed, trip distance, travel time, start/stop/idle time periods, and frequencies on given corridors (see figure 3.2). Drivers can log daily and weekly reports, as well as reports of on-duty status, rests, and resets. All data are transmitted to a secure web portal, which helps managers receive real-time notifications and access driver records. More information about this technology provider can be found at the following website: http://www.eroad.com/.

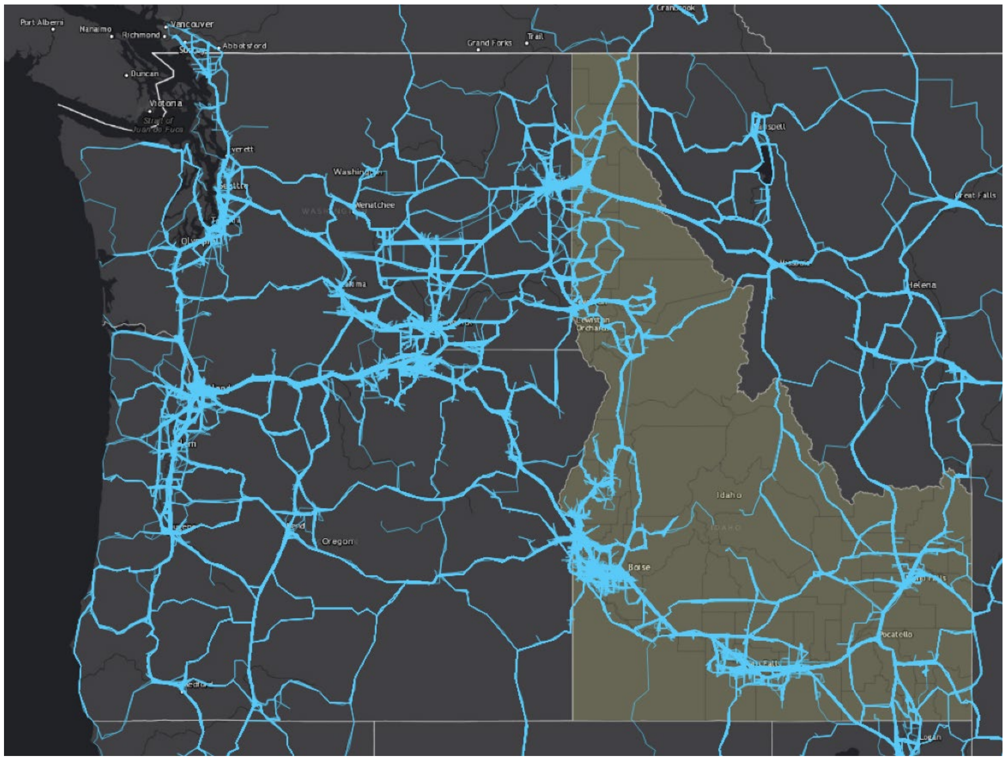


Figure 3.2 Spatial representation of EROAD-equipped vehicles in the Pacific Northwest.

For this project we worked with EROAD to identify truck trip data to better understand specific freight supply-chain characteristics from commodities identified from an establishment survey by industry type (Jessup and Hernandez, 2020). These industries were

- Airports
- Computer electronics
- Hay producers
- Hospitals
- Meat processing
- Potato processing
- Sawmill
- Transportation equipment manufacturing
- Warehousing and/distribution.

The merging was accomplished by using geospatial software to match the above-identified commodities with corresponding EROAD trips at a more disaggregate commodity level in comparison to current practices of utilizing data such as the FAF data and trying to disaggregate them by utilizing a set of assumptions that might either overestimate or underestimate true commodity flows (Bujanda et al., 2014; Opie et al., 2009). The following sections summarize the merged data in reference to the Idaho case study (Jessup and Hernandez, 2020).

3.3. Idaho Case Study Facility Location and Geospatial Details

To better understand the potential advantages of utilizing freight telematics such as EROAD data for demand and forecast modeling applications, this section presents the disaggregate commodities from the industries outlined above merged with EROAD truck trip data. The following descriptions of the commodities identified above outline the contents of the geospatial maps of facility locations merged with the EROAD data, shown in figures 3.3 through 3.5 (Jessup and Hernandez, 2020).

Figure 3.3 provides merged information on facilities related to airports, computer electronics, hay producers, and hospitals.

- **Airport:** Eight airport locations in Idaho receive and ship freight. All but two of these airports are located adjacent to a major Interstate.
- **Computer Electronics:** Thirty-seven computer electronics facility locations in Idaho receive and ship freight. Once more, the majority of these facilities are located adjacent to major Interstates.

- **Hay Producers:** Seventy-four hay producer facility locations in Idaho receive and ship freight. Of the hay producer facility locations, the majority are located in southern Idaho.
- **Hospitals:** Forty-three hospital locations in Idaho receive and ship freight. The majority of hospitals in the EROAD data are located in southern Idaho.

Figure 3.4 provides merged information on facilities related to meat and potato processing and sawmills.

- **Meat processing:** Sixty-five meat processing facility locations in Idaho receive and ship freight. As with the previous facility types, the majority of meat processing facilities are located in southern Idaho.
- **Potato processing:** Twelve potato processing facility locations in Idaho receive and ship freight. As with the previous facility types, the majority of meat processing facilities are located in southern Idaho; specifically, adjacent to I-84.
- **Sawmills:** Seventy-six sawmill facility locations in Idaho receive and ship freight. Unlike the previous facility types, the majority of sawmill facilities are located in northern Idaho.

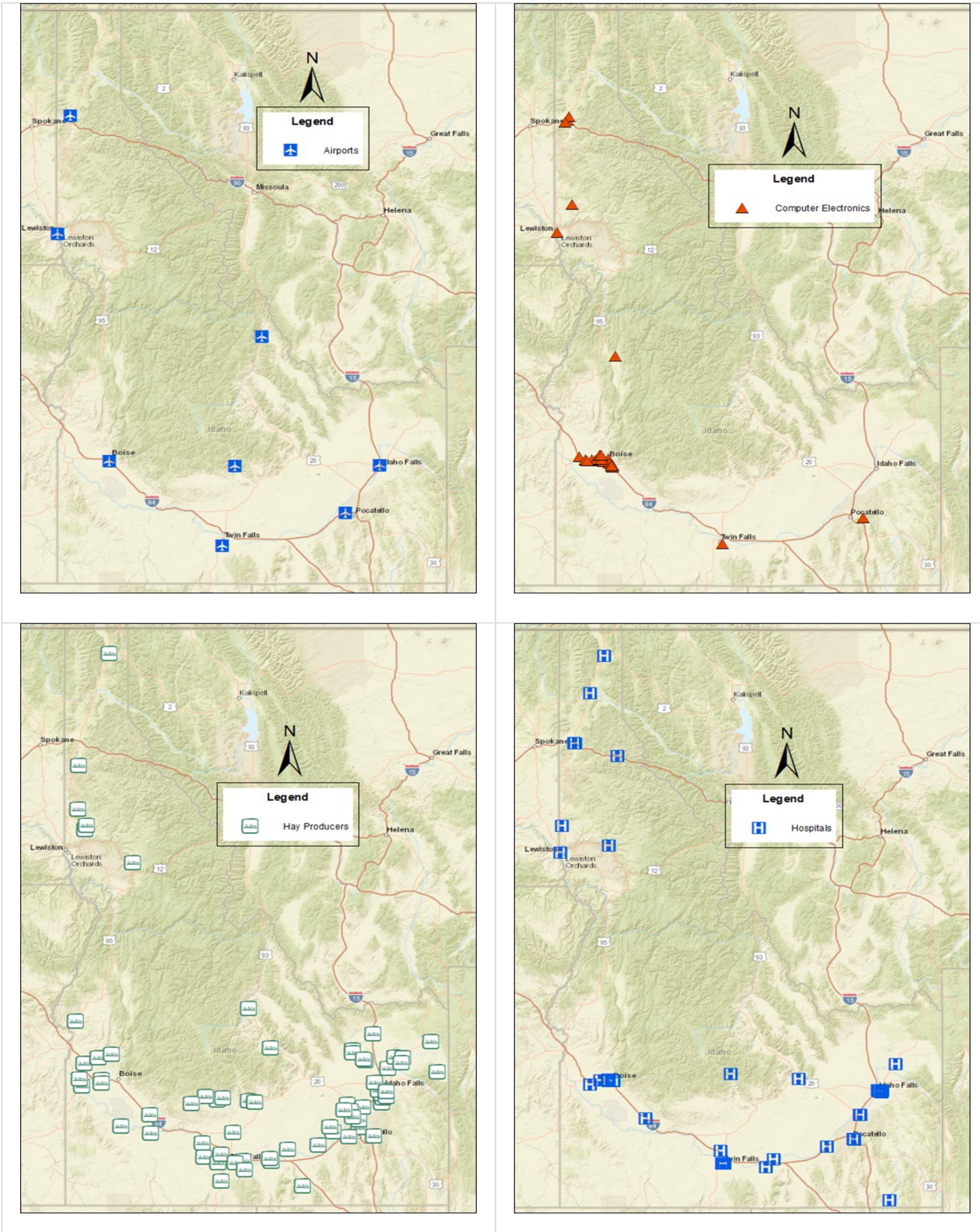


Figure 3.3 Locations of airports, computer electronics, hay producers and hospitals in Idaho per EROAD data.

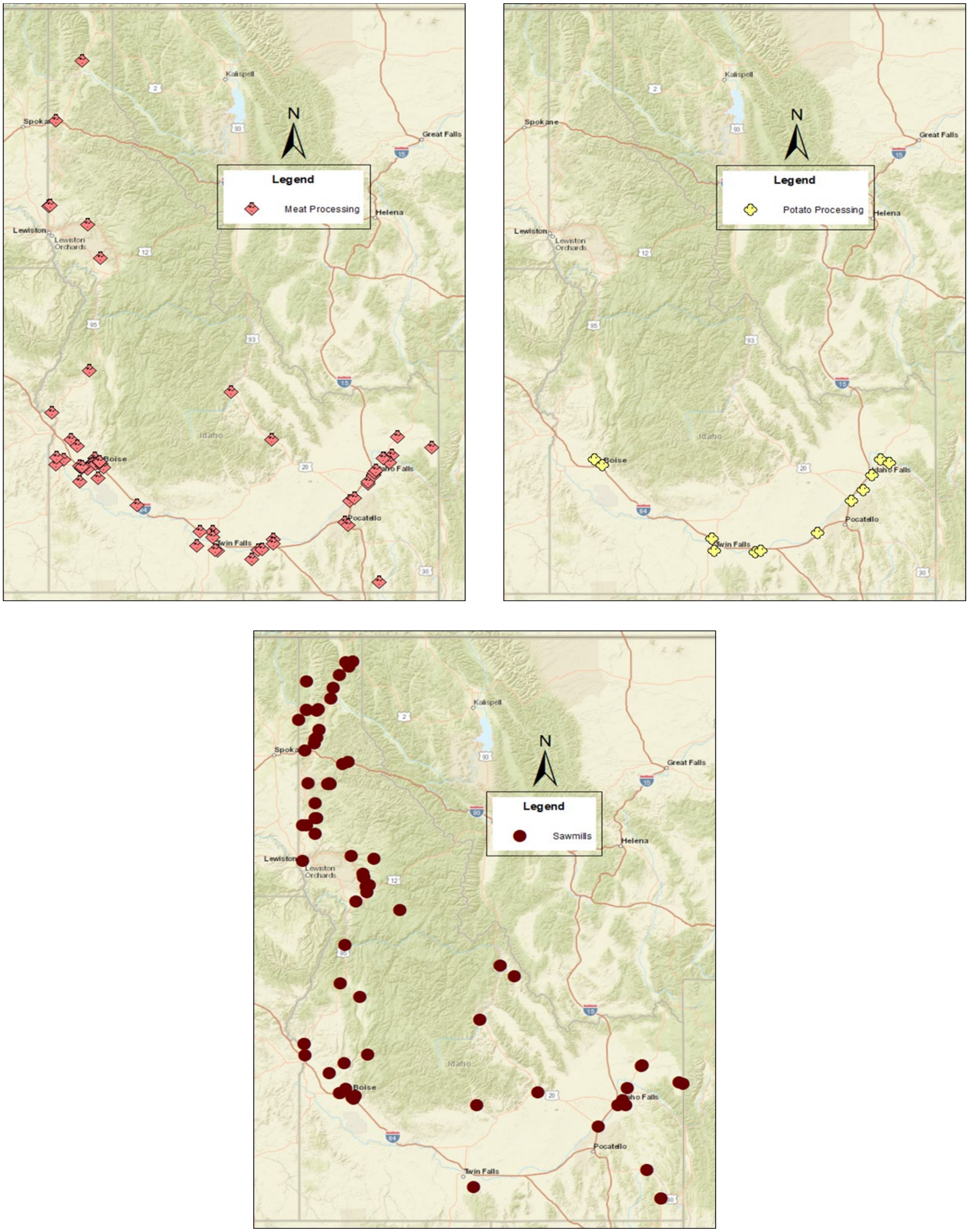


Figure 3.4 Locations of meat processing, potato processing and sawmills in Idaho per EROAD data.

Figure 3.5 provides merged information on facilities related to transportation equipment manufacturing and warehousing and distribution.

- **Transportation equipment manufacturing:** Eight-nine transportation equipment manufacturing facility locations in Idaho receive and ship freight. These facility locations appear to be evenly distributed across Idaho.
- **Warehousing and distribution:** There are 359 warehousing and distribution facility locations in Idaho that receive and ship freight. Although the majority of these facilities are located in southern Idaho, a larger proportion (in comparison to previous facility types) are located in northern Idaho.

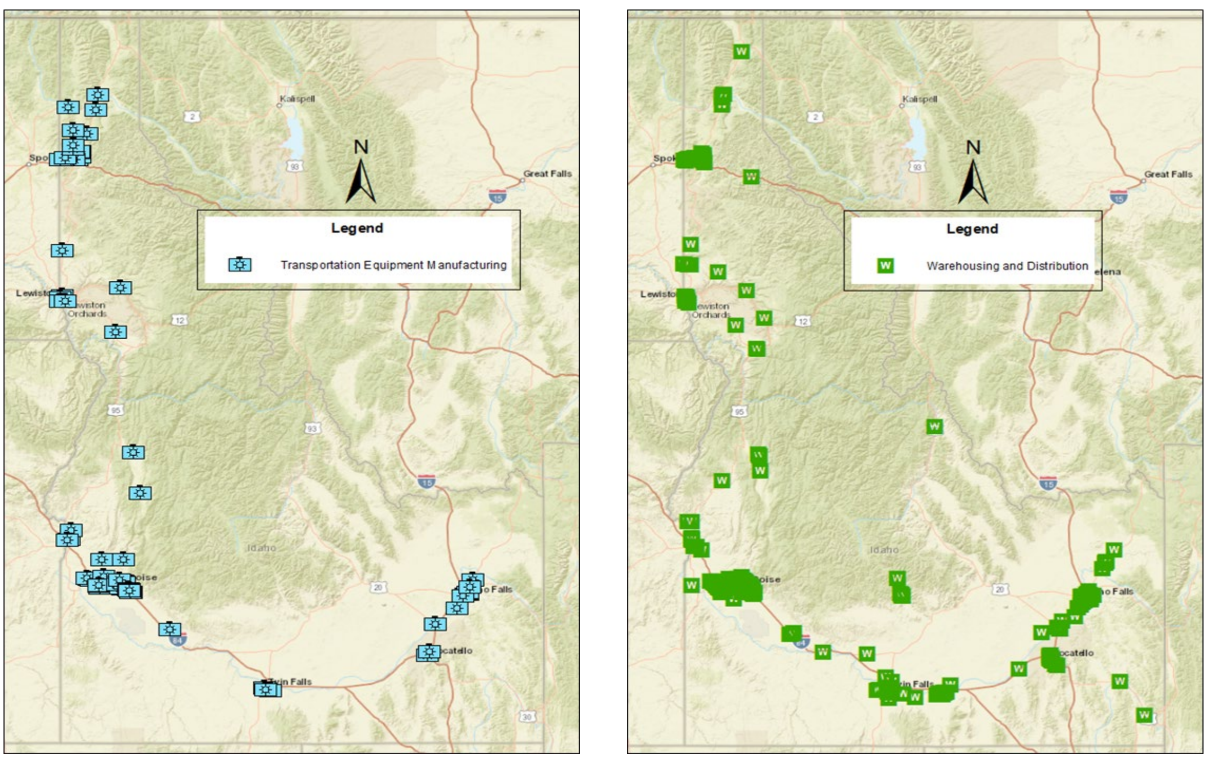


Figure 3.5 Locations of transportation equipment manufacturing and warehousing and distribution in Idaho per EROAD data.

3.4. Demand and Forecasting the Potential of EROAD Data

This section provides an overview of the potential of freight telematic data merged with the facility locations detailed in section 3.3. The data described within the following sections provide information at a more disaggregate level than those found in sources such as the FAF and have the potential to be used by transportation planners in analyzing freight movements and freight needs and limiting the number of assumptions on how the data were collected and disaggregated.

3.4.1. Commodities Destined to Facilities in Idaho by Industry Type

Figure 3.6 illustrates a holistic view of all commodities at a disaggregate level with corresponding merged truck trips from the provided freight telematic data. For additional detail on commodities, readers are referred to Jessup and Hernandez (2020).

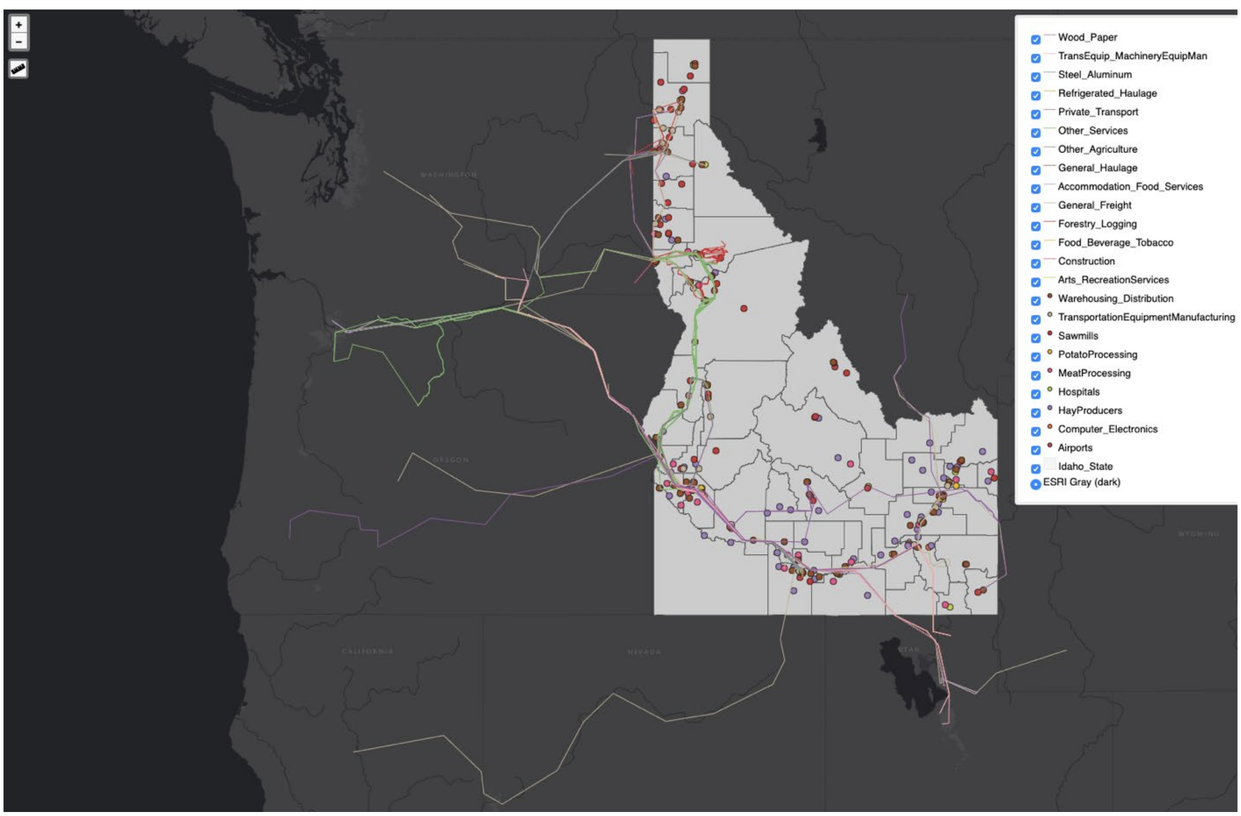


Figure 3.6 Holistic view of truck trips destined to Idaho.

At a more micro level, the following descriptions provide some further insight into commodities being transported into Idaho (Jessup and Hernandez, 2020).

- ***Accommodation and food services***

  Nearly all of the shipments head to facilities in southern Idaho, with one headed to a facility in northern Idaho. The facility types receiving these goods include warehousing and distribution facilities, sawmills, and meat processing facilities. From EROAD records, the average gross vehicle weight (GVW) destined to these facilities is 36,737 pounds, the maximum is 50,000 pounds, the minimum is 32,000, and the standard deviation is 6,231 pounds.

- ***Arts and recreation services***

  Just one EROAD record contains an arts and recreation services shipment to a facility in Idaho This shipment originates in Utah, destined to a transportation equipment manufacturing facility, and has a recorded GVW of 51,000 pounds.

- ***Construction***

  Two EROAD records of construction shipments are destined to facilities in Idaho, both of which are headed to transportation equipment manufacturing facilities near northern Idaho. One facility receives goods from Washington, where the incoming shipment has a recorded GVW of 26,000 pounds. The other incoming shipment is from within Idaho and has a recorded GVW of 80,000 pounds.

- ***Food, beverage, and tobacco product manufacturing***

  The single record for this industry type is destined to a warehouse and distribution facility in Idaho, shipped from within Idaho, and has a recorded GVW of 80,000 pounds.

- ***Forestry and logging***

Facilities receiving goods from this industry include warehousing and distribution facilities, transportation equipment manufacturing facilities, sawmills, and computer electronics facilities. All of these shipments originate from and are destined to facilities located in northeastern Idaho, with one shipment originating from Washington. The mean value GVW for these shipments is 84,895 pounds; the maximum is 105,500 pounds, the minimum is 80,000 pounds, and there is a standard deviation of 9,540 pounds.

- ***General freight***

  General freight shipments head to a variety of facility types, including warehousing and distribution facilities, transportation equipment manufacturing facilities, sawmills, potato processing facilities, meat processing facilities, and computer electronics facilities. The majority of these shipments are destined to warehousing and distribution facilities. The locations of origin for these incoming shipments include Oregon, Montana, Wyoming, California, Utah, and Idaho. The mean GVW value is 73,750 pounds; the maximum is 105,500 pounds, minimum is 17,000 pounds, and the standard deviation is 25,850 pounds.

- ***General haulage***

  In the EROAD records, there are two shipments, both originating from and destined to Idaho. Also, both are headed to a warehousing and distribution facility, and both have a recorded GVW of 80,000 pounds.

- ***Other agriculture***

  Of the three records found in the EROAD data for warehousing and distribution facilities in Idaho, two originate from Oregon and one from Washington. The recorded GVW for the shipments originating from Oregon are 105,500 pounds and 80,000 pounds, while the recorded GVW for the shipment originating from Washington is 95,500 pounds.

- ***Other services***

  Other services shipments are destined to Idaho facilities, in particular, warehousing and distribution facilities, transportation equipment manufacturing facilities, sawmills, and computer electronics facilities. The locations of origin for these shipments include Washington, Oregon, and Idaho. The mean recorded GVW is 66,000 pounds. The maximum is 90,000 pounds, the minimum is 14,000 pounds, and the standard deviation is 23,425 pounds.

- ***Private transport***

  For private transport shipments destined to warehousing and distribution facilities in Idaho, one of the shipments originates within Idaho and the second shipment originates in Utah. The Idaho shipment has a recorded GVW of 46,000 pounds, and the Utah shipment has a recorded GVW of 80,000 pounds.

- ***Refrigerated haulage***

  The single EROAD record for refrigerated haulage is destined to a warehousing and distribution facility in Idaho, originating from Idaho, and has a recorded GVW of 56,000 pounds.

- ***Steel and aluminum***

  One of the recorded steel and aluminum shipments originates in Washington destined to warehousing and distribution facilities, while the remaining shipments originate from and are destined to Idaho. According to EROAD records, the mean recorded GVW is 43,667 pounds; the maximum is 46,000 pounds, the minimum is 32,000 pounds, and the standard deviation is 5,218 pounds.

- ***Transport equipment, machinery and equipment manufacturing***

  Warehousing and distribution and transportation equipment manufacturing shipments come from Washington, Utah, Oregon, and Idaho. The mean GVW is 81,605 pounds. The maximum is 105,500 pounds, minimum is 51,000 pounds, and standard deviation is 20,103 pounds.

- ***Wood and paper products manufacturing.***

  Shipments are destined to facilities in Idaho that include warehousing and distribution facilities, transportation equipment manufacturing facilities, sawmills, meat processing facilities, and computer electronics facilities. Shipments originate from Washington, Oregon, Wyoming, Montana, and Idaho. The mean recorded GVW for these shipments is 96,405 pounds; the maximum GVW is 105,500 pounds, the minimum GVW is 28,000 pounds, and the standard deviation is 18,156 pounds.

3.4.2. Commodities Originating in Idaho by Industry Type

Figure 3.7 illustrates a holistic view of all commodities at a disaggregate level with corresponding truck trips originating in Idaho. For additional detail on these commodities, readers are referred to Jessup and Hernandez (2020).

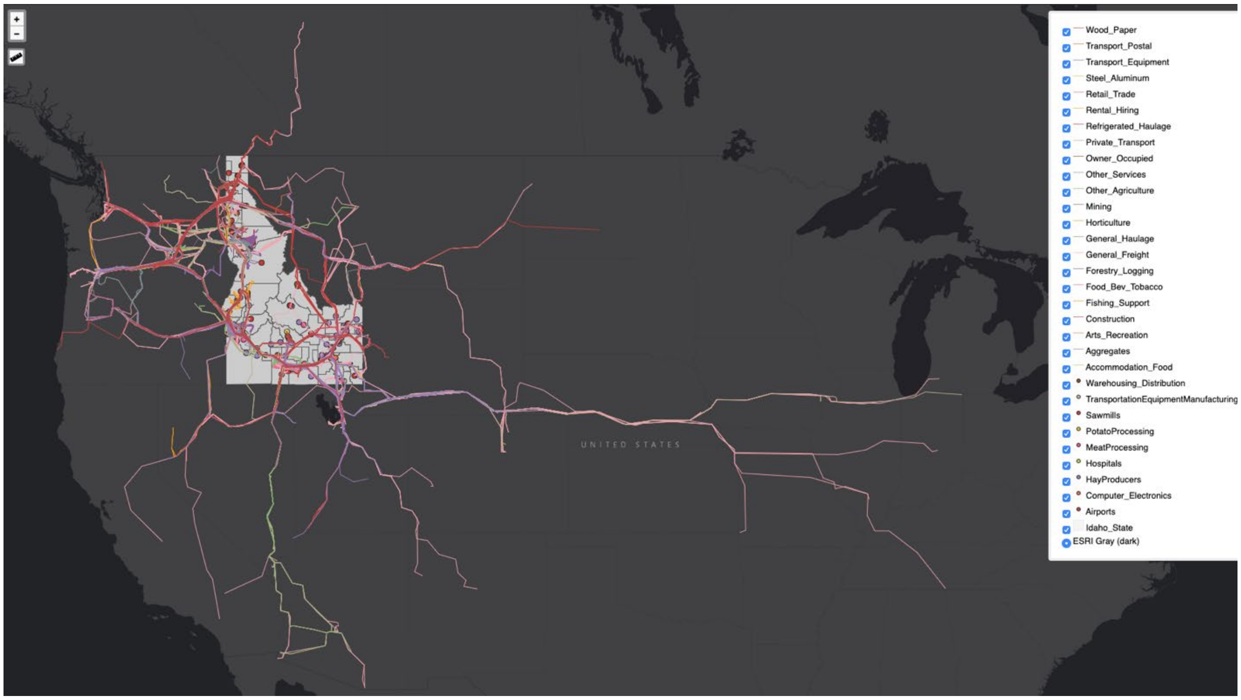


Figure 3.7 Holistic view of truck trips originating in Idaho.

At a more micro level the following descriptions provide further insight into commodities being shipped from Idaho (Jessup and Hernandez, 2020).

- ***Accommodation and food services***

  This industry originates from three distinct facility types: warehousing and distribution, sawmills, and meat processing facilities. Of the shipments originating from these facilities, the average reported GVW is 35,905 pounds; the maximum is 50,000 pounds, the minimum is 32,000 pounds, and the standard deviation is 6,094 pounds

- ***Arts and recreation services***

  According to EROAD data records, just one shipment originates from a facility in Idaho, a transportation equipment manufacturing facility. The shipment is reported to be destined to Oregon and has a GVW of 51,000 pounds.

- ***Construction***

There are only two trips recorded. One trip is destined to Idaho and the other to Washington. The shipment destined to Idaho has a GVW of 26,000 pounds, and the one destined to Washington has a GVW of 80,000 pounds.

- ***Food, beverage, and tobacco product manufacturing***

  There is only one record of a shipment originating from a facility in Idaho. The origin is a warehousing and distribution facility, and the shipment has a GVW of 80,000 pounds.

- ***Forestry and logging***

  All recorded shipments originate from facilities located in western Idaho. The majority of forestry and logging shipments originate from warehousing and distribution facilities, with some shipments originating from sawmills, computer electronics facilities, and transportation equipment manufacturing facilities.

- ***General freight***

  General freight originates from warehousing and distribution facilities, transportation equipment manufacturing facilities, sawmills, potato processing facilities, meat processing facilities, and hospitals. Based on data, these shipments are destined to Montana, Washington, Oregon, Utah, and Arizona. That average reported GVW for these shipments is 73,962 pounds. The maximum GVW is 105,500 pounds, the minimum is 26,000 pounds, and the standard deviation is 25,493 pounds.

- ***General haulage***

  All shipments originate from warehousing and distribution facilities located in southern Idaho. The average GVW of shipments leaving these facilities is 84,000 pounds. The maximum GVW is 96,000 pounds, the minimum is 80,000 pounds, and the standard deviation is 6,928 pounds.

- ***Other agriculture***

  Destinations include Oregon and Montana, with shipments originating in northern Idaho. Shipments in EROAD records indicate a maximum recorded GVW of 95,500 and a minimum recorded GVW of 80,000.

- ***Other services***

  Other services shipments originate from warehousing and distribution facilities, sawmills, and computer electronics facilities. The primary location of origin is western Idaho, with the destination being Idaho or Oregon. The average recorded GVW for other services shipments originating in Idaho facilities is 68,372 pounds. The maximum GVW is 90,000 pounds, the minimum is 14,000 pounds, and the standard deviation is 19,787 pounds.

- ***Private transport***

  Shipments are destined to as far as Indiana and originate from warehousing and distribution facilities located in western and southern Idaho. The maximum recorded GVW is 80,000 pounds and the minimum recorded GVW is 46,000 pounds (only two observations are provided in the EROAD data records for this industry type).

- ***Steel and aluminum***

  Steel and aluminum industry shipments are destined primarily to Utah, with some shipments destined to within Idaho and some to Oregon. These shipments originate in warehousing and distribution facilities or transportation equipment manufacturing facilities. Of the records provided by EROAD, the maximum recorded GVW for these shipments is 46,000 pounds and the minimum recorded GVW is 32,000 pounds.

- ***Transport equipment, machinery and equipment manufacturing***

Shipments for this industry are from warehousing and distribution facilities and transportation equipment manufacturing facilities located in western and southern Idaho. Destinations include other facilities in Idaho, Oregon, and Utah. The recorded GVW for outbound shipments indicates an average GVW of 80,000 pounds; the minimum GVW is 51,000 pounds, the maximum GVW is 105,500 pounds, and the standard deviation is 21,047 pounds.

- ***Wood and paper products manufacturing***

  This industry, according EROAD data records, ships goods from warehousing and distribution facilities, transportation equipment manufacturing facilities, sawmills, and meat processing facilities. The shipments originating in northern Idaho are destined to Oregon, while those originating in southern Idaho are shipped within-state.

3.4.3. Commodities Passing Through the State of Idaho

Figure 3.8 illustrates a holistic view of all commodities at a disaggregate level with corresponding truck trips passing through the Idaho. For additional detail on these commodities, readers are referred to Jessup and Hernandez (2020).

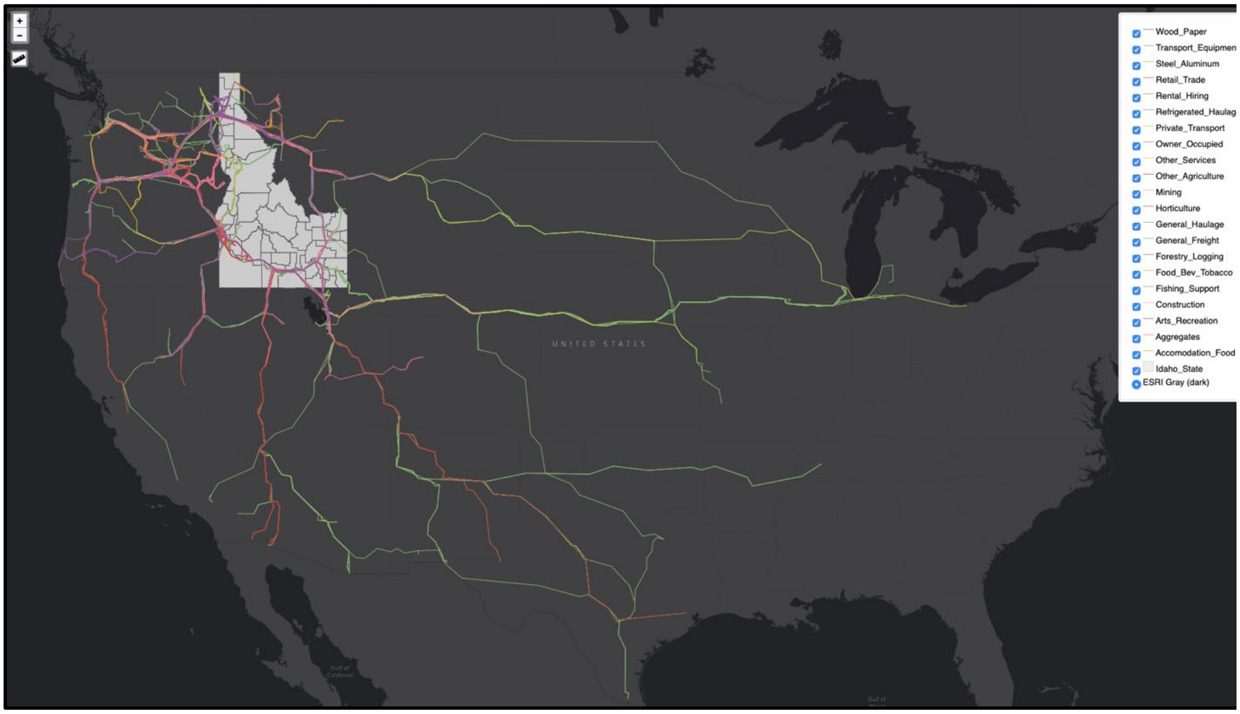


Figure 3.8 Holistic view of truck trips passing through Idaho.

The significance of understanding what passes through a state in terms of freight at a disaggregate level is important because such information provides states with an idea of infrastructure utilization and the potential to attract new business.

CHAPTER 4. SUMMARY

This research project investigated and provided information to address the freight data gap that currently exists for available statewide and regional freight and commodity flow information. To do so, the researchers developed and implemented an innovative freight data capture methodology that incorporates existing and new freight data collection techniques (through newly formed partnerships with freight telematics providers). Although EROAD data were utilized for this project, the information provided illustrates the capability of using such data either by themselves or merged with additional information, as shown in this project, to provide a more detailed understanding of commodity flows for freight modeling and/or forecasting applications.

In future work, EROAD data (or other freight telematic data) may be evaluated in more granular detail for those high-value, time-sensitive, consistent shipping volume products for which an enhanced understanding of the impediments (congestion points) to efficient freight movement is desired. This analysis did not focus at that level, but identifying where trip delays are occurring and determining how to address those transportation inefficiencies is something that EROAD information would allow.

Since a significant challenge faced by state transportation agencies is adequately addressing current and future transportation system needs based upon existing and evolving transportation activity on the multi-modal network, partnering with a technology provider in the future (EROAD or another similar firm) could be an efficient way to obtain the necessary information on specific freight supply chain activities.

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