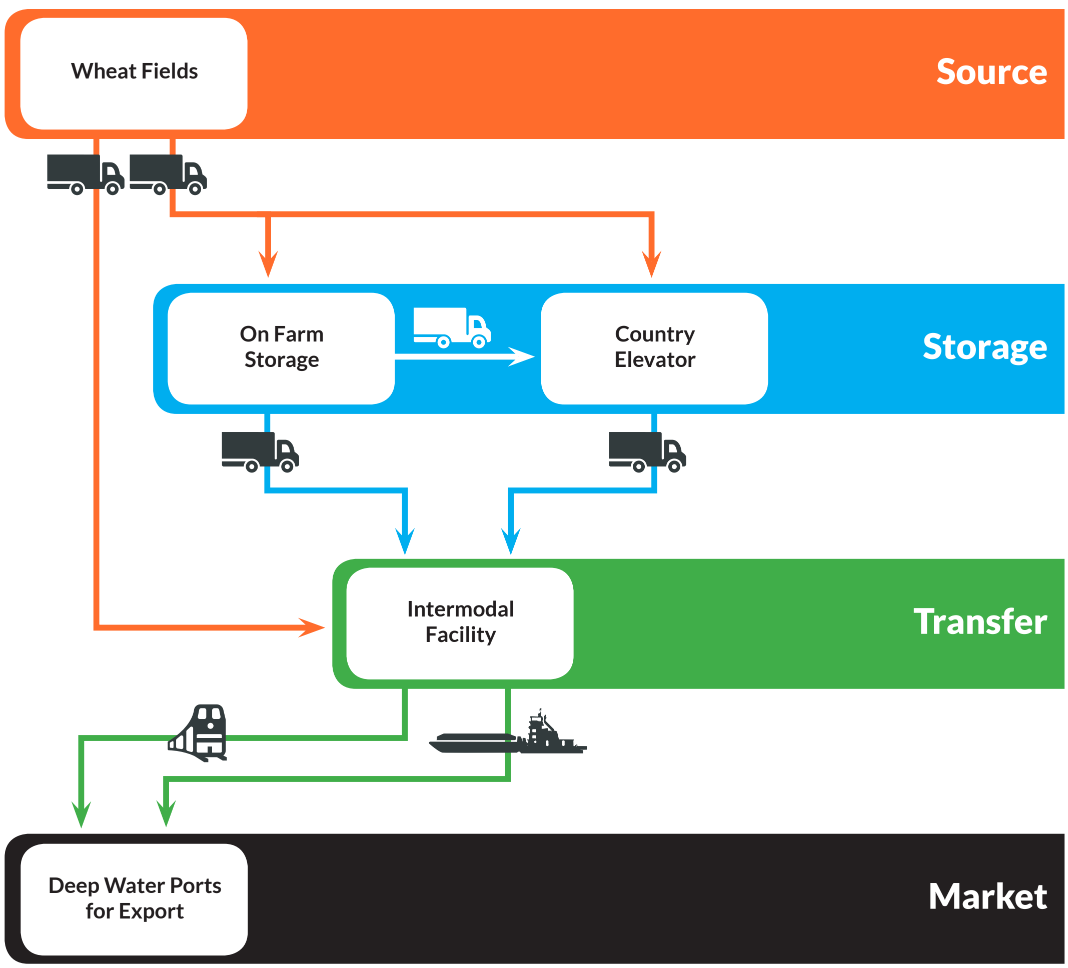
Wheat Supply Chain Data Collection

WA-RD 853.1

Jeremy Sage
Ken Casavant

February 2016

RURAL WHEAT SUPPLY CHAIN



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WSDOT Research Report

Research Report
SHRP2 – Wheat Supply Chain
Agreement T1462-05

Wheat Supply Chain Data Collection

by

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As the Washington State Department of Transportation's (WSDOT) interest in developing a statewide freight model has grown, so too has the need to better understand potential responses of major industries to different policy and market scenarios aimed at reducing freight emissions. This research seeks to understand the wheat supply system and its transportation characteristics, as well as potential behavioral responses by wheat suppliers to changes in policy and market conditions, particularly the feasibility of alternative fuel adoption. To accomplish this, the research team has conducted both new interviews within the wheat supply chain actors, as well as identified existing data sources that help broaden the picture of wheat movement. Results suggest that research is needed to better understand and develop both the power generation of alternative fuel engines as well as the logistics of fuel distribution infrastructure. This is particularly evident for rural freight networks that move heavy agricultural or natural resource based products.</td></tr>
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EXECUTIVE SUMMARY

By and large, wheat movement of the Pacific Northwest is geographically driven by the relative location of the production region to the rail and barge infrastructure. All production has at least some highway truck component to it; however, that segment is often rather short as the ton-mile expense of moving a heavy, bulk commodity like wheat by truck can be prohibitively expensive over long distances. As such, the segments made by truck are in effort to support and stage the movement of the wheat for the longer rail or barge movements.

Despite the short movements, the importance of the truck segment should not be understated. Wheat production, like that of many agricultural products, takes place across a dispersed landscape, thus requiring the utilization of many of the region's roads. Many of these roadways often do not rise to the level of perceived freight corridors when considered on a volume basis. They are however significant collector routes for much of the regional freight of southeast Washington. As policy scenarios or infrastructure investments are considered in the future, it is important in the context of wheat movement that the entire supply chain, across modes, be considered prior to assuming significant shifts in truck utilization.

The enclosed report seeks to summarize the necessary considerations that should be accounted for when attempting to consider specific supply chains in the development of statewide freight models. The wheat industry of Washington State offers a unique opportunity to visualize the potential shortcomings of a blanket freight category that assumes all freight decision makers respond in unison to policy or market changes. As we advance our understanding of potential responses, several key lessons learned arise:

- While there are a large number of farms and thus farmers, there are rather few actors making major transportation decisions. Many farmers throughout the region belong to a farmer cooperative that serves to aggregate the individual production of the numerous farmer members. Currently, roughly 26 buyers/shippers operate 300+ elevators.
- Wheat is too expensive to routinely move long distances by truck. Truck legs of wheat movements have historically been quite short and continue to be most often less than 20 miles.

- Potential shifts in movement are most likely to be induced by market conditions – Price, freight availability, rail and barge rates, customer location and need.
- Unlike other industries where production is concentrated and may be readily located on or near major freight corridors, wheat is heavily dispersed and has a significant reliance on rural and county roads.
- With wheat supply chain movements and importance better understood, the logistical realities of policy alternatives like implementation of alternative fuel networks may be better modeled for their practicality and potential adoption by the users. Implementation considerations should account for the necessary fueling infrastructure to reach dispersed rural locations with limited demand.

INTRODUCTION

Wheat is among the primary commodities produced in Washington State, ranking third behind only apples and milk. Among the highly favorable soils and climate of Eastern Washington, Whitman County has traditionally been one of the largest wheat producing counties in the nation.[1] Beyond Whitman County, much of southeastern Washington has significant acreage in wheat production. The history of grain development in Washington has largely gone hand-in-hand with technological development and the evolution of transportation within the region. Whether it has been steam boats on the Snake River, railroads around its falls and rapids, or the development of the highway system, all have served to support one of the highest density wheat producing regions in the world.

In excess of 80 percent of the wheat grown in Washington is destined for export. Given the commodity characteristics of wheat, it is most frequently transported to export terminals via barge or rail. Decisions on whether to use barge or rail as the primary means of movement are multifaceted, though rely largely on the geographic relationship of the farms and elevator storage areas to the modal loading facilities. Independent of the use of rail or barge, truck movements are always a component of the total supply chain, even if for only a few miles.

As the Washington State Department of Transportation's (WSDOT) interest in developing a statewide freight model has grown, so too has the need to better understand potential responses of major industries to different policy and market scenarios aimed at reducing freight emissions. This research seeks to understand the wheat supply system and its transportation characteristics, as well as potential behavioral responses by wheat suppliers to changes in policy and market conditions. To accomplish this, the research team has conducted both new interviews within the wheat supply chain, as well as identified existing data sources that help broaden the picture of wheat movement.

The information presented in this report is intended to coincide with that similarly developed for food distribution in the Puget Sound region, thus providing a diverse pair of case studies from

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[1] http://www.agcensus.usda.gov/Publications/2012/

which to observe a spectrum of potential behavioral responses to policy and market condition changes. The overriding intent of these combined reports is to:

- Elaborate upon the relationship between data collection efforts and subsequent availability and accurately modeling key state supply chains' behavioral responses to different state policy scenarios aimed at reducing freight emissions and their impacts on the freight system in Washington State.
- Examine the interplay between policy scenarios and market forces driving key supply chains' involvement with the transition to natural gas fuels for freight systems.

Using the above points as a basis of discussion, the remainder of this report summarizes the relationship between truck trip generation rates across the wheat producing regions of Washington and potential changes to such generation and volume of movement based on potential responses to policy and market changes. This discussion includes that of data needed to support the inclusion of wheat supply chain information in a statewide freight model including availability of existing data sources. We conclude with a discussion of experiences, successes, challenges, and lessons learned with implementation of this innovative local freight data collection project.

THE NEED FOR DATA DEVELOPMENT

At least since the passage of MAP-21, a renewed interest in performance based investments has taken center stage among transportation agencies in the prioritization of infrastructure projects. Specifically, WSDOT has undertaken several overlapping research efforts to better capture the benefits and impacts of improved truck transportation to the regional economy of Washington. These research efforts include the development of a freight benefit/cost methodology for project planning by Sage et al (2013).[2] These benefit-cost and economic impact methodologies rely on modeled responses of the freight system to changes in the network that may allow more efficient movement. However, a generation of expected benefits or impacts is directly dependent upon the

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[2] Sage, J.L. et al. 2013. *Development of a Freight Benefit/Cost Methodology for Project Planning.* WA-RD 815.1. http://www.wsdot.wa.gov/research/reports/fullreports/815.1.pdf

quality of output from models used and thus upon the assumptions made about travel behavior. The methods and results identified by Sage et al (2013), are significantly driven by the relationship between congestion relief and travel cost, and as such are largely only applicable to the more urban regions of the state. Sage and Abdel-Rahim (2015) have expanded upon these results to suggest mechanisms to better include and account for the significant number of freight miles that occur outside urban centers, particularly as they relate to intermodal transportation.[3] Both of these reports build on themes produced for WSDOT to the effect of developing a better understanding of the movement of goods on Washington's roadways and the subsequent effects that roadway and other asset quality has on the utility of the state's transportation system. These earlier studies include efforts by Casavant et al (2004) to establish a series of attributes that facilitate viable inter-modal truck facilities,[4] as well as a full exploration by Simmons and Casavant (2010), of the interplay of modal transportation in the state when the river system experiences an extended outage.[5]

In order to effectively advance the discussion and consideration of freight efficiency impacts from transportation investment, the anticipated response of the freight community to those investments must be known. The transportation community readily has commuter based travel models that permit an anticipated response measure based on origin-destination parameters, as well as trip purpose and other traveler attributes. However, we frequently lack similar level of disaggregation when considering freight movement. This lack of detail generates important limitations for several reasons:

- The nature of the freight being moved may dictate potential travel response to policy or market based changes that result in changes in cost structure;
- Market conditions of the commodity may dictate the feasibility of modal shifts;

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[3]Sage, J.L. and Abdel-Rahim, A. 2015. *Performance-Measure Based Asset Management Tool for Rural Freight Mobility in the Pacific Northwest.* Report submitted to PacTrans, August 2015.
[4] Casavant, K., Jessup, E., and Monet, A. 2004. *Determining the Potential Economic Viability of Inter-modal Truck-Rail Facilities in Washington State.* Report Submitted to the Washington State Department of Transportation. December 2004.
[5] Simmons, S. and Casavant, K. 2010. *Historical Waterborne Commerce on the Columbia-Snake River System: Commodity Movements Up and Down River, 1991-2010.* FPTI Research Report #1. November 2010.

- Freight transport characteristics such as bulk movement and weight play significant factors in truck type usage and power needs and thus potential adoption of new technologies;
- Agricultural freight, in particular, has significant seasonality that may not be captured in Annual Average Daily Truck Traffic Counts (AADTT);
- Agricultural production is greatly dispersed, thus relying on a broader set of roadway assets than most industries.

For the reasons above, amongst others, the development of freight travel models should be done with an ability to account for potential discrepancies created by unique industries such as agriculture, particularly when those industries make up significant portions of the AADTT within a region. The remainder of this report highlights several key facets of the wheat supply chain that are needed to accurately model behavioral responses to varying state policy scenarios aimed at reducing freight emissions and their impacts on the freight system in Washington State. It also examines the interplay between policy scenarios and market forces driving key supply chains involvement, or lack thereof, with the transition to natural gas fuels for freight systems.

CHARACTERIZING THE WHEAT SUPPLY CHAIN

Given the dispersed nature of wheat production, and its transport characteristics (e.g. bulk, weight), the current transportation system supporting the wheat and other agricultural industries of Washington is highly intermodal and comprised of all three major freight modes: rail (both Class I and Short Line), trucks using the highway/county road system, barges using the inland waterway system (Figure 1), as well as a set of intermodal facilities to enable the transfer of commodities between modes (Figure 2). Each of these modes serves its part in moving much the wheat of Eastern Washington to the coastal ports for bulk export. The capacity and cost efficiencies garnered by either rail or barge movement for longer distances dictate the movement of wheat from field to nearby storage or intermodal facilities by truck for future movement by rail or barge.

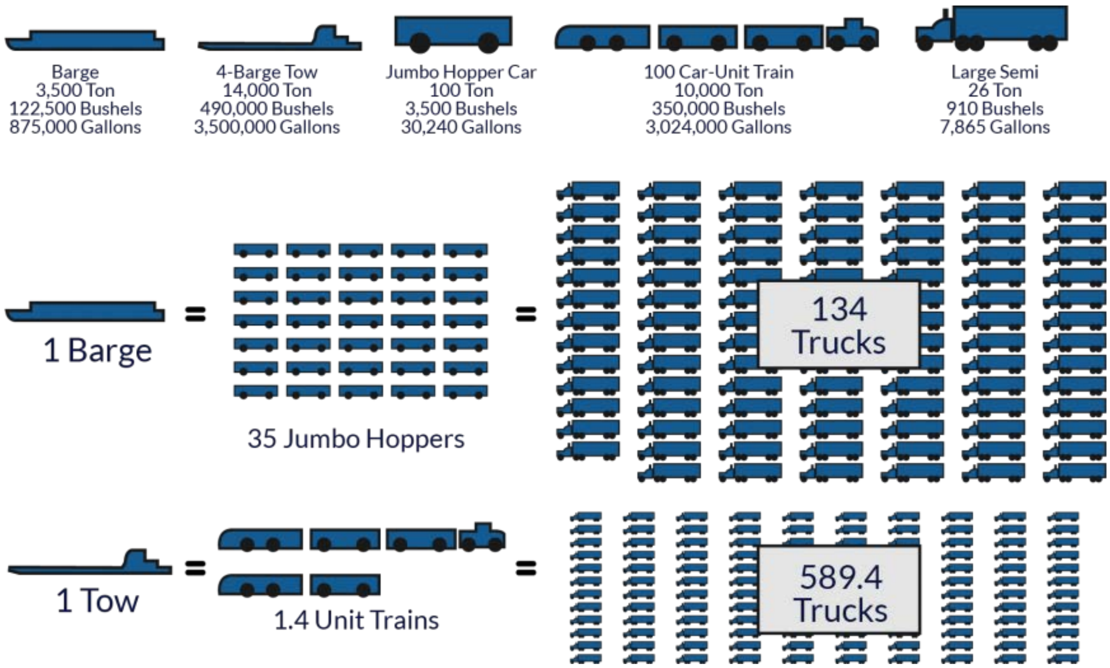
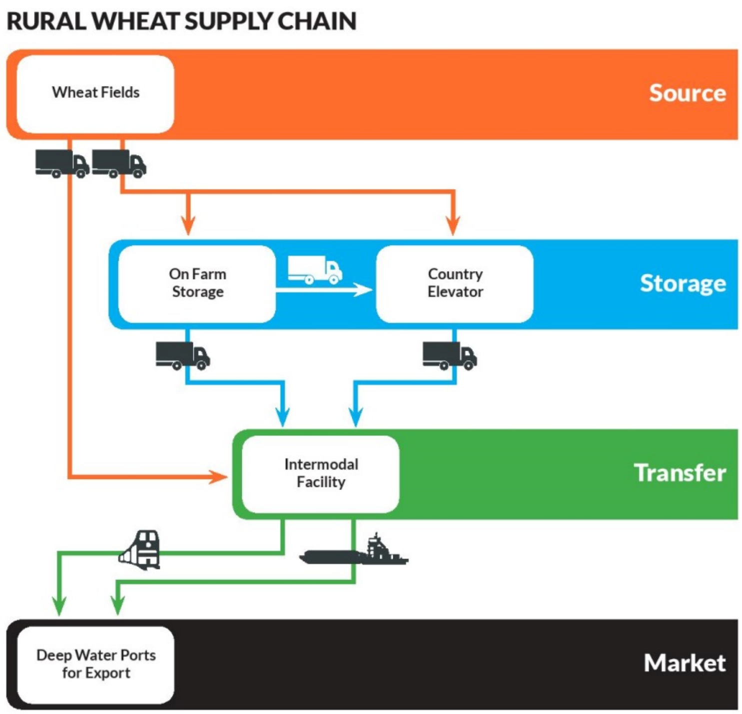


Figure 1. Modal Cargo Comparison (Source: Port of Lewiston)



Note: The Country Elevator and Intermodal Facility may be one and the same.

Figure 2. Typical Wheat Supply Flow from Farm to Export.

As wheat and other cereal grain production is a land intensive practice, an effective and dynamic transportation system is vital to the ability of those farmers to compete in a global marketplace. The competition among, and capacity of, these modes has provided efficient and market responsive service in the region. Though the state's transportation system is quite mature, continual development and adaptation is necessary to maintain any competitive advantage held by the region. Such adaptation requires ready flexibility to changing market conditions, demands, as well as changes to the transportation system itself – both planned and unforeseen. While geography is a major driver of the direction and modal usage within the wheat supply chain (Figure 3), those directional movements are not static. Case in point was the 2011 lock closure along the Columbia-Snake waterway in which all grain movement was halted for three months while repairs were made.[6] Typical movements along the waterway had to be adjusted either by time of movement or direction of movement onto other modes. The supply chain was able to effectively adjust. While the lock outage may be an anomaly within the movement of wheat in the region[7], the necessity to adjust to changing conditions is ever present. Other such conditions include recent deployments of new multi-car loading facilities for rail transport. One such facility, McCoy, has now been in operation for several years, while another, Highline, is in the development process. These large loading facilities have the potential to shift the relative cost of transport between rail and barge for some farmers.

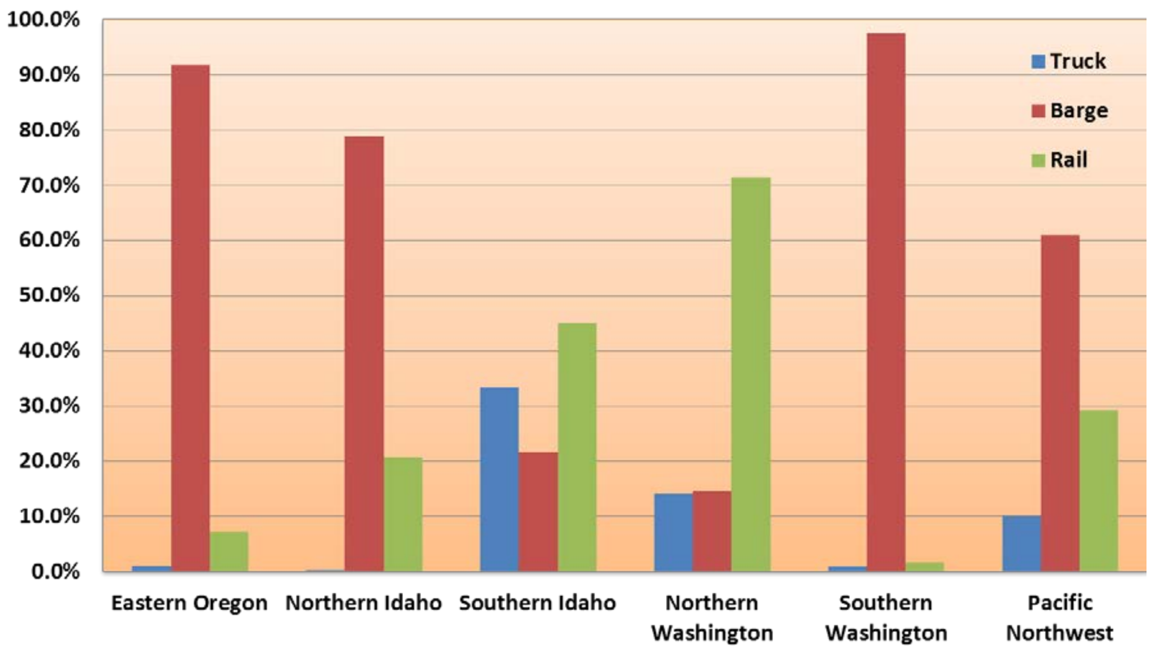


Figure 3. Typical Percentage of Wheat Shipped via Various Modes in the Pacific Northwest.[8]

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[6] Refer to FPTI reports: 1, 2, 9, 10, and 12 for full details on industry response to the closure. http://www.fpti.wsu.edu/reports.htm

[7] The 2011 lock closure lasted approximately 11 weeks. A 14-week closure is currently planned for the end of 2016.

[8]Simmons, Sara and Ken Casavant. FPTI Research Report #12. "Economic and Environmental Impacts of the Columbia-Snake River Extended Lock Outage." August 2011.

Farm Origins

In 2012[9], wheat was grown on more than 2.1 million acres throughout Washington, primarily in the southeast region. These acres produced 141 Million bushels, or nearly 65 bushels per acre.[10] Significant additional acreage is left fallow in any given year to promote soil health, while other parcels of potential wheat producing lands are currently maintained in the Conservation Reserve Program (CRP) (Figure 4). Under the CRP, farmers are paid yearly rental payments by the USDA to remove environmentally sensitive lands from production for up to 15 years per contract. As evident from Figure 4, the major wheat production area of Washington is expansive, covering significant portions of 10 southeastern counties.

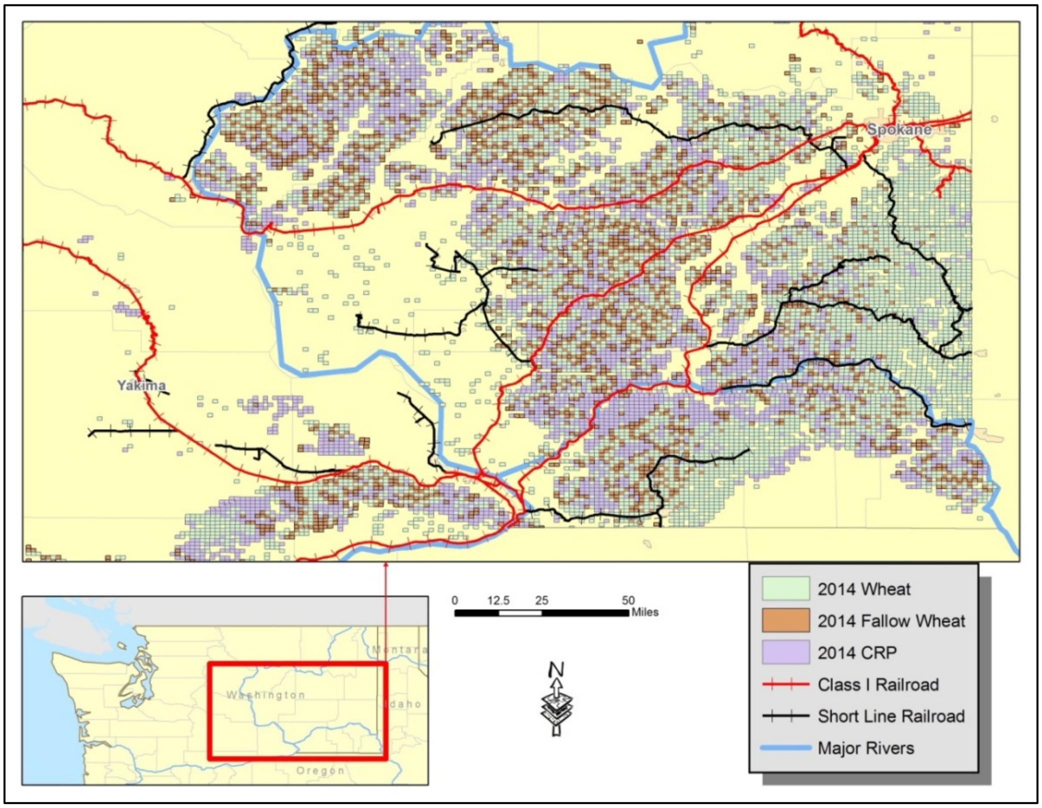

Figure 4. Regional Production Area for Washington Wheat.[11]

[9] Most recent Census of Agriculture.
[10] http://www.agcensus.usda.gov/Publications/2012/
[11] Washington State Department of Agriculture, Agricultural Land Use Maps. http://agr.wa.gov/PestFert/NatResources/AgLandUse.aspx

Roughly progressing sequentially from southwest to northeast, wheat harvest occurs throughout late summer as the crop becomes ready. Upon harvest, much of the wheat is moved by farm truck to local storage. Until recent decades, such movements were conducted by more, smaller trucks, however those trucks are now frequently replaced by larger trucks moving up to 26 tons of wheat at a time. One bushel of wheat weighs approximately 60 pounds, making the entire weight of the 2012 harvest roughly 4.23 million tons. This yield thus generates an estimated 162,716 truck trips between farm and grain elevator (Table 1).

Table 1. Farm Truck Trips to Support Wheat Harvest.

2012 Wheat Acres Harvested	2,186,813
2012 Wheat Yield (Bu)	141,020,565
Weight per Bushel (lbs)	60
2012 Weight Yield (tons)	4,230,617
Tons Hauled per Truck	26
Truck Trips Needed to Support Harvest	**162,716**

As previously identified, wheat production takes place over a dispersed geography. Such dispersion places the generated truck trips on numerous roadways throughout the region. Figure 5 below highlights an approximation of the dispersed nature of truck trips generated by harvest throughout the Palouse region, based on the calculations above. The Palouse area is used as an example, given its high density of wheat production and access to multiple modes. Trucks may be expected to begin on the network at the point near the field where they can access a roadway suitable for truck traffic. Each truck collects wheat from approximately 13 acres; actual value depends upon truck size used and crop yield. Using the U.S. Department of Agriculture's CropScape Data Layer,[12] accurate estimates of annual production of specific crops may be generated.

Figure 3 above demonstrated that for Washington wheat farmers, truck movement constitutes a small portion of travel, yet a vital one as wheat does not grow directly on the rail line or the river.

[12] http://nassgeodata.gmu.edu/CropScape/

From the farm, most trucks are destined for nearby storage either to be moved again later by truck, to be loaded onto the rail or barge for its longer segments to export ports.

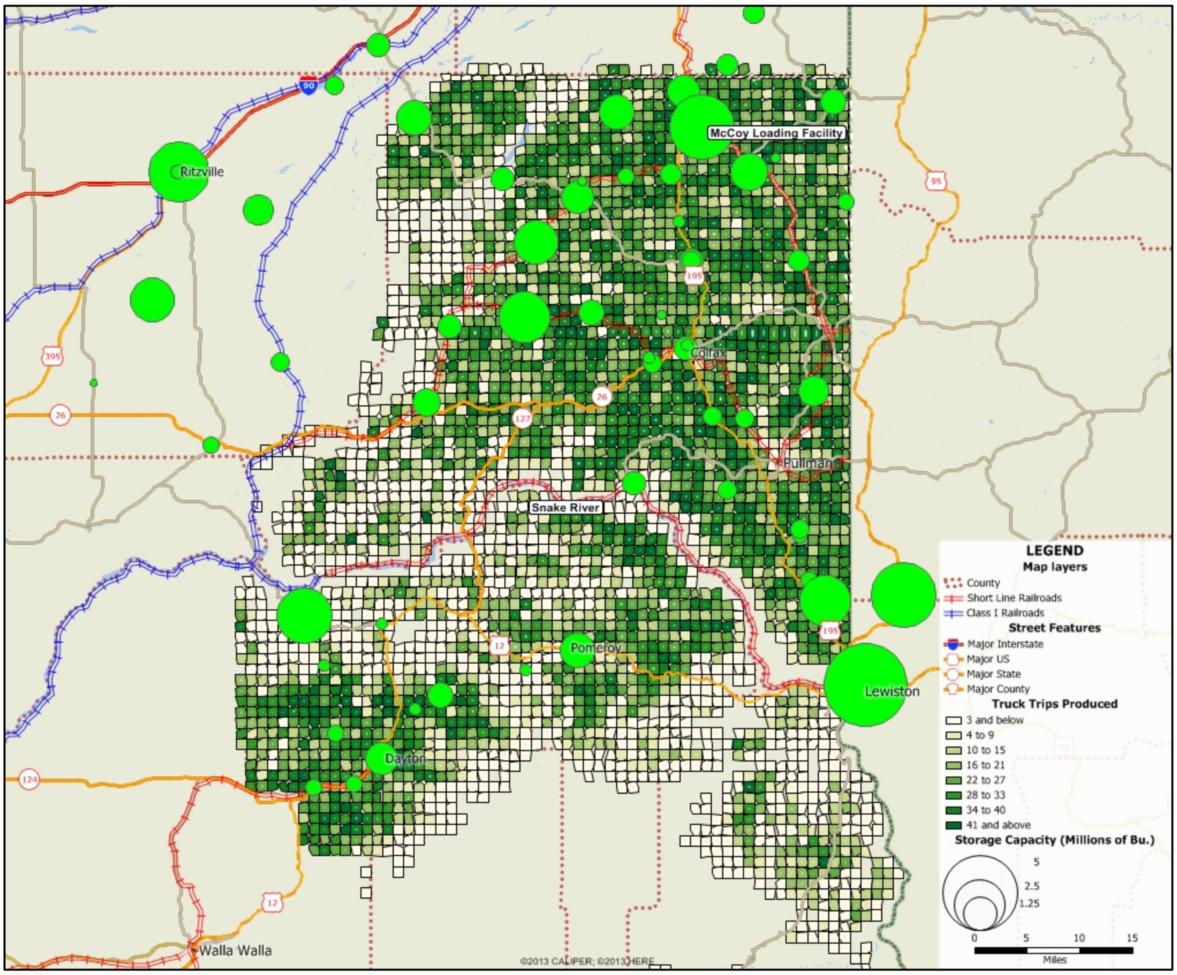

Figure 5. Wheat Harvest Truck Trips Generated (Whitman, Asotin, Garfield, Columbia Counties) 2014. Grid cells represent 1 mi^2.

After the Farm

As one moves up the wheat supply chain, the number of actors quickly diminishes. While there were 2,871 wheat farms in Washington in 2012,[13] there were less than 30 major wheat suppliers and buyers with grain storage capacity in the state. These elevators (mostly cooperatives) have grain elevators storage for just over 131 million bushels of wheat plus additional capacity through ground piles. The storage facilities throughout the region vary considerably in size and access to rail or river connections (Figure 5). More storage can also be found on farm.

Historically, the average elevator attracted farms located 10 to 20 miles from any one of their facilities.[14] Some larger facilities with direct access to rail or barge possessed a slightly larger catchment. Assuming the catchment falls within this range, Figure 6 displays the approximate coverage of the region's wheat production by the known locations of the storage facilities. At a travel band of 20 miles, full coverage of the major wheat production area is captured, while 10 mile bands capture a substantial majority of the producing region.

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[13] http://www.agcensus.usda.gov/Publications/2012/

[14] Clark, M., Jessup, E., and Casavant, K. 2003. *Dynamics of Wheat and Barley Shipments on Haul Roads to and from Grain Warehouses in Washington State*. SFTA Research Report #5. September 2003.

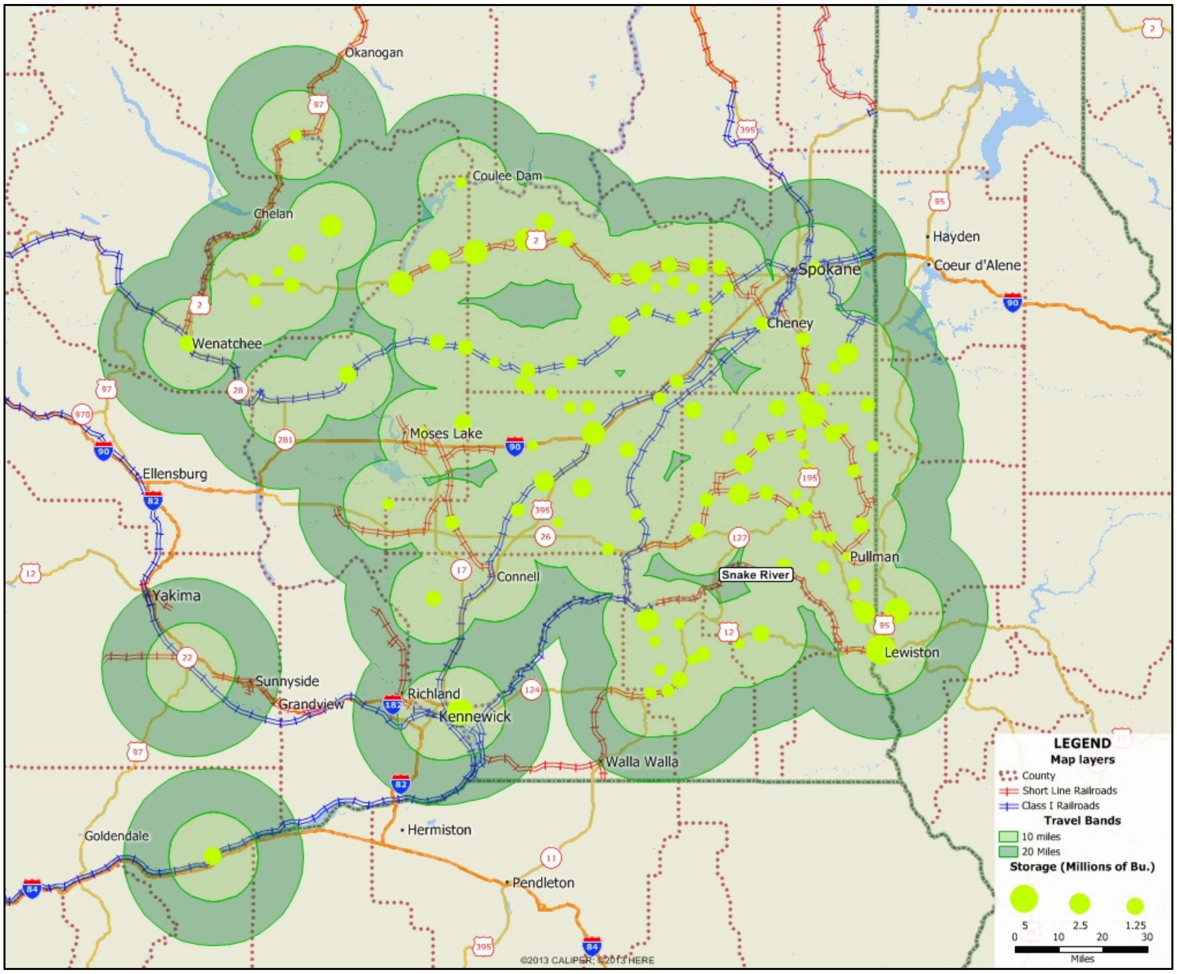

Figure 6. Grain Storage Facility Catchment Areas (10 and 20 mile Buffers).

WHEAT SUPPLY STAKEHOLDER ENGAGEMENT

Survey of Wheat Suppliers

As a substantially homogeneous commodity, the wheat grown by one farmer is largely indistinguishable from that of any other. From the farm, the wheat harvest is collected by, or shipped to, a small set of wheat suppliers. Mostly cooperatives, these suppliers function to serve as an aggregating actor to identify markets and promote the sale and typically export of Washington's wheat harvest on behalf of their farmer members. Given their central role in the supply chain of Washington wheat, these suppliers serve as the primary points of contact in this study. Further, these firms have routinely served as valuable and highly knowledgeable sources of information for the movement of wheat in Washington. A prime example of such insight is the previously conducted research surrounding the 2011 extended lock closure in which the Freight Policy Transportation Institute (FPTI) researchers were able to engage in open communication with the wheat suppliers to ascertain their traditional movements and expected reactions to the closure.

In this round of survey and interview efforts, FPTI successfully contacted 19 of 26 suppliers (73 percent). These suppliers may be found on the Washington Grain Commission Website.[15] We excluded suppliers identified as seed companies. Survey respondents were asked to identify the primary reasons for their modal choice decisions. Of the 19 responses collected, eight indicated that costs were the primary factor, while another seven indicated that the availability or relative location of the mode was a primary consideration. Market price also played a smaller role, two responses, in modal choices.

Responses to the modal choice questions fall in line with the observations shown in Figure 1 that suggest discrete geographic differences in modal usage. These differences reflect the availability and relative rates of the rail and barge modes and the distance required to move the wheat to the nearest access points by truck. Further, these responses are reflective of the relative ton-mile expenses faced in a multimodal supply chain such as wheat. Tables 2 and 3 show the relative equivalencies of the three modes of transport in terms of cargo capacity (Table 2) and costs (Table 3).

Table 2. Standard Modal Capacities.

Standard Modal Freight Unit Capacities	
Modal Freight Unit	**Standard Cargo Capacity**
Highway - Truck	**26 tons**
Rail - Bulk Car	**111 tons**
Barge - Dry Bulk	**1,750 tons**

[15] http://wagrains.org/

Table 3. Modal Equivalencies.[16]

Equivalent Units	Mode of Transportation		
Equivalence By Mode	1 Barge	16 Rail Cars	70 Trucks
Cost per Ton-Mile (cents)	0.72	2.24	26.61
Ton-Mile per Gallon of Fuel	616	478	150

The survey and supplementary follow-up discussions couched economic decision making with respect to transport costs and emissions reductions within a series of questions aimed to reveal stated concerns or reactions by the respondents related to:

- Identified market condition changes in the preceding three years;
- Firm responses to market condition changes;
- Action taken to minimize impact of future market condition changes or uncertainty;
- Identified government policy changes in the preceding three years;
- Firm responses to policy changes;
- Action taken to minimize impact of future policy changes or uncertainty.

In addition to the primary lines of questioning above, the disseminated online survey also sought information from the respondents in regards to catchment area of each of their elevator facilities. Such information is used to generate estimated roadway usage during harvest as wheat is moved from farm to elevator. Respondents in this 2015 survey remained consistent with those previously identified by Clark et al (2003) and used to generate the travel bands in Figure 6.

Responding to Market Conditions

Market conditions routinely impact commodity movements and transportation decisions. "Market conditions," is a broad term covering multiple potential avenues of impact. Such

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[16] Texas Transportation Institute. *A Modal Comparison of Domestic Freight Transportation Effects on the General Public: 2001-2009.* http://www.nationalwaterwaysfoundation.org/study/FinalReportTTI.pdf. February 2012.

scenarios covered include changes in relative transportation rates between modes, changes in market demand or commodity prices. Survey respondents were asked in a yes or no question to identify whether their operations were effected by any changes in market conditions in the previous three years. Of those responding to the question, 47 percent indicated that market conditions necessitated an alteration of their transportation decisions. Of those making such alterations, 86 percent indicated the need to shift some movement of their product from rail to barge, while 43 percent indicated a shift at some point from barge to rail. The high level of fluidity between barge and rail movements suggests the potential sensitivity of many wheat suppliers to the relative rates and availability (rail cars) of transportation by mode. While actual rates can vary in time and location, approximate ton-mile costs by mode are .7 cents by barge, 2.2 cents by rail, and 26.6 cents by truck (Table 3).

Roughly 86 percent of those taking action to alter their transportation decisions identified a change in their timing of shipment. Again, this may be related to both transportation costs as well as market prices for wheat. Respondents were given the opportunity to select any of the following response actions and then elaborate on their reasons for action:

- Shifted some movement from rail to barge;
- Shifted some movement from barge to rail;
- Transported wheat entirely by truck;
- Altered timing of shipment;
- Held more wheat in storage than usual;
- Held less wheat in storage than usual;
- Took other actions.

Most respondents (79 percent) have taken action to seek to minimize impact of market based fluctuations. The nature of the wheat market necessitates a significant degree of long range planning in production, sales and transportation alternatives, thus suppliers routinely seek opportunities to minimize the effects of small market based fluctuations on their larger operations. They indicate they have done so through increased storage, increased access to all modes, and more efficient warehousing operations. Several specific comments from respondents include:

- Cost and availability of rail transportation dictates much of our transportation decisions;
- Freight costs and availability along with crop quality change from year to year, thus changing the way we move our products;
- The largest issues are with the Ports and Longshoremen;
- We move wheat as needed for storage quality and then make movement decisions based on market direction;
- Prices for different shipment periods changed or supported one shipment period over another. Varying market conditions may cause farmer to sell more of their grain and carry over less.

The actions taken in recent years by the respondents is reflective of their sensitivity to fluctuations and reliability of freight modes. These actions include:

- Hedging against fuel surcharges;
- Maximize mill and feedlot direct shipments;
- Improve facilities to receive bigger trucks and improve ability to load rail;
- Direct exporting instead of delivering grain to competitors;
- Continue to ship on the short line to ensure that they will be here in the future;
- Leasing of rail cars to improve availability;
- Ensuring multiple modes of delivery are available;
- Improving warehousing for more efficient trucking.

Responding to Policy Conditions

In a similar style to the questions posed to respondents about previous responses to changes in market conditions, they were also asked to respond to questions regarding their responses to changes in policy conditions. Slightly fewer, 43 percent, of respondents indicated that over the last three years government policies (federal, state, or local) have caused a shift in their transportation decisions. These questions were intentionally left open ended to permit the respondent to identify the policies that were most likely to generate a response by their operation. Unlike a change in market conditions, no single response was highly common among respondents. Fifty percent of those making some sort of change, indicated that they altered the timing of their shipments. Few indicated that a policy generated any type of modal shift, and those that did appear to be temporary as the respondents were making decisions based on road or rail closures for short durations of time, such as seasonal weight restrictions.

Similar to preparing for market based changes, respondents indicated they attempt to buffer themselves from government based actions by ensuring quality access to multiple modes. By possessing access to multiple modes, the respondents indicated their ability to be responsive to customer demands and ensure timely delivery in the event of unforeseen issues on a particular mode or area of production

Considering Fuel Alternatives

Most survey respondents operate with some combination of their own trucks and the hiring of independent trucks and drivers. They used a variety of compensation mechanisms for the trucks they hired out, these include: per bushel hauled, per unit weight, and per mile. Several indicated that fuel costs are directly tied to driver compensation contracts.

When provided information as to the relative costs of fuel to the marginal costs of trucking (about 38 %), and asked whether they have considered alternatives to diesel, only two respondents indicated they have, though neither have attempted or experimented with alternatives. The cost and availability of the fuel, cost of maintenance, and unit power to navigate the hilly region were significant concerns of those who did consider alternatives.

Recognizing that fuel costs are significant to their operations, several respondents utilize typical market based mechanisms to control fuel spending. These mechanisms include the purchase of large quantities at times of perceived low prices, as well as fuel hedging. When contracting permits, many costs associated with a rise in fuel costs are passed along to the customer and/or grower. However, this pass along is not always feasible. Such cases arise when grain is purchased and sold for three months in the future. If fuel prices fluctuate significantly over that time, what was a good buy and sell may become less so if fuel costs rise. In the broader scheme, fuel prices affect the competitiveness of northwest wheat globally.

The importance of both the dispersed nature of wheat production in rural landscape and the transport characteristics of the commodity being moved are perhaps two of the most important considerations in the potential application of alternative fuel usage by the wheat supply chain. On the one hand wheat is a heavy commodity that often relies on truck transport for its first mile movements. In response to increasing demand for efficient transportation, the industry has moved towards larger trucks capable of moving more wheat in fewer trips. These attempts at efficiency gains have necessitated significant power generation from its trucks. The power needs are further desired to navigate the hilly terrain of the major wheat production areas. Secondly, the rural nature of wheat production place truck movement across large landscapes, adding infrastructure constraints to the potential implementation of alternative fuels. Without easy and ready access to the fuels, adoption by the wheat industry would not be practical.

With power needs and the dispersed nature of agriculture in mind, several items of consideration should be included in moving forward on alternative fuels policies and potential adoption recommendations.

Technological Barriers

While support and evidence for the emission reducing potentials of alternative fuels (LNG and CNG) continue to grow, questions remain as to the power generation capability of these fuels on par with that of diesel engines. As such, policies aimed to incentivize the development of higher power output generation of heavy duty trucks running on alternative fuels should be explored. Natural resource and agricultural production based trucks frequently require the capability to move some of the heaviest trucks on the roadway, thus placing their power needs at the higher end of the spectrum.[17] These trucks will frequently weigh out before they cube out.

Where (or when) output is on par with diesel trucks, a program to increase awareness, and thus potential adoption may be encouraged. Based on interviewee responses, such an awareness, when presented to owners and/or operators of trucks involved in wheat movement should be directed towards the identification of the potential return on investment (ROI) for alternative fuel based trucks. Key components of such an ROI may include:

- Evaluation based on the seasonal use of many farm trucks (impacts miles per year and assumed loading characteristics);
- Owners likely to own few trucks (many are owner operators);
- Fuel costs in relation to fuel efficiency;
- Positive ROI with and without subsidy support;
- Necessary payload reductions to offset NG vehicle weight increases;
- Ability (and cost) to perform self-repair of NG vehicles;
- Operators are not likely located on or near major freight corridors (See Logistic Barriers below)

Unlike larger truck firms with many trucks, or retail firms with their own fleets, small owner/operators have a reduced incentive to purchase based on social cost or green marketing. This reduced incentive is not a statement of lacking environmental concern; rather, it is a statement of the homogeneity of the wheat industry in which no single farm, driver, or shipper is distinguishable from the others. As such, there is little to no individual marketing advantage to promotion of emissions reductions.

Logistic Barriers

As stated in the list above, most operators within the trucking leg of the wheat supply chain are not operating on major freight corridors. They are running the majority of their miles from farm to elevator in geographically disparate regions of the state. As such, these locations are likely to

[17] Sage, J. L. and Casavant, K.L. 2014. *Freight Commodity Flows: Selected Washington State Highways.* WA-RD 825.1. http://www.wsdot.wa.gov/research/reports/fullreports/825.1.pdf

be late adopters of the infrastructure necessary to support LNG or CNG refueling. Subsequently, any discussion of wheat supply chain adoption of such fuels hinges on the identification of the feasibility of rurally located service station capacity to store and handle alternative fuels. Key considerations include the physical facilities, as well as the economic incentives (e.g. are subsidies or tax incentives needed or warranted?) to transition and make the fuels available in lower density regions.

Further investigation and research is warranted on the minimum facility location needs to ensure adequate accessibility for rural users without necessitating significant off route travel to refuel. This research includes the identification of the potential for distribution systems for independent or onsite fuel storage.

Technologic and Logistic Needs: Chicken and Egg

The above discussions as to the technologic and logistic needs to entice adoption of alternative fuels within the wheat supply or other agriculturally based supply chain are not new, and are intimately related. In fact, the two discussions should be held simultaneously. The adoption of the new fuels is inherently dependent upon multiple groups of actors making business decisions that affect one another. One the one hand, there is little sense in marketing well performing engines to these owner operators if there are not convenient refueling options available to them. While on the other, there is little incentive to develop the necessary infrastructure for CNG or LNG if the major fuel consumers do not have a viable engine to use that meets their power needs.

CONCLUDING DISCUSSION

By and large, wheat movement of the Pacific Northwest is geographically driven by the relative location of the production region to the rail and barge infrastructure. All production has at least some highway truck component to it; however, that segment is often rather short as the ton-mile expense of moving a heavy, bulk commodity like wheat on truck can be prohibitively expensive over long distances. As such, the segments made by truck are in effort to support and stage the movement of the wheat for the longer rail or barge movements.

Despite the short movements, the importance of the truck segment should not be understated. Wheat production, like that of many agricultural products, takes place across a dispersed landscape, thus requiring the utilization of many of the region's roads. Many of these roadways often do not rise to the level of perceived freight corridors when considered on a volume bases. They are however significant collector routes for much of the regional freight of southeast Washington. As policy scenarios or infrastructure investments are considered in the future, it is important in the context of wheat movement that the entire supply chain, across modes, be considered prior to assuming significant shifts in truck utilization.

Lessons Learned

The preceding report has sought to summarize the necessary considerations that should be accounted for when attempting to consider specific supply chains in the development of statewide freight models. The wheat industry of Washington State offers a unique opportunity to visualize the potential shortcomings of a blanket freight category that assumes all freight decision makers respond in unison to policy or market changes. As we advance our understanding of potential responses, several key lessons learned should be considered:

- While there are a large number of farms and thus farmers, there are rather few actors making major transportation decisions. Many farmers throughout the region belong to a farmer cooperative that serves to aggregate the individual production of the numerous farmer members. Currently, there are roughly 26 buyers/shippers operate 300+ elevators.
    - Several actors spend significant amount of time buying/selling transportation (e.g. rail cars).
    - In terms of truck transport, despite few actors making major decisions, they must draw from a variety of independent owners and operators of trucks to accomplish their movements. In this sense, there is often not a fleet of trucks with central direction or ownership. Subsequently, policies aimed at incentivizing conversion to alternative fuels should be done at an appropriate economic scale of owners with only a few trucks at most. This additionally has direct implications for the types of fueling infrastructure required.

- Wheat is too expensive to routinely move long distances by truck. Truck legs of wheat movements have historically been quite short and continue to be most often less than 20 miles. The elevator/storage presence in the major wheat growing areas effectively cover all productive lands.
- Potential shifts in movement are most likely to be induced by market conditions – Price, freight availability, rail and barge rates, customer location and need.
- Unlike other industries where production is concentrated and may be readily located on or near major freight corridors, wheat is heavily dispersed and has a significant reliance on rural and county roads.
- Most wheat movement estimates are frequently made at the county level, however to increase the network understanding and needs of movement, analysts can utilize USDA CropScape data layer to generate truck trip generation from the farm level. Additionally, most storage facilities (elevators) are licensed by the State of Washington and can thus be geocoded to create an origin destination pair from the farm to the elevator.
- With Origin and Destination knowledge, we can estimate truck volume and thus roadway importance to wheat movement.
- With wheat supply chain movements and importance better understood, the logistic realities of policy alternatives like implementation of alternative fuel networks may be better modeled for their practicality and potential adoption by the users. Implementation considerations should account for the necessary fueling infrastructure to reach dispersed rural locations with limited demand.

APPENDIX A: SURVEY QUESTIONS

Q1 What is the name of the firm for which you are responding to this survey?

Q2 Is your company directly involved in the transportation, or storage of wheat in Washington State?

- ❍ Yes (1)
- ❍ No (If no, please stop and return the survey.) (2)

Q3 Please provide the physical address (or addresses) of your operating facilities. (e.g. loading facility or elevator)

Q4 Please identify the storage capacity of each facility identified above.

Q5 Please identify the means (mode) by which wheat arrives at your facilities (e.g. truck). If you own more than one facility, please identify the facility and describe the arrival mode for each, if they are different.

Q6 Please provide your best approximation of the distance from which wheat is transported to your facilities.

Q7 If wheat arrives at your facility via truck, please estimate the quarterly number of incoming trucks for each facility.

Q8 If wheat arrives at your facility via rail please estimate the quarterly number of incoming carloads for each facility.

Q9 Please identify the means (mode) by which wheat departs your facilities (e.g. truck). If you own more than one facility, please identify the facility and describe the departure mode for each, if different.

Q10 If wheat departs your facility via truck, please estimate the quarterly number of outgoing trucks from each facility.

Q11 If wheat departs your facility via rail, please estimate the quarterly number of outgoing carloads from each facility.

Q12 Please identify the intermediate destination (e.g. barge terminal, rail facility, port) of wheat leaving your facility. If you operate more than one facility, please identify destination from each.

Q13 Please briefly describe your firm's decision factors for mode choice in the transport of wheat.

Q14 In the last three years have market conditions (e.g. rail rates) altered your transportation decisions or mode choice?

- ❍ Yes (1)
- ❍ No (2)

Q15 Answer if Q14=yes

Select any of the following actions you have taken in the last three years due to a change in the wheat market or transportation system.

- ❑ Shifted some movement from rail to barge (1)
- ❑ Shifted some movement from barge to rail (2)
- ❑ Transported wheat entirely by truck (3)
- ❑ Altered the timing of shipment (4)
- ❑ Held more wheat in storage than usual (5)
- ❑ Held less wheat in storage than usual (6)
- ❑ Other Action (7)

Q16 Answer if Q14=yes

Please provide detail on the primary reason(s) for the actions identified above.

Q17 Has your firm taken actions to minimize the impact of future market changes on your transportation decisions?

- ❍ Yes (1)
- ❍ No (2)

Q18 Answer if Q17=yes

Please describe actions taken.

Q19 In the last three years have any government policies (Federal, State, or Local) altered your transportation decisions or mode choice?

- ❍ Yes (1)
- ❍ No (2)

Q20 Answer if Q19=yes

Select any of the following actions you have taken in the last three years due to a government policy change.

- ❑ Shifted some movement from rail to barge (1)
- ❑ Shifted some movement from barge to rail (2)
- ❑ Transported wheat entirely by truck (3)

- ❑ Altered the timing of shipment (4)
- ❑ Held more wheat in storage than usual (5)
- ❑ Held less wheat in storage than usual (6)
- ❑ Other Action (7)

Q21 Answer if Q19=yes

Please provide detail on the primary reason(s) for the actions identified above.

Q22 Has your firm taken actions to minimize the impact of future government policies on your transportation decisions?

- ❍ Yes (1)
- ❍ No (2)

Q23 Answer if Q22=yes

Please describe actions taken.

Q24 Does your firm own or operate its own trucks for wheat movement?

- ❍ Yes (1)
- ❍ No (2)

Q25 Answer if Q24=no

How do you acquire trucks/drivers for your wheat movement? (e.g. Independent For-Hire Drivers)

Q26 Answer if Q24=no

What is the compensation mechanism for these trucks/drivers? (e.g. per hourly, per truckload, per mile)

Q27 Answer if Q24=yes

Select the correct range category below for the number of trucks you own/operate.

- ❍ 1 Truck (1)
- ❍ 2-5 Trucks (2)
- ❍ 6-10 Trucks (3)
- ❍ More than 10 Trucks (4)

Q28 Answer if Q24=yes

The American Transportation Research Institute (part of ATA) recently released a report stating that fuel costs are by far the largest proportion (38%) of the marginal cost to trucking. Have you considered alternatives to diesel as fuel for you trucks?

- ❍ Yes (1)
- ❍ No (2)

Q29 Answer if Q28=yes

What are the trade-offs you consider when looking at alternative fuels?

Q30 Answer if Q24=yes

How do you currently control fuel spending for your trucks?

Q31 How significant is the cost of fuel to your operations?

- ❍ Very significant (1)
- ❍ Somewhat significant (2)
- ❍ Somewhat insignificant (3)
- ❍ Very insignificant (4)
- ❍ Uncertain (5)

Q32 As fuel costs fluctuate, what options are you considering to mitigate the effects to your firm?

Q33 If the cost of natural gas trucks decreases by 20% in the next 3 years, how would you go about deciding whether to purchase natural gas trucks or conversion kits?

Q34 If the price of diesel goes up by 20%, while all other fuel prices remain steady with inflation, how would your firm react? Would you consider purchasing natural gas trucks as a replacement?

Q35 If an unexpected closure of a Lock on the Columbia-Snake system occurred for an extended time (e.g. greater than one month), how would your transportation decisions change?

Q36 If a short line rail line of significance to your operation is abandoned, how would your transportation decisions change?

Q37 Please select all of the options below that you feel currently constrain your firm's efficient operation.

- ❑ Slow Rail Speeds (1)
- ❑ All Weather Road Availability (2)
- ❑ Truck or Driver Availability (3)
- ❑ Rail Rates (4)
- ❑ Rail Car Availability (5)
- ❑ Barge Accessibility (6)
- ❑ Barge Rates (7)

Q38 Is there anything else that you would like to let us know as it pertains to your transportation decisions now and in the future?