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Office of Research

Agricultural Freight Data Improvement
Study SD2014-09
Final Report

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16. Abstract

Historical trends of traffic and truck counts have been the primary means used by the South Dakota Department of Transportation (SDDOT) to forecast traffic volumes necessary for planning roadway improvements and maintenance. However, historical trends do not reflect the rapid changes in agricultural production and the resulting transportation activity in the State. To better explain agricultural freight demand, predict impacts on transportation systems, and improve policy and transportation investment decisions, this research developed a methodology to integrate new sources of data beyond conventional, historical traffic counts to make more reliable decisions and to improve transportation system performance.

The key findings of this study include:

1. Among SDDOT, local agencies and private entities, nine different agricultural freight related purposes and applications of improved data were identified that can be utilized for planning purposes over a horizon ranging from days to months, seasons, and years.
2. South Dakota agencies make limited use of available USDA data along with forecasts and data compiled by agricultural associations to support transportation system decision-making, mostly on the state-owned rail system. Innovative data collection methods such as Unmanned Aerial Vehicles (UAVs) and smartphones offer significant promise for to cost-effective means to filling large gaps in data on local roadway traffic counts and surface condition. At present, privacy and cost of other data sources such as producer production records and remotely sensed data inhibit their widespread use by SDDOT.
3. The demonstration developed a compendium of conventional and “unconventional” agricultural freight data related to major crops and livestock facilities. The demonstration included trip generation estimates for four major crop types and two types of livestock facilities, and testing of various planning scenarios, including facility siting and public roadway closures.

The research recommended that SDDOT should: (1) actively monitor agricultural and transportation industry trends; (2) incorporate available agricultural resources including knowledge of agricultural production and agricultural and transportation industry trends into short- and long-term transportation decision-making; and, (3) lead new data development efforts in partnership with regional and local transportation agencies.

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Acronym	Definition
AADT	Average Annual Daily Traffic
AADTT	Average Annual Daily Truck Traffic
AMS	Agricultural Marketing Service
ATR	Automated Traffic Recorder
CAFO	Concentrated Animal Feeding Operation
CRP	Conservation Reserve Program
DOT	Department of Transportation
ERS	Economic Research Service
ESAL	Equivalent Single Axle Load
FHWA	Federal Highway Administration
GDP	Gross Domestic Product
GIS	Geographic Information System
LTAP	Local Technical Assistance Program
NASS	National Agricultural Statistics Service
OD	Origin Destination
SD	South Dakota
SDDOT	South Dakota Department of Transportation
SDSU	South Dakota State University
SHRP	Strategic Highway Research Program
STB	Surface Transportation Board
STIP	Statewide Transportation Improvement Program
TAZ	Traffic Analysis Zone
UAV	Unmanned Aerial Vehicle
UGPTI	Upper Great Plains Transportation Institute
USDA	United States Department of Agriculture
VMT	Vehicle Miles Traveled
WIM	Weigh-in-motion

1.0 EXECUTIVE SUMMARY

1.1 Background

Like many other Western and Midwestern states, South Dakota's economy has historically been defined by agriculture. In recent decades the State's economy has become increasingly diversified, but agricultural production remains important. During the ten years between 2004 and 2014, farm production grew by 75 percent, and accounted for anywhere from 4.6 to 12.6 percent of the state's gross output, which reached $45.9 Billion in 2014. In comparison, agriculture's contribution to National GDP is approximately 2 percent. This increased production has been primarily driven by a combination of improved technology in cultivation, along with a shifting crop mix and some expansion in acreage planted. Notably, between 2010 and 2014 acres planted with corn increased 27 percent, from approximately 4.5 to 5.8 million acres, largely at the expense of wheat and other grains.

A direct result of the growing production has been an increase in the volume of agricultural freight shipped on South Dakota's highways and rail lines. Markets for the State's crops and livestock have become more diverse than ever, and with it the need for an efficient and resilient transportation system that provides access to domestic markets and deep-water ports for export. Thus, rural truck and rail freight connectivity and efficiency are critical to keeping South Dakota's production and shipping costs competitive with products from other states and regions around the world. Rural roads provide first- and last-mile connectivity from production centers (e.g., farms, feedlots, etc.) to intermediate or final destinations (e.g., grain elevators, processing facilities, ethanol plants, dairies, livestock auction, etc.). In some parts of the State the trip from production to destination is a short one; in other parts where facilities are further apart, or are "transportation disadvantaged" due to the lack of transportation options and rail service, truck trips are much longer. To accomplish truck movements efficiently, greater numbers of larger and heavier trucks are often used to move product.

Regardless of whether standard 80,000 pound or heavier (e.g., 112,000 pound) trucks are used, some of South Dakota's rural roads are not well-suited to accommodate high volumes of truck traffic. Many roads are unpaved, which presents a particular challenge during wet weather and the spring thaw when they may become muddy and impassable. Bridge closures have similar effects. When these conditions occur during harvest there are few options available. Due to the density (or sparseness) of many townships' roadway networks, there are few alternatives to reroute truck trips and rerouting may lead to a significant increase in miles traveled cutting into profit.

The increases in production resulting from changing cropping patterns and higher yields, combined with recurring market fluctuations, translates into demand for a transportation system and services that is constantly evolving. The word "dynamic" is often used to describe the agriculture industry, but given the number of variables and uncertainty, that word does not quite do the industry justice. And, for public agencies throughout the State, such as the South Dakota Department of Transportation (SDDOT), regional planning agencies, tribes, counties, townships and others that plan, design, invest, and operate transportation system infrastructure, keeping pace with ongoing changes in agricultural production in particular regions may seem difficult at best.

Presently, SDDOT uses historical trends of traffic and truck counts to predict future volumes needed to develop project plans and support decisions such as surface design, roadway geometrics, turn lanes, safety features, and the need for lane and shoulder widening. Historical trends, while useful, do not reflect the rapid changes in agricultural production and transportation underway or predicted in the State. As a result, SDDOT has undertaken a research effort to better understand agricultural production growth and shipping choices, and identify ways to integrate new sources of data beyond conventional, historical traffic counts to make more reliable decisions and to improve transportation system performance. This report provides the results of a first step, and develops findings and recommendations for further action.

1.2 Research Objectives and Approach

Conducted as part of the Strategic Highway Research Program (SHRP) 2 C20, this Agricultural Freight Data Improvement Study SD2014-09 addressed three research objectives outlined in ten tasks. These research objectives are as follows:

1. **Identify Data Purposes**. South Dakota DOT identified an initial set of purposes for improved agricultural freight data in the request for proposals (e.g., to develop project plans and support decisions such as surface design, roadway geometrics, turn lanes, safety features, and the need for lane and shoulder widening). However, this research provided an opportunity to identify and explore purposes for improved data that cut across jurisdictional boundaries, reflect public and private sector interests, and include both transportation and agriculture entity perspectives.

   The objective of this task was accomplished by engaging a cross-section of agriculture and transportation stakeholders to identify short- and long-term purposes for improved agricultural freight data. Stakeholder interviews focused on identifying 1) SDDOT and other public agency planning processes where the use of agricultural data would be beneficial; 2) factors that influence agricultural industry decisions on production and attraction, distribution, and mode choice; 3) existing available and derived data from the agricultural sector to support those factors; and, 4) opportunities for data sharing and use of data with external entities and agencies.

2. **Define Data Needs and Sources**. Presently, SDDOT uses historical trends of traffic and truck counts to predict future volumes to plan, design, invest, and operate their transportation systems. From the start, it was evident that new data would be required to more fully satisfy the purposes identified in the first research objective. To determine what data might best be suited to fulfill the desired purposes, data requirements were first defined and then sources of data were evaluated against their ability to satisfy those requirements. Where suitable data does not presently exist, approaches for its development have been proposed. Innovative data sources were considered in this context and a path towards developing best data sources initiated.

3. **Demonstrate Data Acquisition and Application**. Building on the findings in previous tasks, this research objective aimed to synthesize best existing, available data from both transportation and agricultural sources to demonstrate how improved agricultural freight data can better inform the myriad purposes defined at the onset of the research. This

objective illustrated how incorporating new, innovative sources of information can further enhance decision-making by South Dakota's agricultural and transportation stakeholders.

Central to achieving this objective was the creation of a prototype spreadsheet tool that would demonstrate the potential benefits of combining and aligning existing data related to agriculture and transportation to achieve a common baseline for analysis. Following an initial illustrative example focusing on field crop production, the tool was also used to demonstrate its utility for addressing questions related to other agricultural activities, such as those surrounding feedlots or a livestock auction. The results of this demonstration are scalable not only to different and larger geographies in South Dakota, but the approach employed and the spreadsheet tool can readily be repurposed to other crops and the needs of agricultural freight issues in other states and regions.

1.3 Findings and Conclusions

During the course of this project, a series of findings related to key project topics were identified. These findings have been organized to support the recommendations of the Research Team.

1.3.1 Purposes for Improved Agricultural Freight Data

Drawing on the stakeholder discussions, the project team identified nine categories of applications where improved agricultural freight data would be beneficial. Table 1 lists these potential applications, along with their primary constituencies. Consistent across all stakeholders is a desire for improved information on current and future truck and rail system demand. Each of the other potential applications identified (from left to right) rely on this information to fulfill their purpose.

Table 1 Potential Purposes for Improved Data—Derived from Interviews

Potential User Purposes and Applications	SDDOT	Local Road Agency	Private Sector
Predict truck and rail demand (current, future)	●	●	●
Assess system condition, performance, and local impacts (e.g. surface, quality of life)	●	●	
Determine maintenance needs (e.g., surface management, resurfacing)	●	●	
Inform maintenance and design standards (e.g., bridge & surface design; geometric & structural considerations)	●	●	
Determine large investments needs (e.g., multimodal, roadway construction)	●		
Prioritize investments (multimodal, inform STIP)	●		
Aid siting or permitting of grain elevators and other facilities	●	●	●
Identify primary transportation system users and beneficiaries	●	●	
Identify unintended or undesigned uses of transportation facilities	●	●	

In some cases demand data may be used to assess a certain aspect of the system (e.g., surface or bridge condition), and in other cases the information may be combined with other sources of information to make a decision (e.g., determine maintenance needs, inform standards development, prioritize investments, etc.). Time horizons range from short (e.g. daily) for operational actions to long-term (5-years or more), for strategic actions that may involve substantial capital investment. Each of these decisions relate to various aspects of the systems' condition and performance, as well as the ability of the system and facilities to serve demand.

1.3.2 Data Needs & Sources

This research identified four general principles that the data should ideally meet to support the potential uses:

- Wherever possible, data should be actual, not estimated;
- Data should be linked to known temporal and spatial points;
- Data should be publicly available; and,
- Data should be available at no cost or low-cost.

The primary data requirements were categorized in two ways, first by spatial granularity, temporal granularity, and collection frequency, and second by data types of agricultural data, facility data, and transportation data. Requirements were considered in this way due to the unique nature of each of these elements. With the constant evolution in agricultural production and markets, data related to this industry should be frequently updated to ensure that a current picture is in focus. Agriculture-related facilities are closely linked to production and require similar data collection frequency for the same reason. Given its more static condition, data collection on transportation infrastructure can be conducted on a less frequent basis. For example, bridge condition may be updated once every two years, while roadway geometry would only be updated following (re)construction. However, collection of this data is intensive due to the sheer number of roadway segments throughout the State—from Interstates to township roads—as well as the number of data elements that are necessary to describe these segments.

Through a review of existing, publicly available data the Research Team found that agricultural data published by the U.S. Department of Agriculture (USDA) and the South Dakota Department of Agriculture (SDDA), are quite robust, have coverage at the township level and are published at least annually. Private sources on agricultural production such as FarmLogs, along with remotely sensed data using satellites that could become future data sources were excluded from the demonstration due to their privacy and cost considerations. All of these data sources were hence labeled "unconventional".

All of SDDOT's transportation traffic and infrastructure data are housed in its Transportation Inventory Management Program. The agency has a robust short-term count program, monitoring 7,500 count locations, the majority being traffic volume counters on the state highway network. The largest data gap was related to local roadways—that is, essentially all roads that are not under State jurisdiction. The gaps included lack of truck counts (AADTT), truck classification counts, and surface condition information, which was a limiting factor in the demonstration.

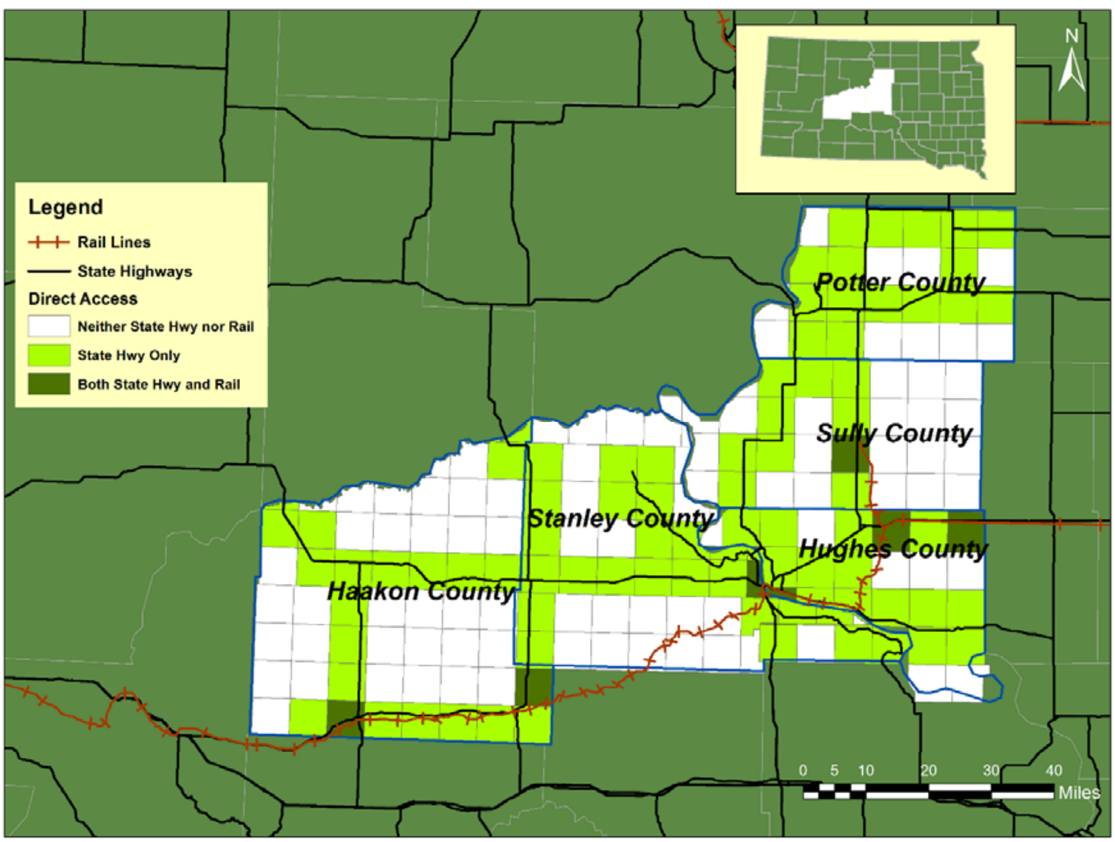
1.3.3 Demonstration Findings

For purposes of the demonstration, the project team developed a prototype Excel spreadsheet tool that incorporated a variety of data related to South Dakota's agricultural production and transportation system. This tool could synthesize and summarize conventional and unconventional agricultural freight data sources, derive trip generation information, and develop composite information in the form of maps and metrics. Following a development phase, the tool was tested with the following example applications:

- **Perform template calculations for the trip generation** step of a travel demand modeling framework for three types of agricultural freight—(a) major field crops, (b) a Concentrated Animal Feeding Operation (CAFO) and (c) a livestock auction facility; and,
- **Develop data for illustrative maps and metrics** for four purposes—(a) facility siting decisions, (b) local public decisions regarding a CAFO, (c) local public decisions regarding livestock auction facility, and (d) state and local public decisions regarding temporary roadway and bridge closures.

Central to the demonstration was a compendium and summaries of conventional transportation data and unconventional agricultural freight data related to the three types of agricultural freight. Results for the example applications were charted and mapped, an example of which is shown in Figure 1. It shows where townships in the demonstration area have direct access to state highways or rail-served agricultural facilities. A producer's proximity to processing and other agricultural facilities, along with the quality of their highway access, has a direct bearing on their potential profitability. Not all townships have such direct access, and the higher the agricultural production of a region or the capacity of a facility, the greater is the need for such direct access.

Figure 1 Demonstration Area Map of Direct Access of Townships to State Highways or Rail-Served Agricultural Facilities



Source: ESRI and SDDOT GIS data, UGPTI and Cambridge Systematics Analysis. Note: The demonstration area is a five-county region of Haakon, Hughes, Potter, Stanley, and Sully counties.

1.4 Recommendations

On the basis of the findings of this research, five recommendations have been proposed for further action by the South Dakota Department of Transportation. These recommendations lie within three categories: (1) Monitor Agricultural and Transportation Industry Trends, (2) Incorporate Agriculture Resources in Transportation Decision-making, and (3) Local Transportation Data Development.

1.4.1 Monitor Agricultural and Transportation Industry Trends

SDDOT should actively monitor agricultural and transportation industry trends.

As shown in the research, while the word "dynamic" is often used to describe the agricultural industry, given the number of variables and uncertainty, that word does not quite do the industry justice. For public agencies throughout the State, including SDDOT, regional planning agencies, tribes, counties, townships and others that plan, design, invest, and operate transportation system infrastructure, keeping pace with the ongoing changes in agricultural production in particular regions may seem difficult at best.

This research identified data that reflect agricultural production and demand for transportation systems and services in various dimensions. The principal production measures consist of cultivated land by township (acres), cultivated land by crop (acres), and crop yield (bushels per acre). Through a series of hypothetical examples, we demonstrated how varying production data could influence truck demand and transportation system use.

SDDOT should actively monitor these data over time and observe how they trend. This will allow the DOT and other South Dakota transportation stakeholders to maintain an ongoing understanding of field crop production and productivity. At the most basic level, transportation stakeholders can use this information to characterize existing transportation demand, and how it is changing over time.

1.4.2 Incorporate Agriculture Resources in Transportation Decision-making

SDDOT should incorporate available agricultural resources including knowledge of agricultural production and agricultural and transportation industry trends into short- and long-term transportation decision-making.

As shown in the research, purposes for improved agricultural freight data were identified through outreach to a variety of public and private sector, agriculture and transportation stakeholders. These purposes reflect a mix of short- and longer-term, low- and higher-dollar investment decisions that are regularly considered by these stakeholders. Stakeholders all expressed a strong interest in having a means for estimating truck trips (demand) using agricultural patterns and trends. In addition, a method of projecting these trips into the future based on select variables would allow the state to improve investment and maintenance decisions.

This research established a methodology and conducted a demonstration to show that through the synthesis of transportation and agricultural data sources, estimates of current and future truck demand at the township level can be generated based on agricultural production. Altering inputs can also derive alternative future estimates of demand. In doing this, the research illustrated that there is significant utility in using agricultural production to estimate truck demand and that the results could be used as an input into DOT decision-making. However, this research merely demonstrates feasibility, as the data must be operationalized within SDDOT prior to being an effective tool to support decision-making.

SDDOT should take two specific actions to begin to incorporate agricultural data in state and local transportation decision-making:

- **Institutionalize the spreadsheet tool within SDDOT**. The spreadsheet evaluation tool created during this research is a resource that SDDOT should continue to develop and enhance over time. This tool, which serves to consolidate agricultural and transportation data sources and assumptions, should become the responsibility of a specific functional group within SDDOT. This group should be given the responsibility to continue exploring, enhancing, and evaluating the capabilities of the tool. Potential activities would include incorporating additional data, such as soil productivity ratings to redistribute crop yield between townships of a county, establishing standardized methodologies for evaluating facility impacts, etc.

- **Assess evaluation tool outputs for planning**. As shown in the research, the spreadsheet evaluation tool is designed to be flexible; myriad scenarios can be crafted using the tool, and an almost endless array of outputs can be generated. For purposes of this study, the tool was developed to simply demonstrate the use of agricultural data to estimate current and future demand for motor carriage. While an attempt was made during the research to show how this demand could translate into identifying needs (and fulfill the short- and long-term purposes identified), there is still much thought required to use the tool outputs and to make decisions with those outputs.

1.4.3 Local Transportation Data Development

SDDOT should lead data development efforts in partnership with regional and local transportation agencies.

Not surprisingly, the largest data gap identified was found related to local roadways—that is, essentially all roads that are not under State jurisdiction. The gaps included a lack of truck counts (AADTT), truck classification counts, and surface condition information. Had truck count information been available, the Research Team could have tested truck routing assignments to ascertain how production relates to truck volumes on specific roadways. Absent truck count information on study area roadways, there was no means to validate the results of the demonstration. Truck classification information, linked to truck counts, would have provided insight into the types of trucks using the roadways, and potentially the commodities carried.

Data on surface condition was also identified as a gap. This data, when combined with truck demand, can be used to determine and prioritize road improvement needs. For example, on a road segment where truck use is found to be heavy, a surface redesign may be more cost-effective than a simpler repaving job. Both truck count and surface condition information is valuable to planners for managing the transportation system whether the tool is applied or not.

SDDOT should take two specific actions related to improving local transportation system data. These are as follows:

- **Field data collection.** Throughout the research effort SDDOT and transportation stakeholders acknowledged the data needs in the State, but also that a robust data collection program at the local level may be expensive and may not yield benefits commensurate with the cost and effort involved. Instead, SDDOT should coordinate with local agencies to pursue spot collection of local data—including truck counts, truck classification counts, and surface condition information—and use proximity to agricultural activity and need as a consideration in determining collection locations.

- **Monitor and incorporate innovative sources of transportation data.** To supplement or perhaps eventually supersede the spot local data collection described above, innovative sources of data should be monitored and adopted when found suitable. Forthcoming transportation data sources have the potential to provide statewide coverage with high geographic granularity at relatively low cost. These could include crowd-sourced applications installed on smartphones that leverage the GPS in smartphones to identify system chokepoints, road hazards and other real-time traffic information. Future development that incorporates the accelerometers and microphones that are commonplace in mobile phones may allow crowd sourcing of surface conditions as well. Once such applications are broadly adopted, and data density in South Dakota's agricultural regions is found to be sufficient, it may become possible to acquire surface and roadway condition data at a far lower cost than is possible through conventional methods.

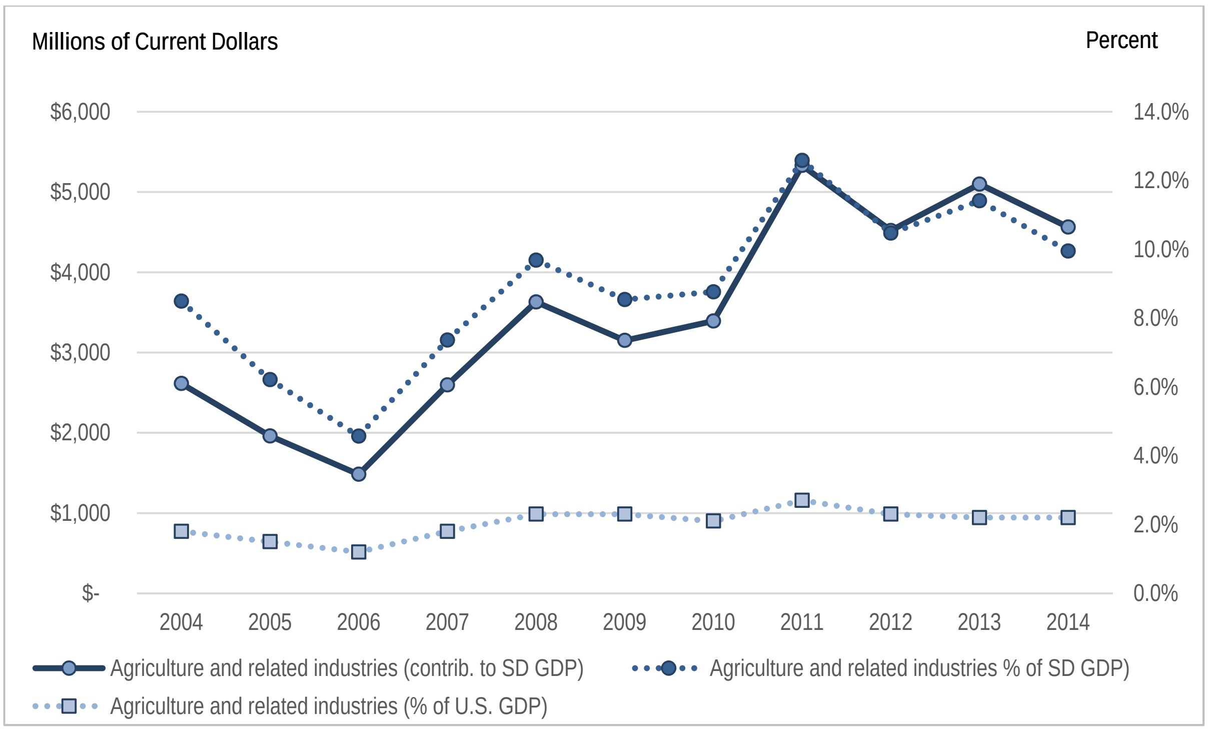
  A second innovative data collection method entails the use of Unmanned Aerial Vehicles (UAV, or Unmanned Aerial Systems [UAS]) to monitor bridge and surface conditions. Current research indicates that remote sensing using these aircraft may allow the characterization of unpaved road conditions. The principal benefit of UAVs is their lower cost compared to other traditional options such as ground-based data collection and overflights by manned aircraft, and has the potential to provide wide area coverage in a short amount of time, with little or no disruption to the traffic stream. Presently, Federal Aviation Administration (FAA) regulations regarding UAVs and these types of applications are still in flux.

The new data innovations described above have the potential to enable SDDOT and local transportation stakeholders to better understand system operations and needs. Other innovations such as use of commercial sources of farm data such as FarmLogs and remotely sensed data using satellites should be considered for adoption once privacy and cost considerations have been addressed. SDDOT should monitor the development of these and other innovative sources of transportation system data and incorporate them in traffic monitoring and data collection programs once they have proven their utility and cost-effectiveness.

2 PROBLEM DESCRIPTION

Like many other Western and Midwestern states, South Dakota's economy has historically been defined by agriculture; even today, the State's $45.9 Billion economy is dependent on agriculture. South Dakota's economy as a whole is growing, with agricultural production (i.e. the production of crops and livestock) among the fastest growing industries in the State. From 2004 to the present, South Dakota's Gross Domestic Product (GDP)—the value of goods and services—increased by 49 percent across all industry sectors, compared to 42 percent for the U.S. During the same period, the contribution of agriculture to South Dakota's GDP increased 75 percent, albeit with considerable year-to-year variation that ranged between 4.6 and 12.6 percent of GDP (Figure 2). In comparison, agriculture's contribution to National GDP is approximately 2 percent, underscoring the greater importance of agriculture to South Dakota.

Figure 2 Agriculture's Contribution to South Dakota's Gross Domestic Product



Source: U.S. Department of Commerce, Bureau of Economic Analysis.

Considering this economic context, the need for improved agricultural freight data is described in the following subsections on production, distribution, mode choice and assignment. These subsections represent elements of the traditional 4-step transportation planning and modeling framework which was used a framework throughout the research project.

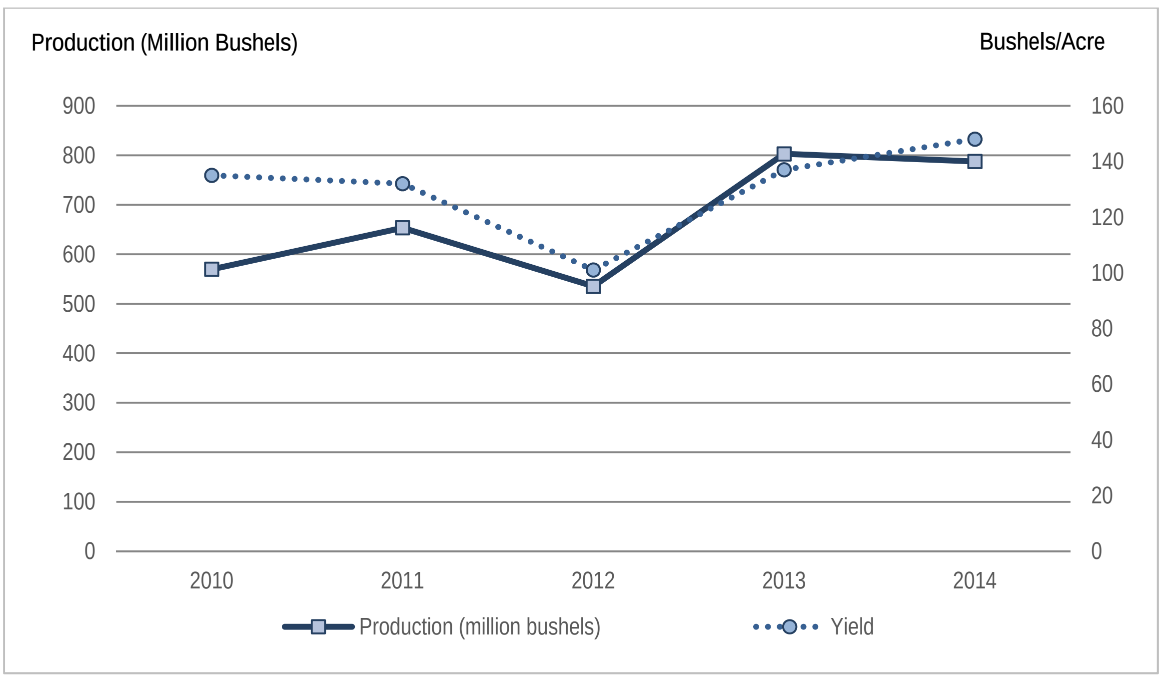
2.1 Agricultural Production

The present-day agricultural industry is very different from that of 30 years ago. Crops grown in South Dakota are not simply used by the State and its neighbors; they are used around the world, and agricultural productivity is in part driven by a large and increasing global demand. To meet this growing demand, two principal elements have driven the historical increases in production over the last 30 years: the development of genetically engineered crops and the associated changes in cultivation practices necessary to maximize their yields, and, to a lesser extent, an increase in cultivated acreage.

The adoption of genetically engineered crops by U.S. farmers has increased steadily for over 15 years. At the same time, insecticide use has decreased as a result of the development of insect-resistant crops. Farmers of genetically engineered crops have benefited from general increase in yield, reduction in input costs, improvement in pest control, increase in personal safety and more efficient time management since their adoption in 1996. The adoption of herbicide-resistance crops complements conservation tillage practices and reduces the need for tillage, which can adversely affect soil and water quality. As a result, in South Dakota production per acre has increased by 50 percent or more for key crops like corn, wheat, soybeans, milo, and sunflowers during the last 30 years. In recent years farmers have realized record harvests, and 2015 is again expected to be similar. As shown in Figure 3, for corn in the last five years, production has increased 38 percent and yield per acre has increased 10 percent. These trends are expected to continue for the next decade.

The increased corn production shown in Figure 3 is also a reflection of an increase in acreage planted. Between 2010 and 2014 acres planted with corn increased 27 percent, from approximately 4.5 million to 5.8 million, largely at the expense of wheat and other grains.

Figure 3 Corn Production and Yield per Acre, Bushels



Source: South Dakota Agriculture Bulletin No. 75, August 2015. Note that 2012 was a drought year.

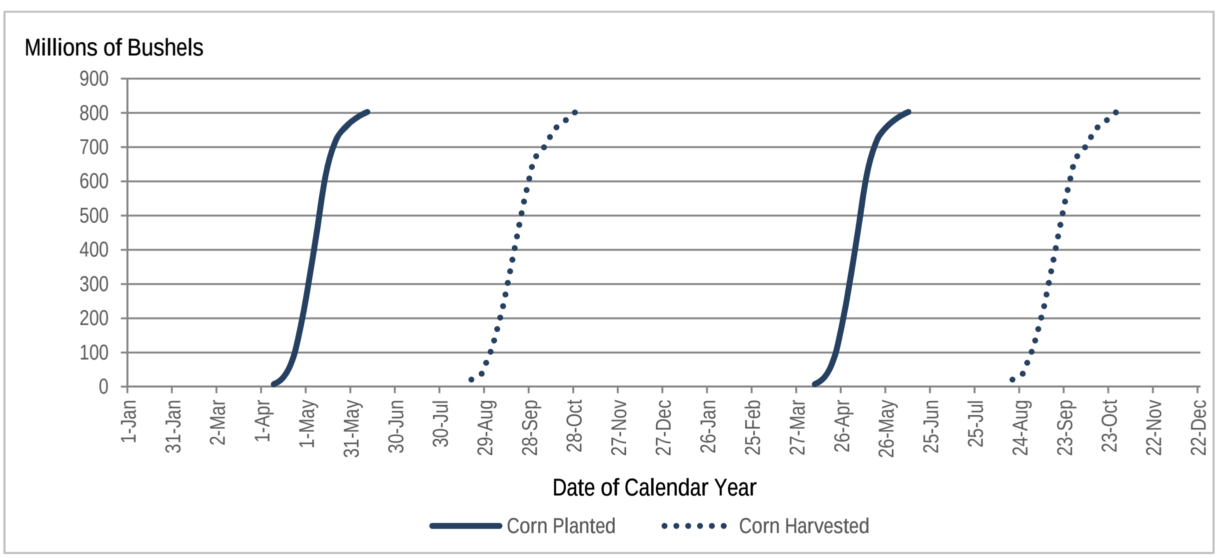
2.2 Agricultural Distribution

Increased crop production has dramatically expanded the amount of agricultural freight shipped on highways and rail lines in South Dakota. Assuming that a standard 5-axle truck loaded at 80,000 pounds can carry between 900 and 1000 bushels of corn, a harvest of 800,000,000 bushels (South Dakota's 2013 production) translates into approximately 850,000 shipments Note, that this number represents only *loaded* trucks for a *single* crop; South Dakota also has major harvests for other field crops including winter and spring wheat, soybeans and others. There are also significant agricultural moves in the State related to the livestock and dairy industries. The movement of agricultural commodities is highly dynamic and affected by many factors including global demand, shipping destination, competition among local grain elevators, and others. Generally, each of these factors relate in some way to market price; agricultural commodity prices are largely determined nationally and internationally. As a result, depending on the market and farmers' interest in maximizing profit, product may move immediately after harvest, sometime later, or multiple times, which will increase the volume of agricultural shipments seen by South Dakota's highways above and beyond that provided in the example calculation.

Fundamental to this research is understanding the nature of agriculture itself, in particular the "farm to market" cycle and the "peaks and valleys" that occur over the course of a year as crops are planted, nurtured, harvested, stored, and ultimately sent to market, each step resulting in truck trips on South Dakota roadways. Field crops have a farm to market cycle lasting over a year that consists of planting, growth, harvesting, storage and sales. The start of this cycle varies by crop. Using corn as an example, planting takes place typically between April and June, with most planting done in the second week of May. Corn harvesting typically takes place between August and October, with most harvesting done around the last week of September.

As shown in Figure 4, corn planting takes place typically between April and June of a calendar year with most planting done in the second week of May. Corn harvesting takes place typically between August and October of the same calendar year, with most harvesting done around the last week of September. The planted and harvested values shown are cumulative.

Figure 4 Likely Average Weekly Distribution of Corn Planted and Harvested in South Dakota, Consecutive Maximum Production Years

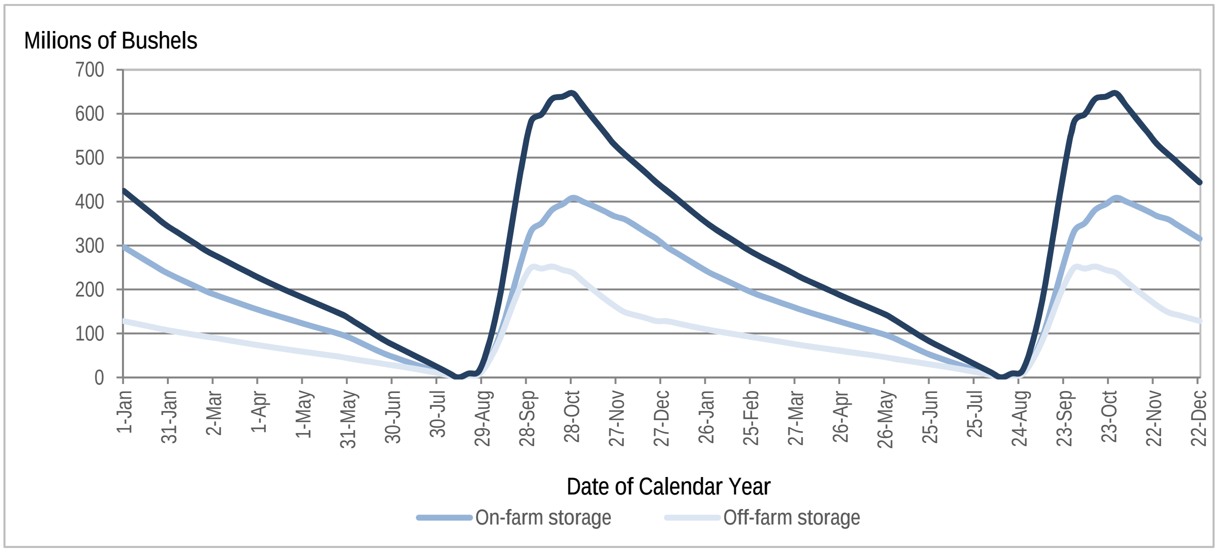


Sources: 2004-2014 NASS, USDA data for South Dakota; Cambridge Systematics estimate of averages.

After harvest, farmers store grain at either on-farm or off-farm grain storage facilities. As shown in Figure 5, in South Dakota, corn is stored both at on-farm and off-farm locations. The percentage share of on-farm storage in South Dakota is higher than the percentage share of off-farm storage. The storage stock rises sharply to a peak value and then gradually declines. Off-farm storage peaks prior to on-farm storage, indicating that corn farmers in South Dakota tend to use a higher percentage share of off-farm storage during the harvest season and use an increasing share of on-farm storage later.

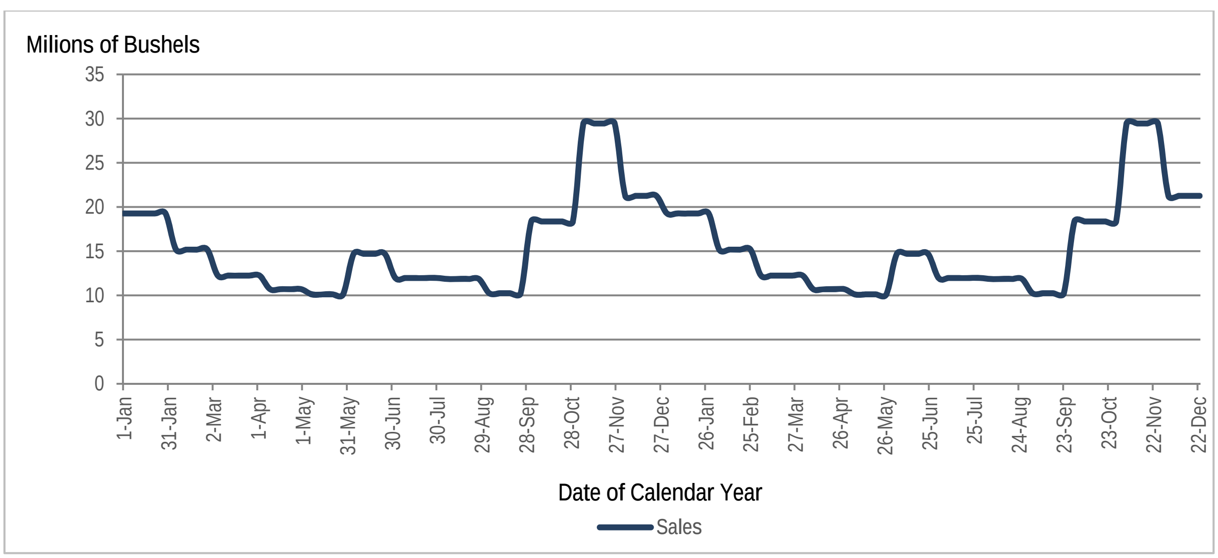
Crop marketing (including corn) is a year-round process. During and immediately after the harvest season, sales activities peak as indicated by corn sales data for South Dakota in Figure 6. Almost half of the corn produced in South Dakota is sold in the four-month period following harvesting. The remaining production is largely sold prior to the next harvest in the following year, from February through September.

Figure 5 Likely Average Weekly Distribution of Corn Storage Stock in South Dakota, Consecutive Maximum Production Years



Source: 2004-2014 NASS, USDA data for South Dakota; Cambridge Systematics estimate of averages.

Figure 6 Likely Average Weekly Distribution of Corn Sold in South Dakota, Consecutive Maximum Production Years



Source: 2004-2014 NASS, USDA data for South Dakota; Cambridge Systematics estimate of averages.

This corn example shows that the demand for transportation is likely to "peak" and fall into a "valley" over the course of a production cycle. Hence, planning efforts that are affected by grain transportation demand should incorporate data on crop forecasts and fluctuations in storage and sale.

Note that Figure 4 through Figure 6 depict a two-year cycle based on averages over 2004-2014 crop years, and inter-annual variability is not reflected. Each year in farming is different, and as a result there are uncertainties in both the X- (timing) and Y- (volume) axes of each figure. Each figure is based on two consecutive ideal production years of 800 million bushels each, but rarely does that certainty exist. Production is based on several factors that include soil conditions, variation in temperature, precipitation, agricultural inputs (seeds, manure, fertilizers, pesticides, etc.), and farming practices. If one of these factors (e.g., precipitation) is not optimal for productivity, the production will be different, and will likely be lower as in the case of the 2012 drought. The production cycle timing may also be different; in the case of a cooler year, peak harvest may occur several weeks later, to allow crops to achieve more growth. Similarly, there is uncertainty around when and where crops are stored and sold and, as noted earlier in this subsection, this will be dictated in large part by producers' strategy to maximize profit.

2.3 Mode Choice and Assignment

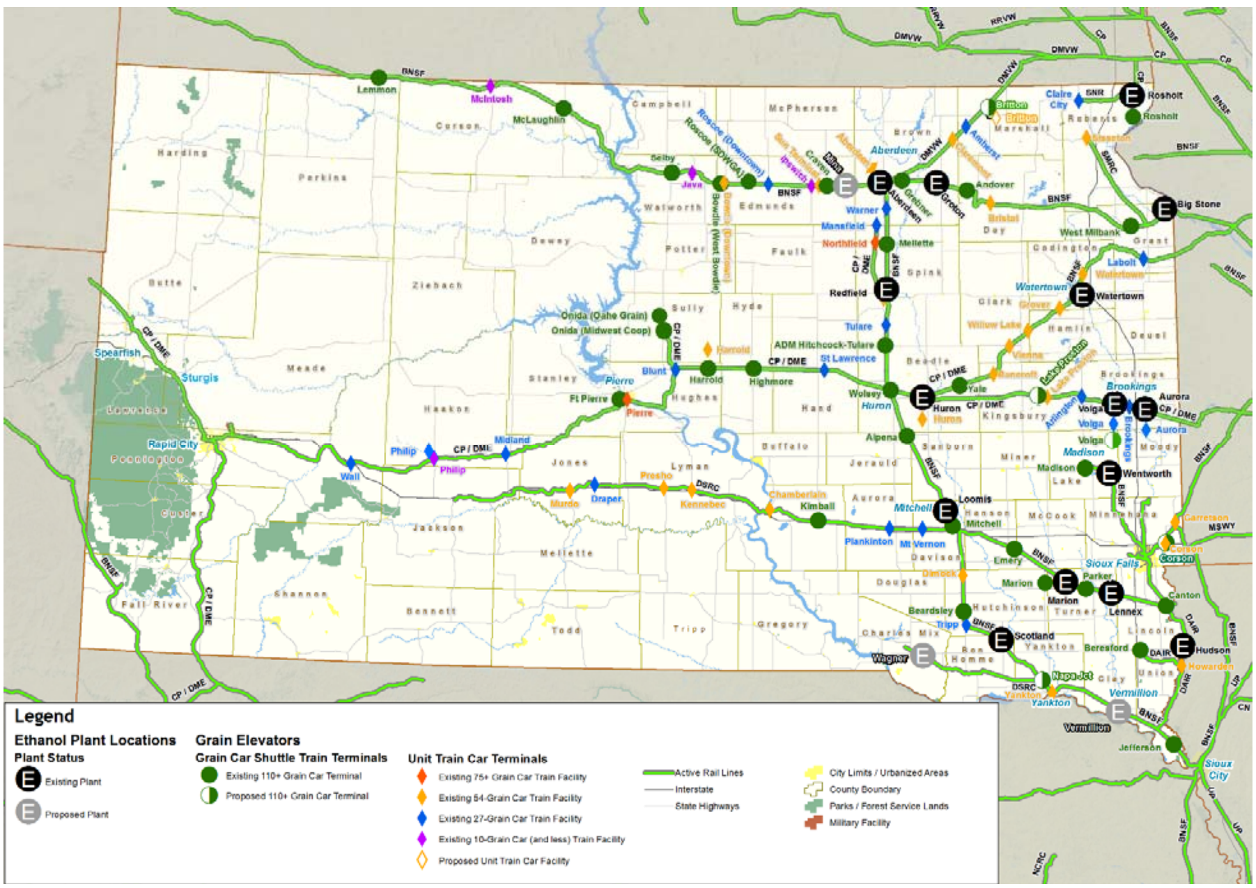
With South Dakota's agricultural products supplying a global market, access to domestic markets and deep-water export ports via rail is essential. In the late 1800s and early 1900s South Dakota's first railroads provided necessary passenger and freight services to connect residents with major markets in nearly every direction. Naturally, most rural towns had rail-served grain elevators and warehouses that connected local producers to the outside world. These facilities focused on serving the local community where they were sited. In the mid-1900s, trucks began to provide producers with the opportunity to move goods to multiple elevators in a larger area and directly to markets, cutting into rails market share. At this time, around 1948, South Dakota had rail mileage of approximately 4,400 miles. Through bankruptcies, consolidations, and abandonments South Dakota's rail mileage shrunk; today it is under 1,900 miles, leaving many communities without direct rail access. Class I railroads, which operate approximately 48 percent of the rail mileage within the State, tend to focus on serving high-volume customers via 110-car unit trains (e.g., shuttle trains).

The advent of the construction of high-efficiency, high-volume rail storage and loading facilities during the 2000s introduced greater competition among grain merchants and higher prices received by farmers. As a result, there was a significant increase in shuttle train movements of grains and oilseeds between 1994 and 2011. The increased shuttle train movements improved railroad efficiency and reduced transportation costs. These 110-car unit train elevators attract and consolidate grain from a very large area, much larger than small elevators (i.e., those that serve 54-car or fewer, unit trains). So, while efficiency increased at larger elevators, at the same time the change drove many small local grain elevators out of business, which has increased the length of truck haul necessary for transporting crops from farms to elevators.

As shown in Figure 6, the east river (located east of Missouri River) areas of the State have the highest historic agricultural productivity and the highest concentration of elevators. While 110-car unit train facilities exist and are planned in this area, the figure also shows a number of other, smaller (i.e., those that serve 54-car, or fewer, unit trains) facilities. Even though these smaller facilities are on rail lines, this does not necessarily equate to rail service. Some of these facilities serve as interim storage points; grain is trucked to the facility for storage, and then trucked again to a rail-served facility, when it has availability, or to another final destination.

Figure 7 shows that grain elevators (in particular, high-volume facilities) are not as prevalent west river (located west of Missouri River) due largely to two factors. First, there simply is not the same density of rail network in the west as in the east. And second, the western part of the state has traditionally been used more for grazing than cultivation. As described previously, different crop varieties and changing production practices are enabling land that was previously not suited for cultivation into active, planted acreage. As production regions expand and move westward, and as new shipping facilities are developed, traffic patterns will evolve and truck traffic will increase where previously little existed.

Figure 7 Ethanol Plants and Grain Elevators with Rail Access



Source: South Dakota State Rail Plan, 2014. Although the figure shows a proposed ethanol plant at Wagner, this project may not take place as per the latest information from SDDOT

Rural truck and rail freight connectivity are critical to keeping South Dakota's production and shipping costs competitive with products from other states and countries. Rural roads provide first- and last-mile connectivity from production centers (e.g., farms, feedlots, etc.) to intermediate or final destinations (e.g., grain elevators, processing facilities, ethanol plants, dairies, livestock auction, etc.). In some parts of the State the trip from production to destination is a short one; in other parts where facilities are further apart, or are "transportation disadvantaged" due to the lack of transportation options and rail service, truck trips are much longer. To accomplish truck movements efficiently, greater numbers of larger and heavier trucks are often used to move product.

Regardless of whether standard 80,000 pound or heavier (e.g., 112,000 pound) trucks are used, many of South Dakota's local roads are not well-suited to accommodate high volumes of truck traffic. As shown in Figure 8, many freight movements originate on unpaved roads. This is very common as many counties and townships throughout South Dakota have no paved roadways. This presents a challenge to agricultural movements during wet weather, as shown in Figure 9.

Figure 8 First Point of Freight Movement from Field

Source: Ken Skorseth, SD Local Transportation Assistance Program, SD State University

Figure 9 Impassable Roadway during Wet Weather

Source: Ken Skorseth, SD Local Transportation Assistance Program, SD State University

As shown in Figure 9, roads that are essentially built from native soil may become muddy and impassable during wet weather and the spring thaw, resulting in a serious chokepoint to commerce. Bridge closures have similar effects. When these conditions occur during harvest there are few options available. Due to the density (or sparseness) of many townships' roadway networks there are few alternatives to reroute truck trips; and, rerouting may lead to a significant increase in miles traveled, raising transportation costs and cutting into profit. With no routing options available, farmers may be forced to delay the movements until the roads have dried out and been repaired. Whether delaying the movements or simply deciding to hold grain until a favorable sale price is presented, the availability of on- or off-farm storage that is accessible, is critical.

2.4 Current State of Agricultural Transportation Planning in South Dakota and Research Need

The increases in production, higher crop yields and changing cropping patterns, combined with the national and international trading and pricing of South Dakota's agricultural products, translates into demand for a transportation system and services that is very different from that of the past. The word "dynamic" is often used to describe the agriculture industry, but given the number of variables and uncertainty, that word does not quite do the industry justice. For public agencies throughout the State, such as SDDOT, regional planning agencies, tribes, counties, townships and others that plan, design, invest, and operate transportation system infrastructure, keeping pace with this ongoing changes in agricultural production in particular regions may seem difficult at best.

SDDOT currently uses historical trends of traffic and truck counts to predict future volumes needed to develop project plans and support decisions such as surface design, roadway geometrics, turn lanes, safety features, and the need for lane and shoulder widening. Historical trends, while useful, do not reflect the rapid changes in agricultural production and transportation underway, or predicted, in the State. To better explain agricultural freight demand, predict impacts on transportation systems, and improve policy and transportation investment decisions, SDDOT and other transportation system owners must better understand agricultural production growth and shipping choices, and identify ways to integrate new sources of data beyond conventional, historical traffic counts to make more reliable decisions and to improve transportation system performance.

3 RESEARCH OBJECTIVES

Agricultural Freight Data Improvement Study SD2014-09 addressed three research objectives, as described in the following subsections.

3.1 Identify Data Purposes

Objective: Identify significant government and industry purposes requiring improved agricultural freight data.

As illustrated in the problem description, freight transportation system use in South Dakota is strongly influenced by agriculture productivity. Agriculture production relies on the multimodal transportation system to move product from field to market. While the agriculture and transportation industries both strive to be as efficient as possible, at a system level operational results are sometimes less than optimal through a combination of factors ranging from infrastructure conditions, to available assets for moving and storing product, as well as commercial considerations.

SDDOT, the research project sponsor, identified an initial set of purposes for improved agricultural freight data in the request for proposals (e.g., to develop project plans and support decisions such as surface design, roadway geometrics, turn lanes, safety features, and the need for lane and shoulder widening). However, this research provided an opportunity to identify and explore purposes for improved data that cut across jurisdictional boundaries, reflect public and private sector interests, and include both transportation and agriculture entity perspectives. Through exploring purposes for improved agricultural freight data, there may be similar purposes identified and opportunities to integrate activities among these varied stakeholders.

The objective "Identify Data Purposes" was accomplished in Task 3, *Identify Purposes for Improved Agricultural Production and Transportation Data*, during stakeholder outreach, and over continued dialog with members of the Research Panel. The Research Team's approach to this task was to engage a cross-section of agriculture and transportation stakeholders to identify short- and long-term purposes for improved agricultural freight data. Stakeholder interviews focused on identifying 1) SDDOT and other public agency planning processes where the use of agricultural data could be beneficial; 2) factors that influence agricultural industry decisions on production and attraction, distribution, and mode choice; 3) existing available and derived data from the agricultural sector to support those factors; and 4) opportunities for data sharing and use of data with external entities and agencies.

3.2 Define Data Needs and Sources

Objective: Define needed data and evaluate existing and innovative data sources to address the significant purposes.

As illustrated in the problem description, SDDOT currently uses historical trends of traffic and truck counts to predict future volumes to plan, design, invest, and operate their transportation systems. SDDOT acknowledges that this approach does not reflect the rapid changes in agricultural production and transportation underway in the state. From the start, it was evident that new data would be required to more fully satisfy the purposes identified in the first research objective. To determine what data is best suited to fulfill the desired purposes, data requirements were first defined and then sources of data were evaluated against their ability to satisfy data requirements. Where suitable data does not presently exist, approaches for its development have been proposed. Innovative data sources were considered in this context and a path towards developing best data sources initiated.

The objective "Define Data Needs and Sources" was accomplished in Tasks 5 and 6. In Task 5, *Define Data Requirements.* The Research Team's approach was to identify ideal data requirements to support purposes identified in the first research objective. These requirements were considered in the context of spatial and temporal granularity and collection frequency.

In Task 6, *Identify and Assess Data Sources*, the Research Team's approach was to link available data to data requirements to make an assessment of the most promising data sources with respect to meeting data requirements. This approach enabled the identification of data gaps and possible areas of opportunity for investigating innovative sources of data.

3.3 Demonstrate Data Acquisition and Application

Objective: Demonstrate and evaluate the acquisition and application of an improved data set within a limited but typical geographic area in South Dakota.

Building on the findings in previous tasks, this research objective aimed to synthesize best existing, available data from both transportation and agricultural sources to demonstrate how improved agricultural freight data can better inform the myriad purposes defined at the onset of the research. This objective also illustrated how incorporating new, innovative sources of information can further enhance decision-making by South Dakota's agricultural and transportation stakeholders.

The objective "Demonstrate Data Acquisition and Application" was accomplished in Tasks 7 through 9. In Task 7, *Develop Plan for Test of Data Collection and Application*, the Research Team's approach was to develop a demonstration plan in partnership with SDDOT and the Research Panel to ensure that the demonstration location contained suitable transportation system data. The demonstration area of central South Dakota was selected for this reason and because it contained multiple agricultural activities, including crop production, livestock production, rail and non-rail served grain elevators, and a significant livestock auction facility. Prior to commencing the demonstration a meeting of the Research Panel was convened to receive agreement on the proposed location and approach.

In Task 8, *Demonstrate and Evaluate Test of Data Collection and Application*, the Research Team's approach was to focus on combining and aligning the many existing, disparate data sources developed by numerous agricultural and transportation entities to achieve a common baseline for analysis. The focus of the initial demonstration was field crops in the demonstration area. Using a spreadsheet tool developed by the project team, a series of queries were executed to illustrate how the combination of agricultural and transportation system data can aid in fulfilling the primary purpose of the research project.

Data to support this demonstration were synthesized in a spreadsheet tool designed with the intent that as new data can be readily incorporated into the tool as it becomes available. In Task 9, *Describe Scale-Up*, the Research Team's approach was to show how the data, and the spreadsheet tool could be used to support questions related to other agricultural activities, such as those surrounding feedlots or a livestock auction.

The Research Team's approach to the demonstration and tool development took into account that this research is a Strategic Highway Research Program (SHRP2) C20 project. While South Dakota has an agricultural story similar to other Midwestern and Western states, there are other states that have very different types of agriculture, such as the orange groves of Florida, the apple orchards of Washington, or the cranberry bogs of Massachusetts. The results of this demonstration are scalable not only to different and larger geographies in South Dakota, but the approach employed and the spreadsheet tool can be easily repurposed to other crops and the needs of agricultural freight issues in other states and regions.

4 TASK DESCRIPTIONS

Agricultural Freight Data Improvement Study SD2014-09 contained eleven distinct tasks that were conducted over the seven-month research period. The following subsections provide descriptions of these tasks and brief discussion of the related work conducted by the Research Team.

4.1 Review Project Scope Review

Task: Meet with the project's technical panel to review the project scope and work plan.

At the project onset, the Research Team worked with SDDOT to refine the work plan for this research. The Research Team conducted a meeting with SDDOT 2014-09 Research Panel on March 2, 1015 in Pierre, SD to review the project scope and work plan. The meeting provided an opportunity for the Research Team to gather initial input from the Research Panel on reasons why they (their agencies and organizations) may require improved agricultural freight data, as well as ascertain any resources they could provide to the Research Team. This meeting provided initial insight into purposes improved agricultural freight data, transportation data sources available through SDDOT, and started the process of identifying key stakeholders to engage in later tasks.

4.2 Describe Agricultural Production and Transportation Status and Trends

Task: Through review of published information, describe the current state of and significant trends in production and transportation of agricultural commodities in South Dakota.

The objective of this task was to review and describe the current state of, and identify significant trends in, agricultural production and the transport of agricultural commodities. This was done so the Research Team could begin to identify the key factors that drive the way the transportation system is used today by the agricultural industry in South Dakota and to establish whether any of the factors are predictive.

The Research Team reviewed and documented published literature that described current trends and the state of production of South Dakota's agricultural commodities, including corn, wheat, and livestock. The Team also reviewed and documented recent trends related to the transport of these commodities via truck, rail, barge and ocean carrier, as available. The sources were catalogued based on trend types, as defined by the Research Team, and included topics such as agricultural practices, land use, weather, mode use, commodity pricing and revenue, and agriculture product demand.

4.3 Identify Purposes for Agricultural Data

Task: Through interviews with select local, state, and federal officials and key industry stakeholders, identify the most significant short- and long-term purposes for which improved agricultural production and transportation data are needed.

The objective of this task was to develop and execute an outreach program focused on key stakeholder groups to identify the most significant short- and long-term purposes for improved agricultural production and transportation data. Again, an initial list of potential purposes was identified by SDDOT in the request for proposals for this project and noted that improved data could be used ”to develop project plans and support decisions such as surface design, roadway geometrics, turn lanes, safety features, and the need for lane and shoulder widening.” However, this research provides an opportunity to identify and explore purposes for improved data that cut across jurisdictional boundaries, reflect public and private sector interests, and include both transportation and agriculture perspectives.

Table 2 Potential Agricultural Transportation Stakeholders

Stakeholder Type	Purpose for Engagement
State of South Dakota and other public sector transportation agencies (Federal, regional, local and tribal)	The State and other public agencies have a substantial stake in this research. The agricultural industry uses 82,559 miles in the State. These miles are comprised of 7,809 miles of State highways, 35,358 miles of county and county secondary roads, and 31,231 miles of township roads. SDDOT also owns nearly 400 miles of railroad. Both the highway and rail transportation systems are the conduits to get harvested goods to market and are the places where these agencies can provide the biggest benefits to the agricultural community.
Public sector economic development agencies	These State and local agencies have an interest in maintaining and expanding industry footprints throughout South Dakota. These agencies work directly with major cooperatives to site new grain elevators and agronomy centers and have insight into how they make location decisions. These factors will be an important consideration in determining new data that can enhance public agency decision-making.
Public sector agricultural support services	Several centers provide agricultural support at both the national and State level. The USDA is the largest of these centers and houses substantial data resources. The USDA has recently published the results of the 2012 Census of Agriculture, a glimpse provided every five years on farming operations, including production expenses, market value of products, and operator characteristics. This data source is unique in that it has consistent data for all farms in every county in the U.S.
Agricultural producers (e.g., farmers and ranchers)	Producers have significant financial interest in the preservation and improvement of South Dakota’s transportation system to open their products to broader markets. South Dakota cannot consume all the products that it produces, thus it is imperative that markets throughout the U.S., Canada, and the rest of the world are accessible.
Facility operators, co-ops (e.g., Gavilon, Ft. Pierre Livestock Auction)	Substantial grain that leaves the State is housed temporarily in grain elevators and their supporting facilities. Industries in the State rely on these facilities and on rail transportation to bring in raw materials in (e.g., fertilizer) and to ship products to domestics and export markets. These facilities are dotted throughout the State, but the facilities with shuttle- and unit-train capabilities are the largest generators of traffic. Some areas in South Dakota are currently “transportation disadvantaged”, and do not have multiple shipping options; in these cases grain is trucked significant distance to get loaded on rail, or ultimately trucked to other final destinations.
Carriers (i.e., trucking companies, railroads, ocean carriers)	Many types of carriers interface with the agricultural industry. Trucking fleets that transport grain to elevators or to market take several shapes and include farmer owners, co-op owners, and temporary fleets that are leased during harvest. A number of railroads in the State from Class I to short line railroads are connected to shuttle and smaller elevators in the State. For short line railroads, having connectivity and access to Class I railroads and markets is critically important for their viability. A substantial portion of the harvested product is exported, and competitive arrangements with ocean carriers are essential to the supply chain.

To fully explore the purposes for improved agricultural freight data, the Research Team conducted one-on-one interviews with stakeholders that represented a wide array of interests in agricultural production and distribution, as well as individuals involved in public and private freight transportation. These stakeholders were asked a series of questions related to the types of short-and long-term decisions they make and generally, how they understood an improved agricultural freight data could enhance those decisions. Table 2 identifies the types of stakeholders that were targeted. Appendix A provides a listing of the stakeholders interviewed.

In addition to collecting stakeholder perspectives on their purposes for improved agricultural freight data, stakeholders were queried on how they currently make decisions and the data they use to support that decision-making. This was done to better understand the details regarding the availability of transportation and agricultural data in the state. Questions asked on existing data related to 1) data available, 2) data collection techniques and frequency, 3) data owners, and 4) data users.

The purposes identified in this research are presented in the Findings and Conclusions section of this report. While many short- and long-term purposes for improved agricultural freight data were identified by public and private sector stakeholders, at the foundation of all purposes is the question "how does agricultural activity translate into transportation system use?" The need for developing a correlation between agricultural production and truck demand was a common theme among stakeholders and became a focus of the Research Team.

4.4 Prepare Technical Memorandum

Task: Prepare a technical memorandum summarizing the results of Tasks 2 and 3 and meet with the project's technical panel.

At the conclusion of Task 3, the results of Tasks 2 and 3 were compiled in an Interim Technical Memorandum, representing the deliverable for Task 4. A Research Panel meeting was conducted on April 24, 2015 to review the contents of the Technical Memorandum, findings to-date, and to receive approval from the Panel to continue proceeding with the research. The Interim Technical Memorandum began the process of answering the following questions:

- Why (for what purposes) is improved agricultural freight data needed?
- What are the most important agriculture and transportation industry trends that should be captured?
- What types of data are currently available?
- What are the biggest data challenges?

The findings of the Interim Technical Memorandum provided critical inputs into Tasks 5 and 6, however these findings were refined through the course of the project as new information was uncovered through additional research and stakeholder outreach. The Interim Technical Memorandum recommended that the research effort continue as scoped, without modification.

4.5 Define Data Requirements

Task: Define the data requirements—including definition, quality level, granularity, collection frequency, accuracy, latency, and other key attributes—needed to address the purposes identified in Task 3.

To determine what data sources are best suited to fulfill the purposes for improved data (articulated in the Task 4 Interim Technical Memorandum), data requirements were defined. Data requirements helped assess the suitability of existing data sources in the following task and identify gaps in available data.

The Research Team identified "ideal" data requirements to support the purposes. First, requirements were considered in the context of ensuring the demonstration could be easily repeated by SDDOT (i.e., the DOT could ask the tool questions annually to inform their STIP process), as well as be used by others in different states or regions to support their purposes. These requirements include:

- Wherever possible, data should be actual—not estimated,
- Data should be linked to known temporal and spatial points,
- Data should be publicly available, and
- Data should be no-cost or low-cost.

Data requirements were also further considered in the context of spatial and temporal granularity and collection frequency and latency. A level of complexity was added to this, as these requirements were determined in part due to category of data. The three data categories correlate to the different, unique elements of the agricultural and transportation industries and systems and include: 1) agricultural data, 2) facility data, and 3) transportation data. Each of these categories has its own data requirements. As previously described, the agricultural industry is constantly evolving and, as a result, data related to this industry should be frequently updated to ensure that a current picture is in focus. Agriculture-related facilities are closely linked to production and require similar data collection frequency for the same reason. Given its more static condition, data collection on transportation infrastructure can be conducted on a less frequent basis. For example, bridge condition may be updated once every two years, while roadway geometry would only be updated following (re)construction. However, collection of this data is intensive due to the sheer number of roadway segments throughout the State - from Interstates to township roads - as well as the number of data elements that are necessary to describe these segments.

The data requirements were fed into the following task to assess the suitability of existing data sources for the demonstration.

4.6 Identify and Assess Data Sources

Task: Identify existing and new, unconventional data sources and assess their feasibility, availability, completeness, reliability, cost, and adequacy (alone and in combination) to meet the defined data requirements.

The objective of this task was to identify and assess the suitability of existing and new (unconventional) sources of data to fulfill purposes for improve agricultural freight data identified earlier in this research. In this task the Research Team's approach was to link available data to data requirements identified in the previous task to assess the most promising data sources with respect to meeting data requirements. This approach enabled the identification of data gaps and possible areas of opportunity for investigating innovative sources of data. In taking this step, there was some correlation between the data used and the results of the demonstration conducted in subsequent tasks. For example, in cases where the data requirements were not well aligned with available sources, limitations of the demonstration became known.

4.7 Develop Demonstration & Evaluation Plan

Task: Develop, for approval of the project's technical panel, a plan for demonstrating and evaluating the acquisition and use of an improved set of data elements within a limited but typical geographical area in South Dakota.

The objective of this task was to develop a plan for demonstrating and evaluating the acquisition and application of improved agricultural freight data within a case study area in South Dakota. While there are many purposes for improved agricultural freight data, at the foundation of all purposes is the question "how does agricultural activity translate into transportation system use (i.e., truck demand)?" The Demonstration Plan developed to answer this question is further described in the following subsections:

- **Demonstration Framework.** This section provides a short overview of the traditional 4-step transportation planning and modeling framework that was used as a framework for this demonstration.
- **Technical Approach.** This section illustrates the technical approach for determining truck demand in the case study area, highlighting data requirements, model inputs and outputs, parameters, assumptions, and the step-by-step process for estimating the number of trucks.
- **Case Study Locations.** This section describes in more detail the available data and how it demonstrates the framework, as well as specific needs and attributes of the demonstration locations.

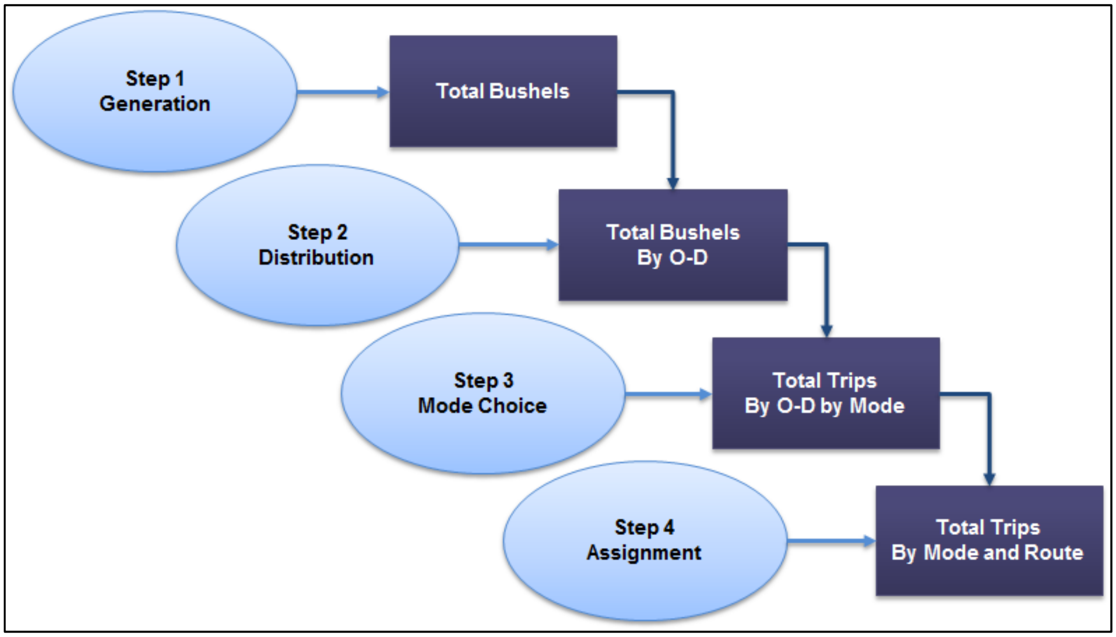
The demonstration plan was presented to the Research Panel during an interim progress meeting held on June 4, 2015.

4.7.1 Demonstration Framework

The basic concepts behind the traditional 4-step transportation planning and modeling framework have been applied to this research, as shown in Figure 10. The strength of this demonstration framework is that it identifies seasonality in agricultural production and relates it to variability in transportation system demand.

The basic concepts behind the 4-step framework, shown in the figure, applied to this research are described below.

Figure 10 Demonstration Framework



- **Step 1: Generation—**Freight generation refers to the number of trips (or tons, bushels, or other unit) coming to or from an activity zone or facility. These trips are either produced in a zone or attracted to a zone:
    - **Production—**It is assumed there is some way to relate the amount of freight generated at any location with land use variables that can be predicted over time. Land use classifications can be as simple or as complex as the data can support. For example, each crop has different production rates. This is important in South Dakota because each of the different crops have different yield and different planting, harvesting and marketing periods. Theoretically, if the amount of land in production for different types of crops is known or could be predicted, this could be used to develop freight generation equations. This would require data on factors such as land availability, crop yield, and natural factors such as weather.
    - **Attraction—**Understanding freight attraction can be complex, and may lead to difficulties in the 4-step approach due to the multi-faceted nature of the crop supply chain. There are two primary aspects to understanding agricultural freight attraction in this demonstration—what the product is being used for (e.g., is it destined for a processing plant? is it destined for export?) and the specific logistics and supply chain of the product (e.g., where are elevators? how are they used?). The global demand and price of processed agricultural commodities are key determinants in understanding differences in attraction from year to year.

      Additionally, if freight is stored at an elevator or another location before being moved to its final destination, some facilities may serve as both generators and attractors at different times.
- **Step 2: Distribution—**This step establishes the origin-destination (O-D) linkages between the productions and attractions and is heavily dependent on logistics and supply chain

characteristics such as location of storage or distribution facilities, transportation cost and inventory cost, vertical integration characteristics of the logistics chain such as ownership and operation of supply or sales businesses in addition to primary production, truck fleet, rail track, etc., and market characteristics which are the same as those influencing the differences in attraction from year to year. As these characteristics change, the distribution pattern also changes from year to year.

- **Step 3: Mode Choice—**This step is dependent to some degree on the origin-destination patterns, but also on the vertical integration characteristics of the logistics chain, and the relative cost and performance of modes. In the mode choice step, volumes of freight (e.g., tonnages or bushels) are also converted to number of trips based on the mode assigned.
- **Step 4: Assignment—**This step reflects access that is available to and from points of production, road condition, and other factors that are captured in data generally available to SDDOT. Types of assignment that can be used include shortest path assignment (if known), or if disaggregated route data is not available, a general assignment of flows based on the percentage of roadway types in a given county or region. Weather in particular has a major role in disrupting a normal traffic flow pattern, particularly when road conditions are poor prior to the weather event. This requires a dynamic and rapid response from the agency(s) responsible for the jurisdiction that is affected by the weather event.

4.7.2 Technical Approach

This subsection provides an overview of Research Team's proposed technical approach to the demonstration of determining truck demand to inform the various purposes and applications of improved agricultural freight data. This description is an idealized approach for field crops and elements of this approach were incorporated into the demonstration case studies, particularly to determine farm production for major crops and departure pattern of trucks (in equivalent single axle loads or ESALs) from farms at township level To improve the usefulness of the demonstration to a broader range of purposes and applications, the Research Team in coordination with SDDOT expanded the technical approach to demonstration case studies. This was achieved by including other types of improved agricultural freight data such as livestock arrival and departure and animal feed consumption patterns at animal feedlot and auction facility, and by developing supplementary types of transportation investment decision support information such as transportation quality variables by township, characteristics of "last mile" connectors to an agricultural facility, characteristics of affected detour roadway due to bridge and road closure, etc. The details on additional data sources used and methods developed in the evaluation of demonstration case studies are described within the demonstration findings (Section 5.4) of this Report.

The expansion of the technical approach, short duration and resource constraints of this research project, the idealized technical approach, particularly to determine distribution pattern to final uses, mode choice and route assignment, was not fully realized for the demonstration case studies. These are however important for a travel demand modeling and forecasting application.

4.7.2.1 Assumptions

Several assumptions are required at the onset of the demonstration, including:

- **Crop Type.** Several crops can be modeled as part of the demonstration framework. The scale of the analysis of the case study area is driven by commodities (for which data is available) that would make the most contribution to transportation demand. The framework can be applied to multiple crops, either individually or by incorporating multi-level analyses for each crop, as required, to the variables and parameters used in the analysis. To establish a baseline, each crop may be modeled separately using crop-specific model factors using a similar procedure as described in the demonstration. However, there is significant complexity that must be captured to include more than one crop in a single model.[1]

- **Temporal Scope.** The demonstration framework can be applied over different time periods, for example a harvest season, one quarter of a year or one year. It assumes that the crop yield is in units of bushels per acre, based on the amount that will be harvested within the time period.[2] Similar to crop type, the temporal period can be adjusted to cover additional time periods, or the framework can be applied to individual time periods to make comparisons during different times of the year. Farm production in bushels, truck trips in ESALs departing farms and livestock truck operations at animal feedlot and auction facility were estimated on a quarterly basis and annual basis in the demonstration.

- **Geographic Scope.** The demonstration framework does not disaggregate trips by location below the township level. The demonstration framework can be scaled up to a larger region to discover the effects at the county, multi-county or statewide level. The demand and transportation quality variables were estimated at township level. Some roadway characteristics were also identified at individual agricultural facility level.

- **Commodity Use Type.** Each facility will have a demand for the crop for a certain use type such as storage, food or ethanol production, animal feed, or other use. Some facilities may have a demand for more than one use type, and a separate price may be offered for each use. Commodity uses influence the prices offered for the crop. As supply remains constant, changes in commodity uses or demand influence price of the commodity and vice versa. The final uses of agricultural freight were not quantified in the demonstration but departure from farms for interim storage or use were quantified.

4.7.2.2 Overview of Model Parameters and Other Data Requirements

As described in the approach to defining data requirements, three categories of input data are required for this demonstration: Agricultural Data, Facility Data, and Transportation Data. For each of the steps in the 4-step framework, Appendix B provides an overview of the required data, the best

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[1] To consider more than one crop in a single model, agricultural parameters must be adjusted to reflect different values for each crop, when appropriate to do so. Additionally, the transportation and facility parameters may need to be adjusted to reflect different values for each crop (e.g. demand for corn, demand for wheat). Not all facilities, capacity, or transportation types may be suitable for each crop (e.g., sunflowers may have different storage requirements than wheat), adding additional complexity to the model.

[2] The temporal scope is based on the time of harvest, not planting. So if crops are planted at separate times, for example, or will have multiple harvest periods, the crops to be considered in the demonstration study are those that are ready for harvest within the study time frame.

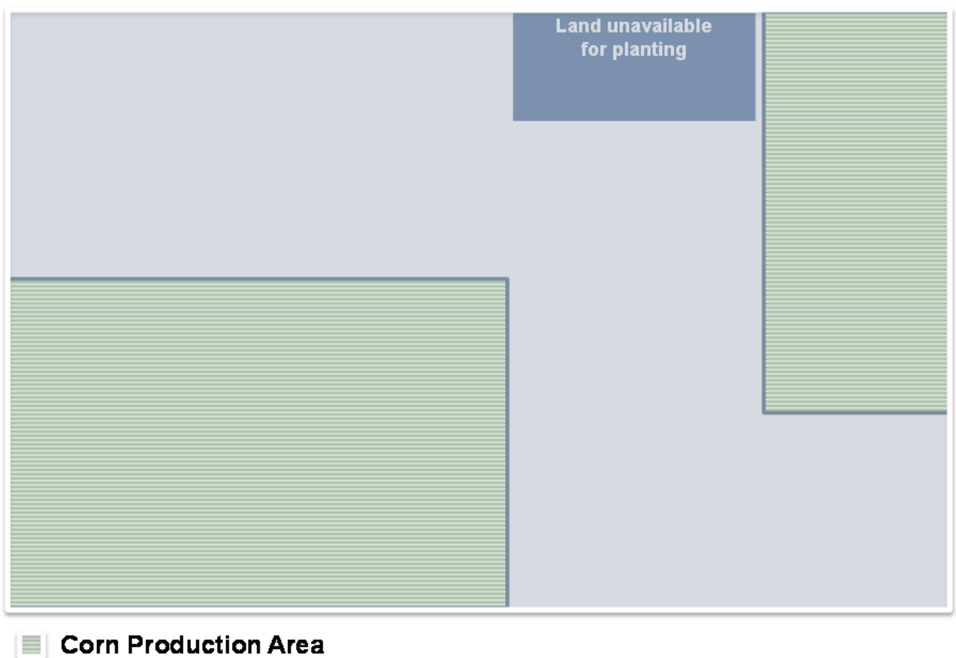
available data source, whether or not the source meets the temporal, spatial and collection frequency requirements, and an indication of whether or not the data can be adjusted.

The demonstration framework and the idealized technical approach relies on a range of base data, much of which is not at a level of detail to adequately address the purposes identified. The framework therefore allows for the introduction of supplemental data and assumptions. These assumptions can be introduced and used as 'levers.' Levers refer to specific adjustments made to the data inputs to reflect different scenarios, and ranges of results versus a specific result. Levers pertaining to cropland use shifts, crop yield growth factors and truck fleet mix shifts were identified in this research. Data inputs for Steps 2 through 4 of the framework rely on the outputs of previous steps; as more assumptions are made early in the process the results will be less precise.

4.7.2.2.1 Step 1A: Production

The purpose of this step is to determine the amount of crop produced in each production location in the case study area. The output was expected to be a vector of crop produced, in bushels, by each production location. Figure 11 depicts Step 1A—Production.

Figure 11 Demonstration Abstraction of Step 1A



Source: Cambridge Systematics

Process. First, determine the locations of available land for planting for each crop, and the size of each area in terms of acreage. We assumed in the demonstration that a crop will be ready to harvest within the study timeframe. The location of each plot of available land is important to develop accurate estimates of distance and routing between production locations and facilities. In the demonstration, land available for each crop was based on a five-year average value, but could also be determined through a stand-alone model based on factors such as weather, global demand, price and supply chain costs.

Second, determine the crop yield, in bushels per acre. For purposes of the demonstration, crop yield was set as a parameter, but could also be determined through a stand-alone model for determining crop yield that incorporates agricultural factors such as weather, seed type, fertilizer use, soil condition.

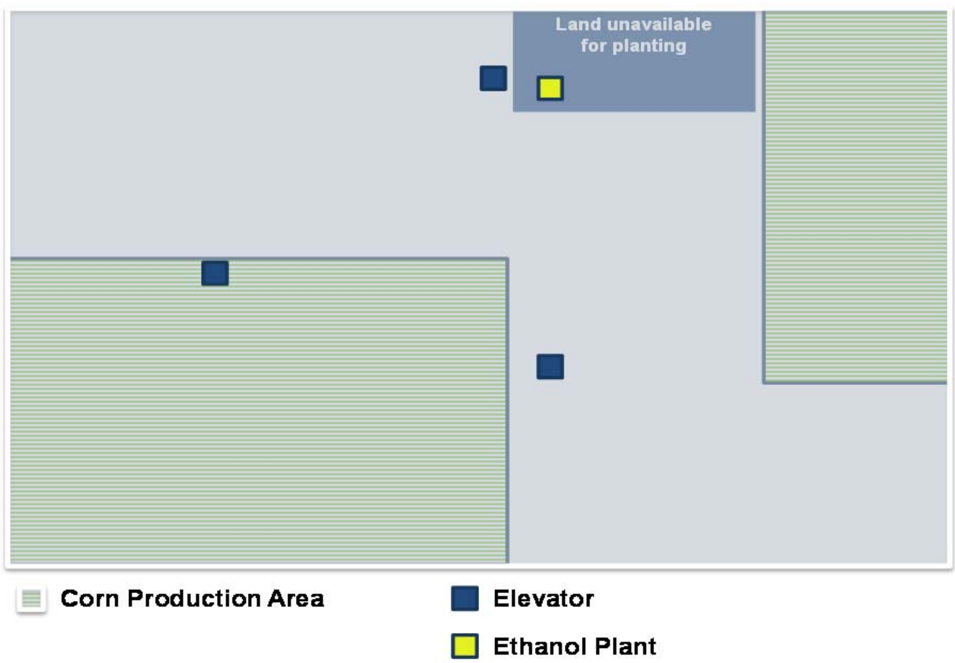
Available land for each crop and crop yield were used as levers in the demonstration process (i.e., varied to show different scenarios that reflect wet and drought years). In the demonstration, national forecasts and demonstration area trends in these parameters were used to adjust the levers.

Third, apply the crop yield factor to each plot of land available to determine the amount of crop produced. The total bushels generated by each plot of land was expected to be used in Step 2. In the demonstration, the total bushels generated at township level by quarter under current and future conditions were estimated.

4.7.2.2.2 Step 1B: Attraction

The purpose of this step is to determine the demand for each crop for each facility in the study area and facilities outside of the study area. The output was expected to be a matrix of demand for the crop, in bushels, by facility and use type. Figure 12 illustrates step 1B—Attraction.

Figure 12 Demonstration Abstraction of Step 1B



Source: Cambridge Systematics

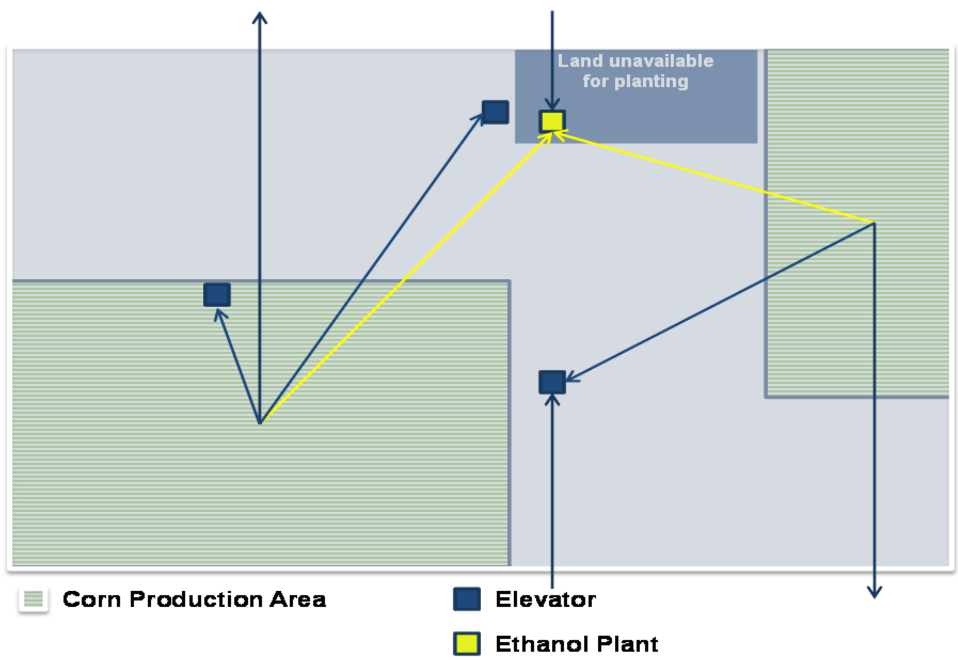
Process. First, determine the locations of facilities that will serve as destinations for each crop and the demand for the crop at each respective facility. Facilities may be both in and outside of the study area. Facilities inside the study area should be located so that it is possible to develop estimates of distance and routing from production locations to the facilities. Facilities outside of the study area may be similarly located, or generic facilities could be used to simulate demand outside of the study area (for example, all grain elevators to the east could be considered as a single facility; destinations to the west could be similarly combined).

Second, determine the demand for each crop at each facility. If multiple uses are considered (e.g., food or ethanol production, or export), the demand at each facility should be associated with one or more of these use types. Note that facilities may also take crops from outside the study region; this could be reflected in the available demand by assuming that a certain amount of demand will be taken by crops outside of the region. In the demonstration, specific information for demand for each crop at individual facilities was not available; only state-level data for demand at on-farm and off-farm storage facilities was available. Facility capacity could have been used as a proxy for demand; facilities with more capacity could have been assumed to have more demand. In the demonstration, departure pattern of trucks in ESALs by quarter during a year for farms to interim storage or use was estimated. The total off-farm storage demand in the demonstration area was compared to the total off-farm storage capacity also in the demonstration area. The selected demonstration area did not contain any ethanol plant, but it did contain a Concentrated Animal Feeding Operation (CAFO), hence attraction of animal feed to the CAFO was estimated.

4.7.2.2.3 Step 2 and 3: Distribution and Mode Choice

The purpose of these steps is to use the outputs from Step 1A and Step 1B to determine how much and by which mode products are moving in between production locations and attraction facilities. This step was expected to also convert bushels to trucks or truck-equivalent rail cars. The output was expected to be a matrix of the number of trucks moving from each origin (production location) to each destination (facility). Figure 13 and Figure 14 illustrate Steps 2 and 3, respectively.

Figure 13 Demonstration Abstract of Step 2



Source: Cambridge Systematics

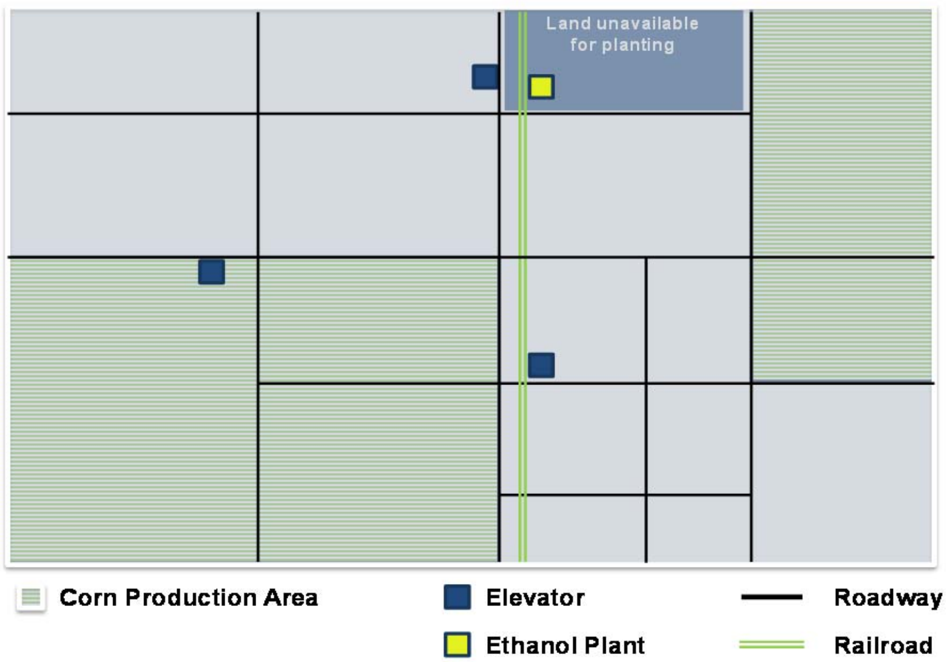
Process. First, determine the over-the-road distance between production areas and facilities. This will also serve as the shortest route to be used in Step 4.

Then, determine whether rail service is available between production areas and facilities. For each facility that has rail service, it is assumed that a portion of the crops will move by rail. In this case, the crop will be taken via truck from the production location to the rail facility and will make the rest of the trip via rail. In that case, the over-the-road distance between the facilities will be the distance from the production location to the rail facility. Some crops however may move by truck the full distance from the production to the attraction facility. A lever that can be adjusted as part of this process is the assumption of what percentage of traffic is able to move multimodally or by truck and then rail.

Next, the user cost of transportation between production areas and facilities is determined, using the shortest distance over the road, and, if rail service is available, the cost of transport by rail. For the demonstration, user cost of transportation could be estimated based on the distance between the points of production and attraction.

In the demonstration, a distance based accessibility by trucks for farms by township to grain elevators with and without rail access was estimated. Aside this, there was limited effort to estimate the distribution and mode choice for agricultural freight due to a shift in focus to other research activities, short duration and resource constraints.

Figure 14 Demonstration Abstract of Step 3



Source: Cambridge Systematics

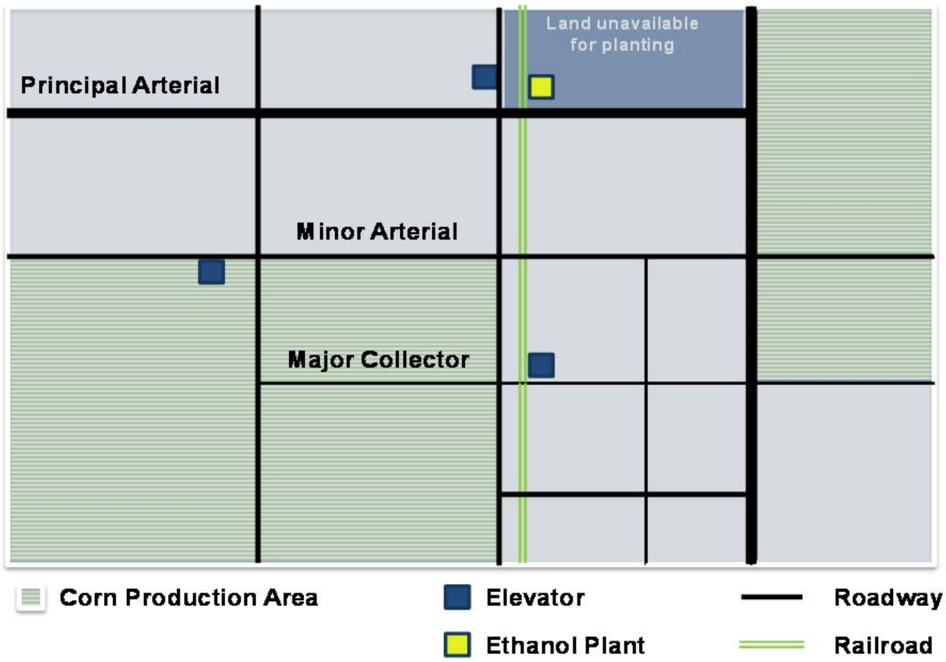
Next, assign crops between origins and destinations. The assignment should take into account the demand and capacity at each facility, net prices (prices offered by type of use minus transportation cost), and amount of each crop available in the study area. One statistical method for accomplishing this assignment would be to use a gravity model. However, other methods may also be used, such as a greedy heuristic (i.e., each crop is sent to the location offering the highest net price) or minimum distance heuristic (each crop is sent to the closest facility), or another heuristic that combines multiple factors.

Finally, determine the load factor of trucks (or truck-equivalents, for rail movements) for each crop, i.e., bushels per truck or head of cattle per truck. Apply the load factor to the movements between origin-destination pairs to determine the number of trucks moving between origins and destinations.

4.7.2.2.4 Step 4: Assignment (truck only)

The purpose of this step is to assign the outputs from Steps 2 and 3, in terms of bushels of each crop moving between origins and destinations, to the roadway network. The output will be a routing of trucks on the roadway network, or a distribution of trucks, by each roadway type, within the study area. Figure 15 illustrates Step 4.

Figure 15 Demonstration Abstract of Step 4



Source: Cambridge Systematics

Process. First, determine the route between each origin and destination pair. Most of this route can be on the highway network, but there will be some first- and last-mile movements to reach the highway network, which should be included as the data is available to do so. If a crop is going to move to a facility by rail, then the route should be from the production location to a rail facility that is connected to the destination facility. If the crop moves to an intermediate location for storage (i.e., a grain elevator) before being shipped to its final destination, then the route should include this intermediate facility. For crops destined for locations outside of the study area, the destination can be represented by a marker on the edge of the study area (for the demonstration we will not model movements outside of the study area).

Next, assign the trucks moving between origin-destination pairs to the network to determine the total traffic related to the crops in the scope of the demonstration.

Alternatively, if specific routing information is not available, the amount of traffic can be estimated by knowing the distance between origins and destinations (again, only including distance within the study area) and estimating the proportion of the distance on each roadway functional class (i.e., arterial, highway).

In the demonstration, route assignment was limited to identification of "last mile" connectors to agricultural facilities mainly due to a shift in focus to other research activities, short duration and resource constraints.

4.7.3 Case Study Locations

A set of geographies and commodities were identified to highlight some of the challenges in understanding the characteristics of agricultural freight demand and its short- and long-term impacts on public decision-making, and ways to expand this understanding to a wider set of geographies and commodities (referred to as "scalability"). This study does not quantify the short-term and long-term impacts, but presents some implications on public planning and decision-making and private sector business planning processes. For example, there are likely changes needed in paving decisions to counter the variance in truck traffic demand. Some details about the demonstration locations are provided below.

4.7.3.1 Selection of Commodities

The Research Team studied the regional and local transportation challenges for the commodities of grain and livestock and related agricultural facilities such as off-farm grain elevators, rail grain terminals and sidings and livestock facilities. On-farm grain storage, a common practice, is considered mainly from a timing standpoint of transportation demand of when grain is leaving a production area (in this study, based on the technical approach this refers to the township). The Research Team also identified input commodities of grain and livestock production. These include fertilizer input for grain production, and animal feed input for livestock facilities (e.g., auction facilities, ranches, feedlots, etc.). The reason for selecting these commodities and related agricultural facilities is that due to natural and market forces their total transportation demand displays a high degree of seasonality within a year, and fluctuations across the years. Due to a large variety in the uses of grain, such as food and beverage manufacturers, animal feed, ethanol and exports, and locations of grain and livestock processing facilities, the (rail or truck) mode splits also are subject to frequent changes.

For these commodities, the short- and long-term impacts of transportation demand (at the lowest level, farmer's decisions on what and how much to produce, where to get inputs from, and where to send output to) on highway paving decisions (e.g., when and where to repair surface to avoid replacement cost) and rail planning decisions (e.g., when and where to assist coordination between farmers and railroads for rail service) are not fully understood. As discussed in the demonstration technical approach, data analysis and modeling in this study attempted to estimate the transportation demand under different lever settings for these commodities and related agricultural facilities. A discussion of the short- and long-term impacts of the projected range of transportation demand on some of the public decision-making processes or applications is included in the demonstration findings (Section 5.4) of this Report.

There are other agricultural commodities such as milk, ethanol, processed grain, other plant and meat products and related agricultural facilities such as dairy plant, grain and other plant based product manufacturing centers (oil, canned or frozen vegetables and fruits, bakery products, beer, etc.), and meat processors. However, the Research Team believes that the input and output sides of transportation demand for these commodities and related agricultural facilities are relatively uniform within a year, and may show some fluctuations across the years, driven mainly by growth in population, changes in per capita consumption and international trade of these processed commodities. The transportation demand for these commodities may be estimated by enhancing the tool developed for the demonstration commodities with additional data and modeling parameters. For example, in the context of dairy production, additional data can include location and production capacity of dairies, and modeling parameters can include rate of dairy output per cow and loaded weight, payload factor and EASLs per dairy truck.

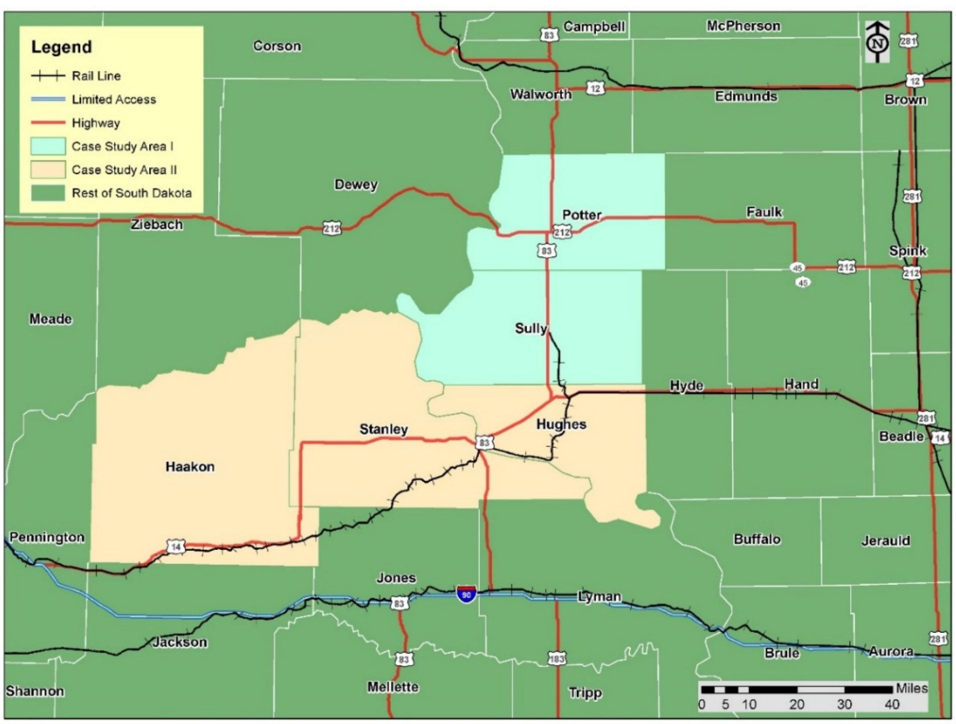
4.7.3.2 Selection of Geographies

In partnership with SDDOT, the Research Team identified two geographies that provide coverage of the selected commodities, as shown in Figure 16. In describing these areas the term “Case Study Area” is used to describe the features of the geographies. Ultimately, the case studies that were conducted in this research effort combined the two areas described into a general 5 county area.

Case Study Area I consists of the counties of Potter and Sully in South Dakota, while Case Study Area II consists of the counties of Haakon, Hughes and Stanley in South Dakota. As seen in Table 4, crop production (taking average over 2000-2014) in Case Study Area I is focused on corn, soybean, wheat, and sunflower production, while crop production in Case Study Area II focused on wheat and hay production. The case study areas are mostly rural with a low population density (with the exception of Pierre, the capital city) and have rail access.

While the case study areas are not directly served by the Interstate system, the national highways of US83, US14 and US212 provide the primary truck access and access to the Interstate system. A network of paved and unpaved other state and local roadways support the national highways. The percentage of paved roadways (bituminous or concrete surface types only) for different counties are as follows: (1) Haakon—10.4% paved, (2) Hughes—24.4% paved, (3) Potter—12.5%, (4) Stanley—24.9%, and (5) Sully—12.1%. The percentages of paved roadways are low due to a rural nature of these counties, low traffic levels, and the significant investment required to build and maintain pavements. Hence, damage to the roadways due to truck movements is likely to be an important concern to local public stakeholders in the case study areas.

Figure 16 Locations of Case Study Areas



Source: SDDOT GIS Data; ESRI GIS Data

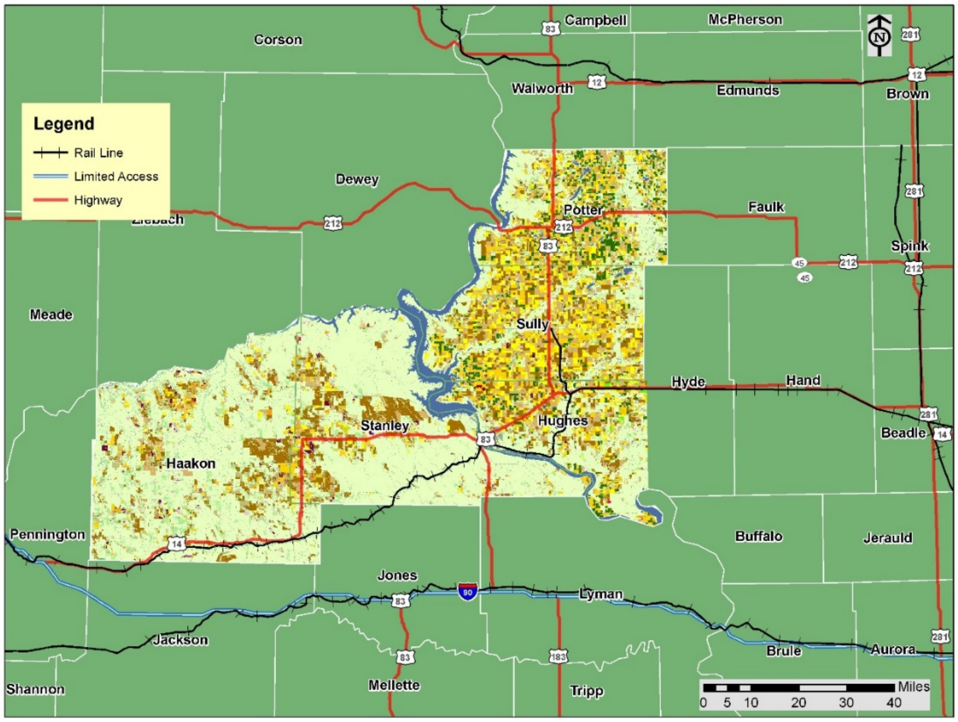
Table 3 Crop Production Data for Counties in Case Study Areas, 2000-2014 Average

County	Crop Type	2000-2014 Average				
		Acres	*Production in Bushels*	*Production in Tons*	*Yield in Bushels per Acre*	*Yield in Tons per Acre*
Haakon	Corn	9,753	650,107		67	
	Hay, (Excl Alfalfa)	42,153		48,613		1.2
	Hay, Alfalfa	45,693		59,150		1.3
	Sorghum	7,278	266,556		37	
	Soybeans	3,133	46,333		15	
	Sunflowers	6,783		7,260,833		1,070
	Wheat, Spring, (Excl Durum)	21,492	616,769		29	
	Wheat, Winter	90,354	3,347,538		37	
Hughes	Corn	25,092	2,567,892		102	
	Hay, (Excl Alfalfa)	14,871		20,821		1.4
	Hay, Alfalfa	9,195		15,064		1.6
	Sorghum	4,655	251,918		54	
	Soybeans	12,170	401,380		33	
	Sunflowers	36,643		55,060,286		1,503
	Wheat, Spring, (Excl Durum)	36,871	1,465,500		40	
	Wheat, Winter	54,069	2,510,077		46	
Potter	Corn	65,547	6,659,927		102	
	Hay, (Excl Alfalfa)	20,964		33,550		1.6
	Hay, Alfalfa	10,667		21,625		2.0
	Sorghum	940	49,000		52	
	Soybeans	44,523	1,284,923		29	
	Sunflowers	48,000		74,743,571		1,557
	Wheat, Spring, (Excl Durum)	71,293	3,156,000		44	
	Wheat, Spring, Durum	500	15,000		30	
	Wheat, Winter	52,746	2,670,692		51	
Stanley	Corn	3,800	239,125		63	
	Hay, (Excl Alfalfa)	27,808		32,631		1.2
	Hay, Alfalfa	13,621		17,400		1.3
	Sorghum	12,055	503,818		42	
	Soybeans	1,550	19,325		12	
	Sunflowers	12,300		11,222,143		912
	Wheat, Spring, (Excl Durum)	25,944	661,778		26	
	Wheat, Winter	63,750	2,176,750		34	
Sully	Corn	73,967	7,765,027		105	
	Hay, (Excl Alfalfa)	19,583		26,900		1.4
	Hay, Alfalfa	5,946		10,343		1.7
	Sorghum	5,289	312,040		59	
	Soybeans	20,847	694,540		33	
	Sunflowers	96,100		150,641,875		1,568
	Wheat, Spring, (Excl Durum)	94,107	3,738,200		40	
	Wheat, Spring, Durum	950	28,000		29	
	Wheat, Winter	109,486	5,391,143		49	

Source: USDA National Agricultural Statistics Service (NASS) Data

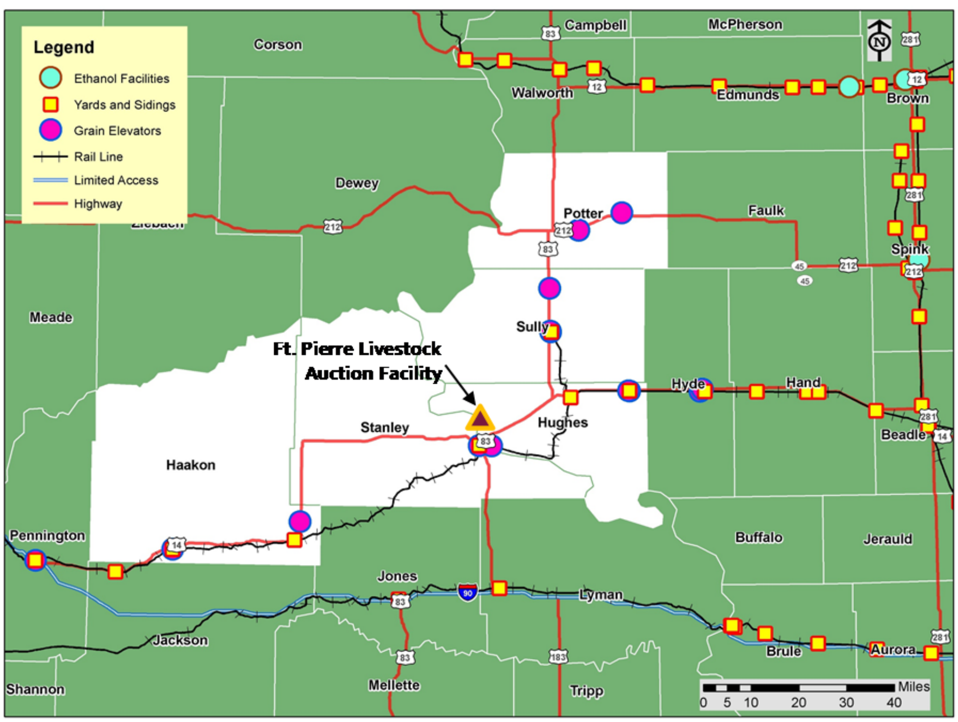
Figure 17 shows the geographical distribution of farmlands and Figure 18 shows the locations of agricultural facilities in the case study areas.

Figure 17 Geographical Distribution of Farmlands in Case Study Areas



Source: USDA CropScape, SDDOT GIS Data; ESRI GIS Data

Figure 18 Locations of Agricultural Facilities in and around Case Study Areas



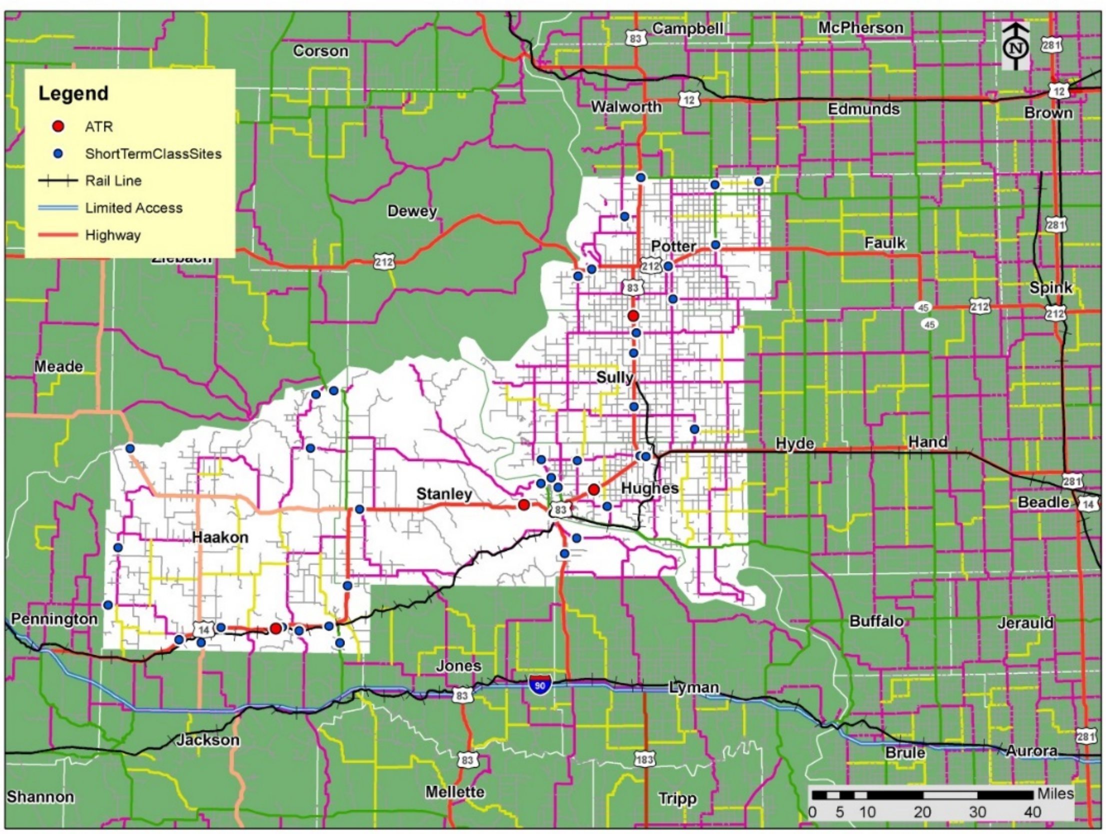
Source: SDDOT GIS Data; ESRI GIS Data; Cambridge Systematics Web Search

In the five-county area, corn, winter wheat, spring wheat and soybeans were identified as major crops. The other crops including hay, sunflowers, sorghum, etc. were not included in the demonstration. A majority of the crop production is east of the Missouri River, in Hughes, Potter and Sully counties. The case study areas contain grain elevators for grain storage and rail sidings for loading grain and livestock onto or off a train. There are no corn based ethanol facilities within the case study areas. However, there are a few ethanol facilities within the map range that can be accessed from the case study areas through US212 and US12. In Case Study Area II, there is a livestock auction facility at Fort Pierre. This is the largest one for feeder cattle in the State.

In addition to agricultural facilities shown in Figure 18, there are likely some fertilizer storage facilities near the farm locations and ranches for rearing animals and storing animal feed; the Research Team was not able to collect this data due to the short duration and resource constraints of this research. There are no known agricultural products manufacturing centers or agricultural processors in the case study areas, so much of the grain, other plant derivatives and feeder cattle is moved out of the case study area boundaries.

Aside having a coverage of selected commodities and having a multimodal transportation system, the other reason for selecting the geographies is that SDDOT has been collecting a long and highly granular time series of truck traffic counts by axle size at weigh stations at Agar, SD on US83 and at Pierre, SD on US14. In addition, this data is supported with several truck counts taken on state and local roadways under the federal program of highway performance monitoring system (HPMS). The locations of the weigh stations (or automatic traffic recorders), and HPMS stations (or short-term classification sites) are shown in Figure 19.

Figure 19 Locations of Truck Count Stations in Case Study Areas



Source: SDDOT GIS Data; ESRI GIS Data

Other potential geographies (such as the areas around Groton, Manchester near Huron, the area around Kimball, and Rapid City) were also considered, but they were discarded for one or more of the following reasons: 1) they did not represent the same level of variety in commodities, especially the commodities that are likely to show large variance in demand; 2) a long time series of truck traffic count data was not available at the location; 3) the weigh station data is likely to contain a large percentage of through traffic , which makes it poor for validation; and 4) the data from other locations cannot be used to check for internal consistencies the same way as the selected adjacent case study areas.

To get an early understanding of the characteristics of total transportation (both agricultural and non-agricultural) demand information and inputs to the agricultural freight demand estimation, some example graphical summaries of these characteristics are shown in Appendix C. The inputs and output data shown are at spatial and temporal granularity, as available.

4.8 Demonstrate and Evaluate Improved Data

Task: Upon the technical panel's approval of the plan, demonstrate and evaluate the acquisition and use of an improved set of data elements for the selected geographical area in South Dakota.

The approach to conducting the demonstration was presented to the Research Panel during an interim progress meeting held on June 4, 2015. Following that meeting, the Research Team proceeded to conduct the demonstration of how an improved agricultural freight data could improve transportation decision-making in South Dakota. As noted earlier, developing a correlation between agricultural production and truck demand was a common theme among stakeholders interviewed and would provide a foundation to address the identified short- and long-term purposes; this became the focus of the Research Team and ultimately the Demonstration—Estimating Truck Demand.

In conducting the Demonstration—Estimating Truck Demand, concepts described in the Task 7 approach were employed to demonstrate the applicability of the methodology for estimating truck demand based on the production in the case study area. The Demonstration was then used as a vehicle to assess its ability to respond to purposes identified. These purposes can be categorized as "what if" scenarios for real-world freight and transportation planning questions such as facility site selection, the impact of a road or bridge closure, the need for lane and shoulder widening, improved geometrics, surface maintenance, and others.

As described in the demonstration approach, 'levers' were introduced to see how truck demand could change based on changing conditions. The levers explored included acres planted per township and changes in truck size and weight regulations. Each of these scenarios provided an estimate of truck demand per township that could be compared to the baseline.

4.9 Describe Scale-Up

Task: Describe how the acquisition and use of an improved set of data elements can be scaled up from the demonstration to statewide and regional application.

Tasks 8 and 9 of this research were conducted in parallel to each other to demonstrate how available data could be applied to different geographies and commodities. The translation of the demonstration to other geographies, to derive the same level of detailed results as in the demonstration, is straightforward. It is straightforward in that it requires collecting the same publicly available data inputs at the state, county or other desired level of geography and incorporating them into the spreadsheet tool developed during this research. The tool developed is expandable and can be modified as new data are identified and developed. Depending on the geography to scale up to, the process has varying degrees of complexity. In the case of developing a tool that represents the entire State of South Dakota, the task would be a fairly complex and would require substantial time and effort to accomplish, but it could be done in the framework provided in this research.

To dig a bit deeper into agricultural issues that are not directly related to crop production, two agricultural facilities were also studied: 1) a Concentrated Animal Feed Operation Facility and 2) the Ft. Pierre Livestock Facility. These studies attempted to develop trip generation rates in a manner similar to the trip generation determined based on crop production.

4.10 Prepare Final Report

Task: In conformance with Guidelines for Performing Research for the South Dakota Department of Transportation, prepare a final report summarizing the research methodology, findings, conclusions, and recommendations.

The Research Team prepared this final report as a summary of the research methodology employed on this project, the principal findings of the research, the conclusions drawn from the findings, and the key recommendations for incorporating improved agriculture freight data within SDDOT and public agency decision-making.

At the conclusion of the project, the Research Team presented an overview of the research conducted and described the findings to SDDOT 2014-09 Research Panel on August 20, 2015. Comments and suggestions offered during the presentation were incorporated into the final report.

4.11 Make Executive Presentation

Task: Make an executive presentation to SDDOT Research Review Board at the conclusion of the project.

At the conclusion of the project, the Research Team presented an overview of the research conducted and described the findings to SDDOT Research Review Board on August 20, 2015. Comments and suggestions offered during the presentation were incorporated into the final report.

5 FINDINGS AND CONCLUSIONS

This section provides an overview of pertinent information collected as part of this research effort and the findings of the Research Team. This section is organized to highlight the findings around the topics of:

- Agriculture and Transportation Industry Trends
- Purposes for Improved Agricultural Freight Data
- Data
- Demonstration Findings

These findings have been organized to support the recommendations of the Research Team.

5.1 Agriculture and Transportation Industry Trends

In Task 2 a literature review of existing conditions and significant trends in agricultural production and transportation in South Dakota, was conducted so that the research team could begin to identify the factors of importance that drive the way the transportation system is used in states with a significant agricultural sector. The literature review focused on answering the following questions:

- What are the trends surrounding agriculture production and transport?
- Which of these are the most important trends that the demonstration data need to capture?
- What existing data sources help inform this?

These sources reviewed were catalogued based on trend types, as defined by the Research Team. These included trends that were related to topics such as agricultural practices, land use, weather, mode use, commodity pricing and revenue, and agriculture product demand.

To better understand which trends may influence how the transportation system is used, Appendix D—Summary of Agricultural and Transportation-Related Trends and Potential Application—was developed to begin to connect these dots. Appendix D is a subjective illustration of how the research framework, (based on the components of a 4-step transportation model) may be influenced by various agricultural and transportation trends. For example, the crops that are grown in the State (i.e., production) relate to a number of trends including agricultural practices, land use, weather, modal availability, pricing and revenue, and agricultural demand trends.

While many sources were consulted and a myriad of trends explored, several trends were identified as central to this research project. The key trends are highlighted below.

These key trends include crop yield, active crop acreage, size and location of new agricultural facilities, transportation system constraints, local concentrations of truck demand and truck driver shortages.

- **Continued improvement in crop yields is likely.** Consistently higher yields were a common theme in the literature review, and there is little to suggest that some increase in yields will not continue into the foreseeable future. Even without further technological development, expanded adoption of genetically engineered crops by existing growers suggests some yield increases will continue.

- **Expansion of planted acreage is expected to slow.** Increases in corn acreage are seen throughout South Dakota. However, this increase in corn acres has come at the expense of acres of other crops (wheat, hay, minor grains and oilseeds), summer fallow (idled land), and land in the CRP. At the national level, acreage enrolled in the Conservation Reserve Program (CRP) is estimated to fall slightly below its legislated maximum under the 2014 Farm Act of 24 million acres, according to USDA Projections.

- **Weather will continue to affect yield variability.** Weather greatly influences crop production, as evidenced by the 2012 drought and the successive years of record harvests. While weather will continue to introduce considerable variability, it cannot be predicted with certainty.

- **Increasing scale of new facilities.** While the number of rail-served grain elevators has decreased, the storage capacity and volume handled at rail-served elevators are increasing. The change in makeup of elevators in the Upper Midwest has been caused by a variety factors such as technology, modal competition, changes in crops, global demand, and regulation. The adoption of 110-car unit trains has had a great influence on this. These movements toward improved efficiency to lower overall operating cost are also seen in the size and scale of other types of new facilities such as feedlots and dairies. The net result will be more truck trips traveling longer distances to these large, standalone facilities. In addition, as improved plant genetics and management practices increase yields and allow crops to be grown on previously unsuitable lands, the need for high capacity facilities can be expected to increase.

- **Transportation system constraints will persist, lowering service quality.** Constraints in the transportation system relate to bottlenecks caused by physical infrastructure, modes, and service providers. Service quality is measured by availability, connectivity, travel time, reliability, frequency, and cost. In recent years, due to a rapid increase in energy-related development of natural gas, crude oil, and ethanol, has caused significant service disruptions to shippers of agricultural products in South Dakota, with the most concerning disruptions occurring during harvest, the peak shipping season. While railroads have worked to clear car backlogs and are expanding infrastructure to provide additional capacity, these disruptions are expected to persist as crop production continues to increase and more is destined for export markets. Additionally, in the Upper Great Plains, intermodal competition is low, resulting in a price disadvantage and low quality of service in many markets.

- **Local trucking demand will increase, but trucking shortages will continue.** As production increases truck demand in the growing regions of the State will also increase. At the same time truck driver shortages are mounting, and nationally it is difficult to hire drivers for long distance service. Growers are often the owners and users of local transportation, and because of this there is a market for lower cost, used equipment that will be used seasonally. There is also a market for new equipment that is bought or scaled up as production changes. The types of vehicles used and their frequency may be related to surface condition, truck size and weight regulations and restrictions, and other system issues.

These trends are critically important, and in a few cases, the demonstration (discussed later in this section) attempted to introduce 'levers' to show how these trends could result in varying levels of truck demand (e.g., increased production) and may influence how the transportation system is used and transportation agencies make investment decisions. SDDOT should actively monitor the key trends identified in this research so that there is ongoing awareness in the DOT, and among South Dakota's transportation stakeholders, related to whether or not these trends are continuing, and if they will continue to be important to agricultural transport in the State.

5.2 Purposes of Improved Agricultural Freight Data

It was critical to develop a demonstration that linked to, and supported, the purposes and applications identified during this project's research. Initiated in Task 3, *Identify Purposes for Improved Agricultural Production and Transportation Data*, purposes were initially identified through outreach to a variety of public and private sector, agriculture and transportation stakeholders. Table 5 provides an overview of the results of that task and a first attempt at categorizing purposes of improved data, aligned with the stakeholders where the need was indicated through interviews.

Table 4 Potential Purposes for Improved Data—Derived from Interviews

Potential User Purposes and Applications	SDDOT	Local Road Agency	Private Sector
Predict truck and rail demand (current, future)	●	●	●
Assess system condition, performance, and local impacts (e.g. surface, quality of life)	●	●	
Determine maintenance needs (e.g., surface management, resurfacing)	●	●	
Inform maintenance and design standards (e.g., bridge & surface design; geometric & structural considerations)	●	●	
Determine large investments needs (e.g., multimodal, roadway construction)	●		
Prioritize investments (multimodal, inform STIP)	●		
Aid siting or permitting of grain elevators and other facilities	●	●	●
Identify primary transportation system users and beneficiaries	●	●	
Identify unintended or undesigned uses of transportation facilities	●	●	

Consistent across all stakeholders is interest in improved information on current and future truck and rail system demand. Each of the other potential applications identified (from left to right) rely on this demand information to fulfill their purpose. In some cases the demand information may be used to assess a certain aspect of the system (e.g., surface or bridge condition), and in other cases the information may be combined with other sources of information to make a decision (e.g., determine maintenance needs, inform standards development, prioritize investments, etc.). In preparation of conducting the research demonstration, these purposes and applications were further examined and refined.

5.2.1 Short- and Long-Term Purposes

Early in this research the link between South Dakota's economy and agricultural production was described; the two are inextricably linked. Also linked to these elements is the transportation system in South Dakota. The transportation system is the conduit that ensures that goods and services are connected to consumers. Because of the state's location and the distance to markets, transportation costs can heavily influence the final price of agricultural commodities and products and the prices received by South Dakota's producers. It is the desire of SDDOT to better understand how the multimodal transportation system is used by the agricultural community so the agency can better plan and make investments to preserve and enhance system condition and performance, and thus maintain a competitive economy.

Digging deeper into the purposes and applications identified in Table 3, they in fact represent a mix of short- and longer-term, low- and higher-dollar investment decisions that are regularly weighed by public and private sector stakeholders. Each of these decisions relate to various aspects of the systems' condition and performance, as well as the ability of the system and facilities to serve demand. The following text describes the short- and longer-term decisions in greater detail. Appendix E includes a matrix with much more detailed information on all identified potential purposes of improved agricultural freight data. Some features of the Appendix E matrix are described below.

Decision-maker. Decisions have been generally grouped by decision-maker. In this research these have been broadly defined to include:

- **Public Sector** (Transportation Agencies). This category includes state, county, city, township and other transportation and roadway agencies
- **Private Sector** (Agricultural Entities). This category includes farmers, grain and ethanol processors, elevators, agronomy centers and other agriculture-related entities.

Temporal Resolution. Public and private sector agricultural and transportation stakeholders make decisions throughout the year for a variety of different purposes. These decisions have been organized within the following temporal resolution categories:

- **Daily and Seasonal Decisions.** For the public sector, these are in-the-moment decisions that are often made as a result of a sudden change in system condition, such as a seasonal road closure. For the private sector, these decisions often relate to amount of seed or fertilizer required for purchase to initiate a crop cycle.
- **Annual Decisions.** Short-term decisions such as local road construction and maintenance, such as routine maintenance and blading of unpaved road surfaces, are often performed on a recurring cycle. Similar annual decisions are made by the public and private sectors.
- **Short-Term Decisions** (4-year TIP). These short-term decisions coincide with a public agency's short-range funded program. In the case of SDDOT, this is the 4-year Transportation Statewide Improvement Program (STIP) which includes projects related to routine maintenance, but also higher cost projects that may be related to improving roadway geometrics, roadway safety, or other types of projects that generally improve bridge and surface conditions.
- **Longer-Term Decisions** (8-year TIP, and beyond). Similar to the 4-year STIP, the 8-year STIP contains a listing of projects that are related to improving transportation system condition and performance.

- **Business Plan** (1-5 years). The private sector has the ability to make large investments in shorter timeframes than the public sector. Their decisions are typically made during their business planning cycle and generally occur within 1-5 years.

To show that public and private sector stakeholders make different decisions in varying timeframes, Table 6 is provided.

Table 5 Public and Private Sector Decision-making Timeframes

Decision-Maker	Decision Timeframe				
	Daily or Seasonal	Annual	Short-Term (0-4 Yrs)	Longer-Term (5-8 Yrs)	Business Plan (1-5 Yrs)
Public Sector (Transportation Agencies)	●	●	●	●	
Private Sector (Agricultural Entities)	●	●			●

Decisions. A sampling of decisions for each stakeholder type is included in the matrix and provided below. Generally decisions relate to the following types of questions:

- Is there a need for transportation investments?
- What data and methods are needed to assess the transportation investment need?
- What course of action should be taken?
- When should action be taken or investments be made?
- How are investments funded and revenue generated?

While this research identified myriad purposes, the demonstration only addressed the question *what data and methods are needed to assess the transportation investment need*, with a particular focus on how improved data can be incorporated into transportation investment decisions.

Public Sector Decisions—Examples

- Daily and Seasonal
  - What roads are unsuitable for traffic during wet weather?
  - Where are emergency closures or maintenance required?
- Annual
  - What roads require annual maintenance (e.g., blading)?
- Short-Term (0-4 Years)
  - What roads and bridges should be rehabilitated or replaced?
- Where are operational improvements required (e.g., traffic signal)
- Longer-Term (5-8 Years, and longer)
  - Where should future developments be sited?
  - Are road designs suitable for levels of use and available funding?

Private Sector Decisions—Examples

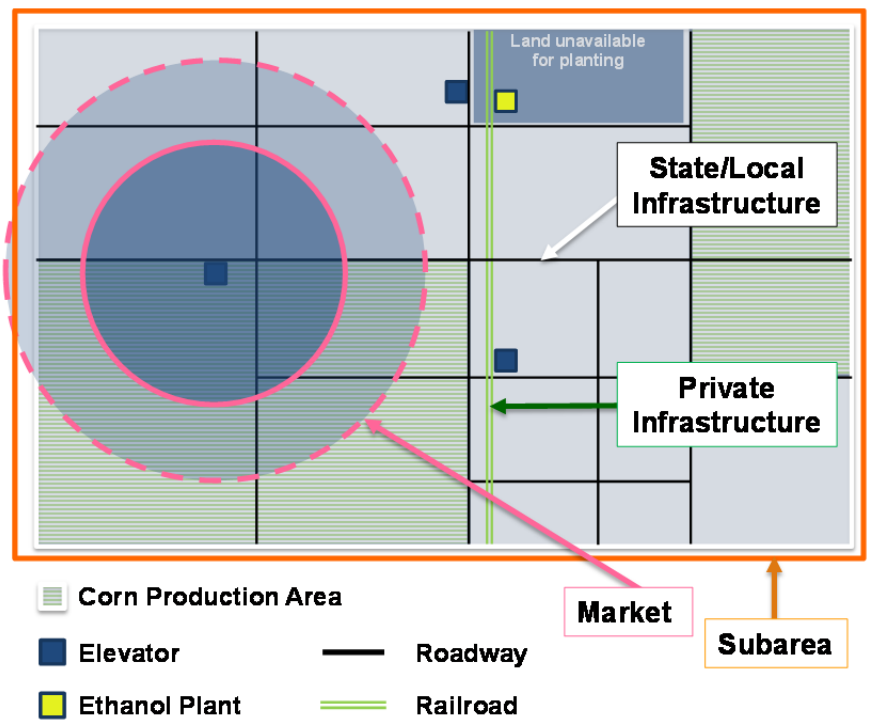
- Daily and Seasonal
  - Where and when should commodities be sold?
  - What route(s) and modes should be used to source or deliver goods?
  - Should storage (permanent or temporary) be used to delay movement?

- Annual
  - What driveways and private roads require maintenance?

- Business Plan (1-5 Years)
  - What is the annual volume and mix of input and output commodities?
  - Where should future facilities be sited?
  - What roads or rail should be rehabilitated or replaced?

Spatial Resolution. The decision examples provided above reflect a series of very broad questions. For most business and transportation agencies they are not interested having the question answered broadly, but with some form of spatial resolution. These decisions have also been organized within the following spatial resolution categories, shown in Figure 20.

Figure 20 Visual Depiction of Spatial Resolution



Source: Cambridge Systematics

- **State and Local Infrastructure.** This pertains to a specific road segment owned or maintained by the State or a local entity.

- **Private Infrastructure.** This pertains to specific infrastructure owned or maintained by the State or a local entity.

- **Subarea.** This pertains to aggregation of roadway infrastructure in a township, county, RPO or other grouping.
- **Market.** This reflects both the catchment area and service area range of a facility and global demand areas.

Due to the level of detailed available data (discussed in the next subsection), the demonstration was conducted at the subarea level, i.e., an aggregation of roadway infrastructure within townships.
Other features of the Appendix E matrix include:

- **Funding.** Decisions relate to investment action, and these require funding. Identification of jurisdiction is provided, which gives insight into potential shared responsibility for investment action.
- **Direct Data Inputs.** To be able to answer the questions (make decisions) for the varying stakeholders, at the spatial and temporal resolutions desired, data inputs must be at the appropriate level of detail and resolution. An attempt at identifying these direct data inputs is included.
- **Derived Data Inputs.** Derived data are also required to answer questions, in particular those that relate to future transportation system condition and performance. An attempt at identifying these derived data inputs is included.

5.3 Data

5.3.1 Data Requirements

This research project identified the ideal data requirements to support the purposes and decisions articulated in the previous section. The primary data requirements were categorized in two ways, first by spatial granularity, temporal granularity, and collection frequency, and second by data types of agricultural data, facility data, and transportation data. The Research Team has identified disparity among the rigor, availability, and coverage across each data category, as described in the following subsections.

5.3.1.1 Spatial Granularity

Spatial granularity relates to the geographic coverage of the data. At the statewide level, there is substantial aggregate data that summarizes information such as crop production by commodity, number of elevators and plants, producers and acreage, truck traffic (AADTT), grain shipments, and the like. Smaller spatial units are county-level (66 counties in South Dakota), township-level (915 individual townships in South Dakota), acre-level (approximately 50 million acres in South Dakota), and point-level (for each facility involved). As noted, more localized and detailed data will provide the most accurate outputs. Table 6 summarizes spatial granularity data needs and availability.

- **Agriculture Data.** Ideal agricultural spatial data is at the acre-level to account for crop types, crop density, and yield produced by growers in the state. Different types of crops will lead to different distribution patterns and trends by producers, and acre-level crop information will provide a clear projection of transportation system use.

- **Facility Data.** Ideal facility spatial data includes point data for each facility with associated attributes describing commodity mix, capacity, throughput volumes, and relevant state and county roadway network service routes.

- **Transportation Data.** Ideal transportation spatial data includes attributes of railroads and state and local roadways for each line segment describing physical and operational data. Data attributes include functional class, roadway material, road and rail infrastructure capacity, and historical road and rail volume.

Table 6 Spatial Granularity

	Statewide Coverage	County-level Coverage	Township-level Coverage	Acre-level Coverage	Road segment (Point)	Facility (Point)
Agricultural	A	A	A/D	D		
Facility	A	A	A			D
Transportation	A				D	D
A=Available Data D=Desired Data						

5.3.1.2 Temporal Granularity

Temporal granularity refers to the point in time and historical coverage of the data. Temporal granularity varies widely among the three primary categories and sub-categories within them. Obtaining regular and current data is as important as obtaining historical data for the framework. Table 7 summarizes temporal granularity data needs and availability.

- **Agriculture Data.** Ideal agricultural temporal granularity is at monthly or quarterly intervals (by commodity and acre), and consist of 10-15 years of historical information. Key data points include yield, available grazing and tilled land, commodity price(s), and commodity use.

- **Facility Data.** Ideal facility temporal data tracks facility performance and consists of detailed monthly bushel volumes, by location and commodity. Other key data points include facility count (increase or decrease), facility capacity (increase or decrease) facility demand by commodity, crop price by facility, and facility volume by crop.

- **Transportation Data.** Ideal transportation temporal data consists of recent and regular truck counts on state and local transportation networks to be associated with relevant facilities. Ideally, truck count year will be matched with facility and agricultural data year for consistency.

Table 7 Temporal Granularity

	Current Year	Minimal lag in collection periods	Historical data—5 years	Historical data—10+ years
Agricultural	D	A/D	A/D	A/D
Facility	D	D	D	D
Transportation	D	A/D	A/D	A/D

5.3.1.3 Frequency Collected

Frequency of data collection is disparate among agriculture, facility, and transportation data. The business aspect of agriculture and associated facilities lead to regular and consistent statistics across all important categories, however this is typically proprietary and competitive information and therefore not readily available. Transportation data is publicly collected, however broad and consistent coverage of detailed traffic counts in the state are not ideal for demonstration purposes.

Table 8 summarizes data collection frequency needs and availability.

- **Agriculture Data**. Ideal agriculture data collection consists of continual statistics for crop seasonality, crop rotation, and commodities. In addition, quarterly reports of crop yield at the acre level can refine transportation mode and routing outputs and identify key trends.
- **Facility Data**. Ideal facility data collection frequency consists of monthly facility demand and crop storage information. Other key data points include price by facility, commodity volume by facility, and modal split (if applicable).
- **Transportation Data.** Ideal transportation data collection frequency consists of daily system demand information, roadway capacity, and ultimately network assignment. Other key data points include AADTT by roadway, vehicle classification, and vehicle weigh-in-motion statistics.

Table 8 Frequency of Data Collected

	Crop Seasonality	Crop Rotation	Quarterly Information	Monthly Demand Information	Daily Demand Information	Annual Surface Information
Agricultural	A/D	A/D	A/D	A/D		
Facility			D	D		
Transportation					A/D	A/D
A=Available Data D=Desired Data						

5.3.2 Data Sources

The following subsections briefly describe data used for public and private sector decision-making, identifying strengths and weaknesses of the sources.

5.3.2.1 South Dakota DOT

At South Dakota DOT, like most State DOTs, internal processes are focused on applying current and historic traffic and truck data to assess state system performance, develop project plans, and support decisions regarding things such as surface design, roadway geometrics, and safety features such as the need for lane and shoulder widening. To accomplish this in the past, SDDOT has relied on simple truck traffic growth trend models that do not reflect dynamic agricultural activity. As a result, predictions (i.e., future truck demand forecasts) based on the simple growth trend models, even for relatively short time horizons, are not sufficiently accurate to meet SDDOT needs.

All of SDDOT's transportation traffic and infrastructure are housed in its Transportation Inventory Management Program. The agency has a robust short-term count program, monitoring 7,500 count locations, the majority being volume counters. It also operates 575 short-term vehicle classification sites, as wel as 51 permanent (32 classification and 19 volume) sites and 15 weigh-in-motion (WIM) sites. While SDDOT's traffic monitoring program primarily covers the state roadway system, counties can make requests to the DOT for local short-term road counter installations.

- **Availability of reliable truck data.** The state currently does not collect WIM data extensively, and is limited in its ability to monitor truck traffic patterns at specific locations. Classification counters cannot determine whether a commercial vehicle is hauling agricultural goods or other commodities. In addition, much of the truck data is collected by sampling techniques, and multiplied by factors and growth rates at the county or traffic analysis zone (TAZ) level to arrive at volume estimates

- **Variability of data**. At the statewide level, fluctuations in yields, weather, livestock and crop prices, harvest periods for different crops, and global market demand can dramatically sway where agricultural trucks are moving, and what they are hauling.
- **Agriculture data.** SDDOT does not currently have the ability to incorporate agriculture production and distribution data into its traffic monitoring activities, however SDDOT relies on National Agricultural Statistics Service (NASS) data to understand rail based agriculture activity on state-owned rail system throughout the state.

5.3.2.2 Other Public Transportation Agencies

Local transportation agencies were consulted to determine if a different, finer level of data may be required for the geographic focus they work in day-to-day, which is often more heavily centered on unpaved roads that are not included in the State highway system. Elevator and grain facilities throughout the state generate a significant amount of truck traffic, and have changed the way producers use the local road system. Agricultural innovations such as drought-resistant crops and other strategies to increase crop yield have increased demand for access to markets for producers, and in turn placed a large number of commercial vehicles on the unpaved local roadways

A county interviewed noted that they could benefit from better estimates of truck traffic in and around the three primary grain facilities, which would help inform design standards and maintenance needs, as well as provide quantitative traffic data to present to its commissioners for transportation funding decisions. As paving local roadways may be cost-prohibitive, the county has turned to alternative maintenance techniques where possible. This includes chemical treatment of the gravel to prolong its condition, stabilize the gravel, and minimize impacts from heavy vehicles.

The county once used counters on its roadway system and is currently exploring classification counters for select roadways (although it is difficult to use tube counters on unpaved roadways). The county has used SDDOT counters in a limited capacity, particularly near the county's landfill. The county doesn't use other state data resources for transportation investment or maintenance decisions.

An MPO consulted during the study noted that better coordinated agricultural freight data could help them and their member counties and townships to estimate development impacts and evaluate how increased truck traffic could impact local residents. With new agribusiness developments, the onus is often placed on counties and townships to provide and maintain adequate infrastructure for heavy trucks, which may not be practical or feasible. Also, impacts from the consolidation of the agricultural sector often present local transportation agencies with influxes of heavy truck traffic and a new set of demands on the local infrastructure.

The MPO has a contract to provide roadway infrastructure information to SDDOT—centerline miles, surface condition, etc.—but does not collect or maintain traffic count data.

5.3.2.3 Private Sector and Agricultural Interests

Stakeholders in the agriculture sector specific to South Dakota (e.g., farmers, grain processors, ethanol firms, elevators, agronomy centers, etc.) were targeted to understand the critical factors they consider in their day-to-day operations that influence their actions related to crop planting, crop rotation, where to store harvest, when to sell, who to sell to, and how to ship the final harvested product to its final destination (e.g., in-state for feed or ethanol production, out-of-state for food manufacturing, or export). They were also consulted on the data they currently use to make decisions.

Private sector stakeholders were, for the most part, not easily able to identify how they would use an improved agricultural freight data source, but agreed that if available it would likely provide benefits to them in the future. These stakeholders currently consult a variety of sources to obtain information on the agriculture sector and shipping options. These include:

- **Primary** - U.S. Department of Agriculture's (USDA) National Agricultural Statistics Service (NASS) and some of USDA's Agricultural Marketing Service (AMS) sources of production, capacity, and trends in freight rates across modes for agricultural commodities.
- **Monitor** - freight information from the U.S. DOT's Surface Transportation Board (STB), UGPTI studies and research, various Grain and Feed outlets, and various information from BNSF and the Soybean Transportation Coalition.

5.3.2.4 Agricultural Data Sources

Several sources currently used by public and private sector stakeholders were identified during the interview process. A relevant finding is that all stakeholder groups are both aware of and use the USDA's National Agricultural Statistics Service (NASS) data for a variety of different purposes, and have come to rely on this as a consistent source. The following section describes several of the available USDA data sources.

5.3.2.4.1 USDA's National Agricultural Statistics Service[3,4]

The National Agricultural Statistics Service (NASS) prepares estimates and reports on production, supply, price, chemical use, and other items necessary for the orderly operation of the U.S. agricultural economy.

The reports include statistics on field crops, fruits and vegetables, dairy, cattle, hogs, sheep, poultry, aquaculture, and related commodities or processed products. Other estimates concern farm numbers, farm production expenditures, agricultural chemical use, prices received by farmers for products sold, prices paid for commodities and services, indexes of prices received and paid, parity prices, farm employment, and farm wage rates.

[3] https://www.federalregister.gov/agencies/national-agricultural-statistics-service (last accessed on April 13, 2015)

[4] http://www.nass.usda.gov/About_NASS/Fact_Finders_for_Agriculture-NASS_at_Work.pdf (last accessed on April 13, 2015)

The NASS prepares these estimates through a complex system of sample surveys of producers, processors, buyers, and others associated with agriculture. Information is gathered by mail, telephone, personal interviews, and field visits.

The NASS is also responsible for conducting the Census of Agriculture. The Census of Agriculture is taken every 5 years and provides comprehensive data on the agricultural economy down to the county level. Periodic reports are also issued on aquacultures, irrigation, and horticultural specialties.

The NASS also created a geospatial data product called the Cropland Data Layer (CDL) that is hosted on CropScape.[5] The CDL is a raster, geo-referenced, crop-specific land cover data layer created annually for the continental U.S. using moderate resolution satellite imagery and extensive agricultural ground truth. There will be some differences between CropScape and official NASS estimates when comparing acreage statistics at the state, district, and county levels.

Overall the benefits of the NASS data include:

- Farmers and ranchers use the data to make specific decisions about their operations, such as what crops to plant, how many cattle or other livestock to raise, when to buy or sell agricultural commodities, and many more.
- Policymakers use the data to: (a) allocate funds based on state and community needs; (b) evaluate the impact and effectiveness of programs and policies; and (c) determine who may be affected by proposed agricultural legislation.
- Community planners and cooperatives use the data to: (a) identify needed services and facilities; and (b) plan recreational, educational, and community awareness programs based on the interests and concerns of local producers.
- Companies and industry groups use the data to: (a) monitor trends; (b) evaluate financial performance; (c) develop unbiased baseline industry information; (d) determine supply, prices, and export potential.
- Researchers and analysts use the data to: (a) monitor industries and their impacts on the economy; (b) adapt new technologies to increase agricultural productivity; (c) forecast trends, evaluate responses, and determine the social and economic implications
- USDA agencies use the data to: (a) administer farm loan, insurance, disaster assistance, and other programs; (b) allocate local and national funds for farm programs (including extension service projects, agricultural research, conservation, farm loans, and land grant colleges and universities).
- Federal and state agencies use the data to plan and administer agriculture programs as well as conservation, consumer protection, education, land valuation, recreation, trade, transportation, water and irrigation use, and worker safety programs.

Advantages

- The data in the Census of Agriculture or the estimates based on surveys are complete.

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

- The data is good for common commodities, as they may not be subject to confidentiality.
- A comprehensive count of farms, ranches, and agricultural production in the entire country is provided once every five years.
- The data is protected; a lockup security measure does not allow early access to sensitive information such as production forecasts for crops or livestock.

Disadvantages

- There are some sampling or non-sampling errors in the surveys between consecutive agricultural census years.
- Although the data can be considered timely for some applications, such as preparing annual crop yield trends over the past years, it may be considered latent for other applications, such as assessing stock shortages on a weekly basis.
- The data may not be good for minor crops as a majority of this data may be subject to confidentiality.
- Depending upon the particular crop, livestock, or topic of concern, surveys vary in size (from a few hundred to tens of thousands), frequency (weekly, monthly, quarterly, or annually), and coverage (the number of states involved).

5.3.2.4.2 USDA's Economic Research Service[6]

The purpose of the Economic Research Service (ERS)[7] is to inform and enhance public and private decision-making on economic and policy issues related to agriculture, food, the environment, and rural development.

The ERS conducts research and development and disseminates information relating to economic and statistical indicators on a broad range of topics including, but not limited to, global agricultural market conditions, trade restrictions, agribusiness concentration, farm and retail food prices, foodborne illnesses, food labeling, nutrition, food assistance programs, worker safety, agrichemical use, livestock waste management, conservation, sustainability, genetic diversity, technology transfer, rural infrastructure, and rural employment.

The ERS provides benefits to public and private decision-makers by providing economic and related social science information and analysis in support of the department's goals of enhancing economic opportunities for agricultural producers; supporting economic opportunities and quality of life in rural America; enhancing the protection and safety of U.S. agriculture and food; improving U.S. nutrition and health; and enhancing the natural resource base and environment.

Advantages

- The ERS provides objective statistics and data on the food, agricultural, and rural sectors.

Disadvantages

[6] https://www.federalregister.gov/agencies/economic-research-service (last accessed on April 13, 2015)

[7] http://www.ers.usda.gov/

- The ERS data products may use alternate methods, e.g., value-based and volume-based methods can be used to estimate share of consumed food that is imported or exported, the outputs of different methods can result in different estimates.

Aside from NASS and ERS, USDA also has the Agricultural Research Service (ARS), Agricultural Marketing Service (AMS), Grain Inspection, Packers and Stockyards Administration, etc. that can provide specific agriculture information, and perform specific research or regulatory functions.

5.4 Demonstration Findings

A demonstration was conducted to synthesize and summarize conventional and unconventional agricultural freight data sources, derive trip generation information, and develop composite information in the form of maps and metrics that support a variety of transportation related purposes—public and private decisions. During the demonstration, a spreadsheet tool was developed that:

- **performs template calculations for the trip generation** step of the travel demand modeling framework for three types of agricultural freight—(a) major crops, (b) a Concentrated Animal Feeding Operation (CAFO) and (c) a livestock auction facility, and

- **develops data for illustrative maps and metrics** for four case study purposes—(a) facility site location decisions, (b) local public decisions regarding a CAFO, (c) local public decisions regarding livestock auction facility, and (d) state and local public decisions regarding roadway and bridge temporary closure.

The demonstration:

1. Developed a compendium and summaries for conventional transportation data and unconventional agricultural freight data related to major crops, a CAFO and a livestock auction facility.
2. Produced template calculations for trip generation that are repeatable for major crops, a CAFO and a livestock auction facility in any other geographic location in South Dakota and other states.
3. Developed illustrative information to make improved decisions regarding purposes identified in the research of: (a) facility site location decision, (b) local public decisions regarding a CAFO, (c) local public decisions regarding livestock auction facility, and (d) state and local public decisions regarding roadway and bridge temporary closure.

These accomplishments were achieved given certain limitations:

1. The demonstration is limited in its geographic scope and agricultural freight typology. Agricultural freight activity needs to be understood for other types of agricultural freight such as those related to dairy, meat and ethanol processing facility, and there are other public and private decisions that require decision support information such as state and local roadway and bridge maintenance.
2. The illustrative decision support information needs enhancement with other types of conventional data sources that are currently not collected at the required spatial or temporal

resolution, for example, surface condition data is collected only on state highway system and not on farm access roads.

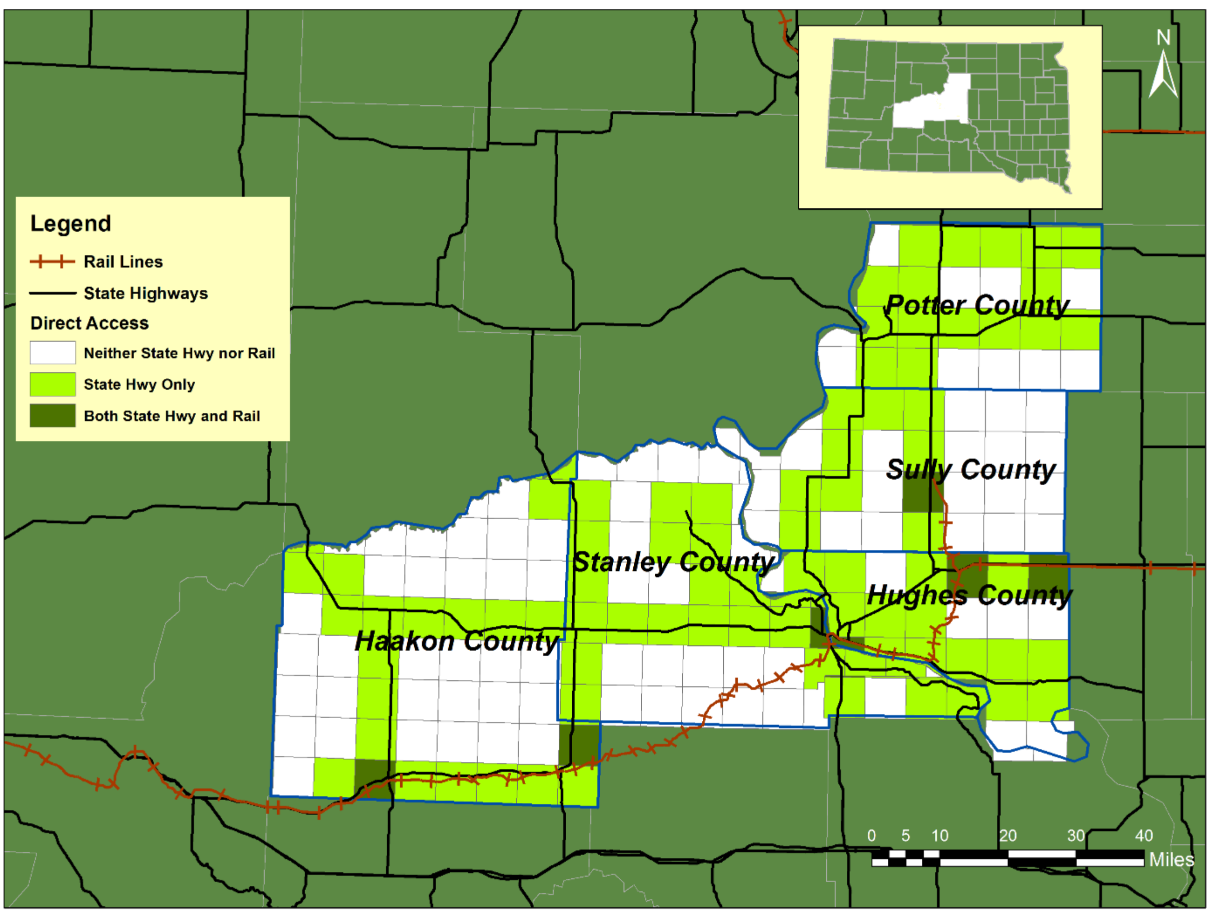
The following subsections document the demonstration and provide additional insights into the data inputs, outputs and application.

5.4.1 Transportation Data Summaries

Township level summaries of data collected from conventional transportation related data sources were prepared. The intent of these summaries is to inform public and private decision makers of the existing conditions on the transportation system in the demonstration area at the granularity of a township.

Figure 21 shows whether townships in the demonstration area have direct access to state highway or rail yards. Farms, grain elevators and other agricultural facilities need to be able to send their products to global markets, hence direct or nearly direct access to state highways and rail lines is essential. Not all townships have such direct access. The higher the agricultural production of township or the capacity of a facility, the greater is the need for such direct access.

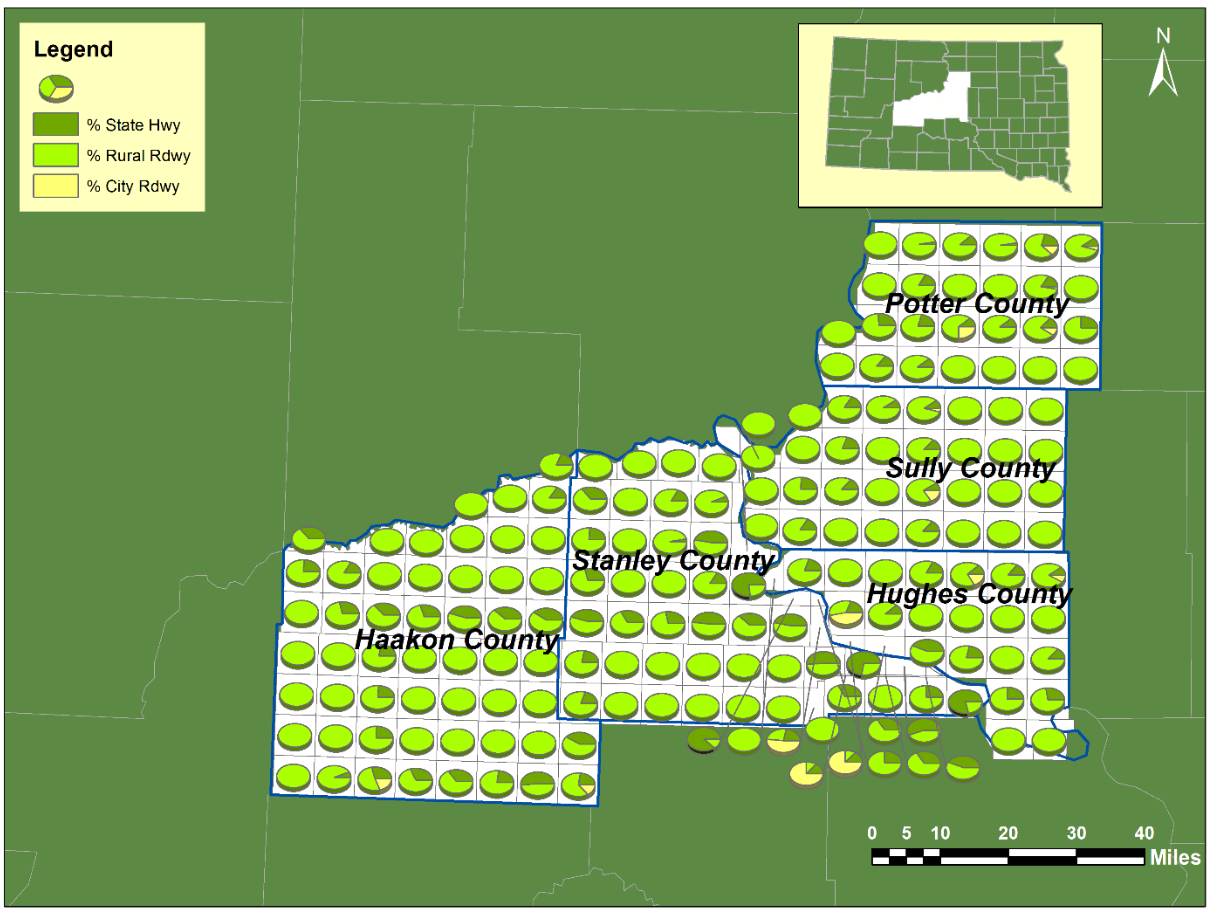
Figure 21 Demonstration Area Map of Direct Access of Townships to State Highway or Rail Yards



Source: ESRI and SDDOT GIS data, UGPTI and Cambridge Systematics Analysis. Note: The demonstration area is a five-county region of Haakon, Hughes, Potter, Stanley, and Sully counties.

Figure 22 shows percentage distribution of roadway miles by owner agency by township in the demonstration area. This helps identify which public agency(s) are responsible for maintaining roads in a township. In the demonstration area, there are no organized townships, so townships are not responsible for maintaining local roads, the city or the county performs this function for them. However, in the eastern parts of the State, counties and townships are both directly responsible for maintaining roads. The population density and agricultural freight activity are higher in the eastern parts of the State. In the western parts of the State where the population density is low and agricultural freight activity is replaced with other economic activities such as mining and tourism, and there are no defined townships, the planning areas are larger—county or city. The presentation of transportation data summaries in the context of agricultural freight therefore needs to be altered for the western parts of the State.

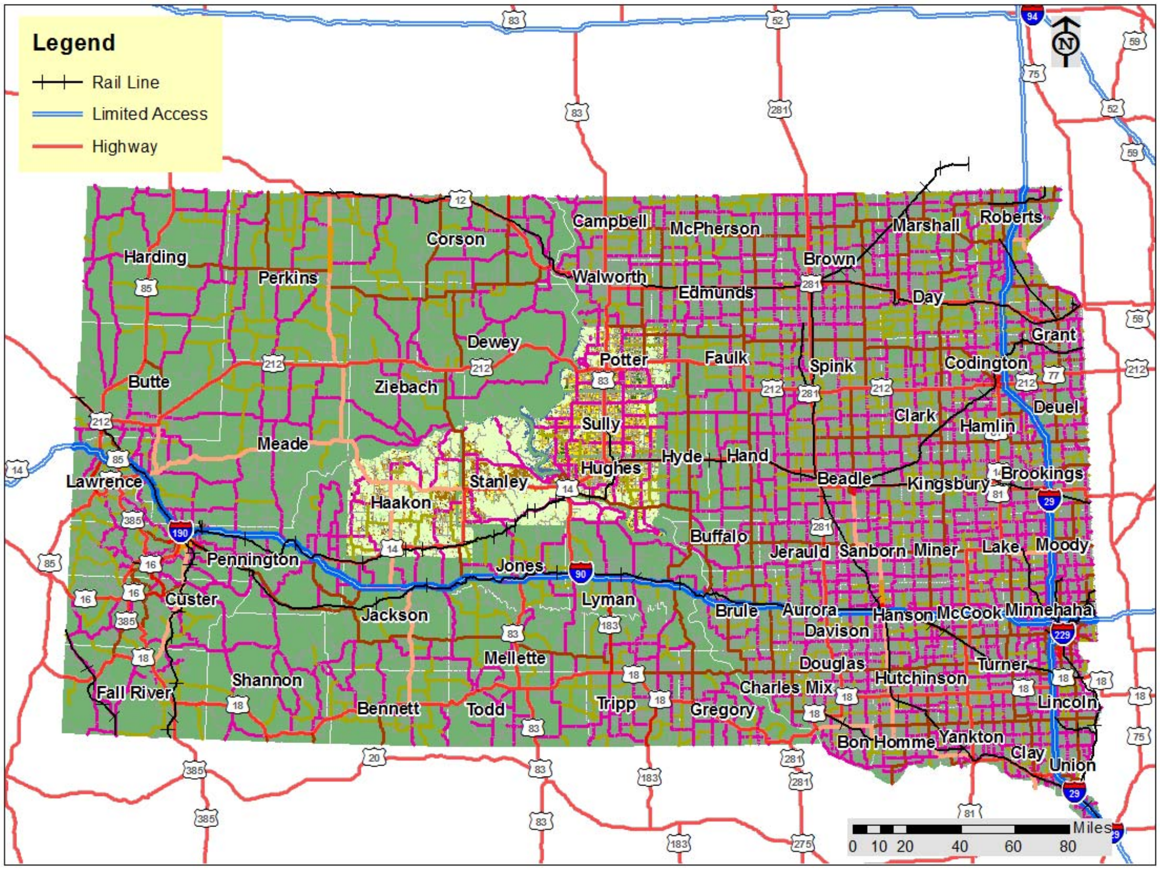
Figure 22 Demonstration Area Map of Percentage of Roadway Miles by Ownership by Township



Source: USDA National 2014 Crop Data Layer (CDL) data, SDDOT and ESRI GIS data. Note: The demonstration area is a five-county region of Haakon, Hughes, Potter, Stanley, and Sully counties.

As shown in Figure 23, with an increase in population density and agricultural freight economic activity from the west to the east of the State, the transportation network density similarly increases. In recent years, growth trends in agricultural freight production have been observed in the western parts of the State, generally counties with a reasonable soil productivity rating and within 100 miles of rail yard access. This growth may increase the need for a denser roadway network in the western parts of the State. The demonstration area has two such counties (Haakon and Stanley counties) that have a low road network density.

Figure 23 Statewide Transportation Network Map

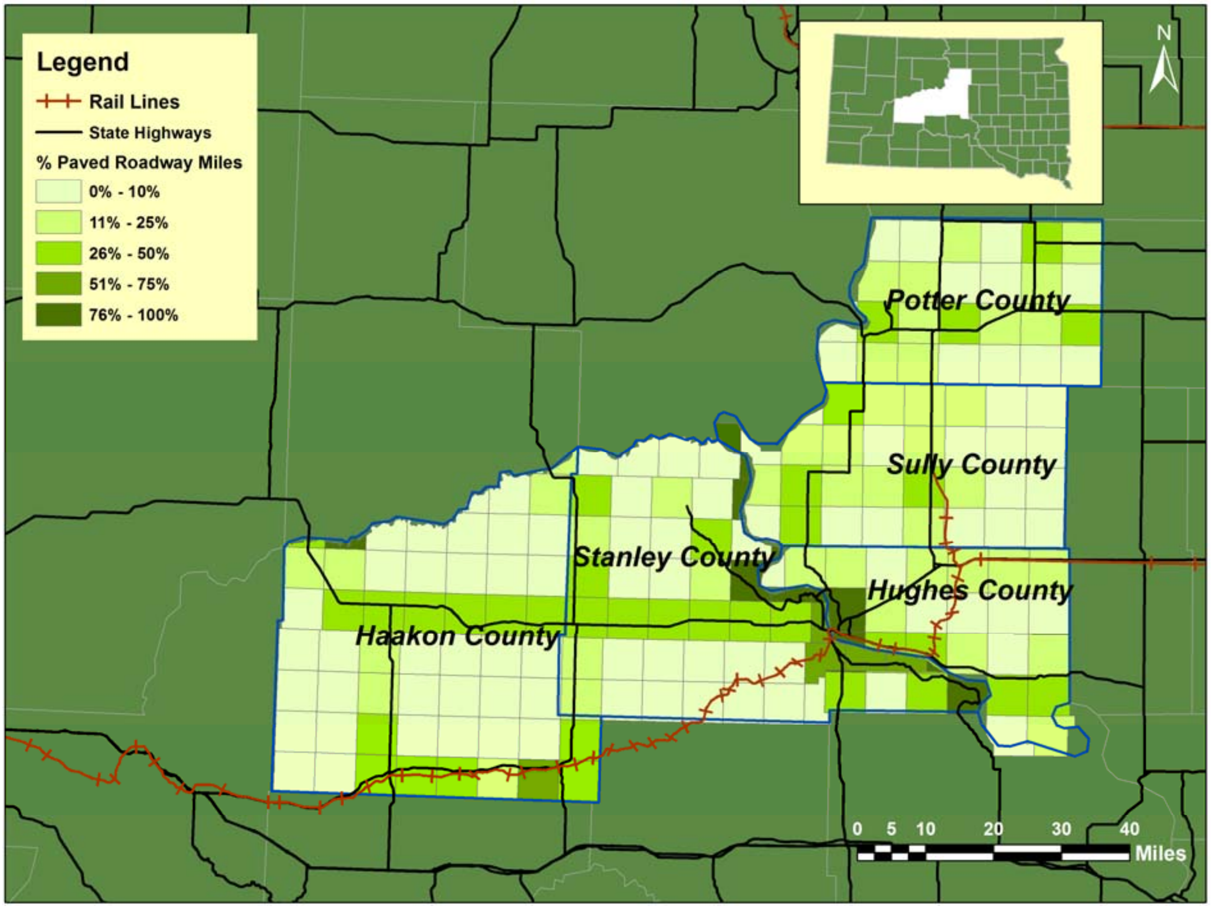


Source: SDDOT and ESRI GIS data

Figure 24 shows the percentage of paved roadway miles by township in the demonstration area. The pattern is very similar to the percentage of State owned highway roadway miles because a majority of State highways are paved, while a majority of other roads are unpaved, unless the roads are located in urban areas, such as Pierre. The other roadways include local farm and agricultural facility access roads and collector roads linking townships to state highways.

It is noted that both paved and unpaved roads can be in good or poor condition. Under the same weather conditions, an unpaved road in well-maintained condition may have better load carrying capacity than a paved road in poorly maintained condition. However, when a paved and unpaved road are both well-maintained and adequately designed, the paved road on average imposes a lower vehicle operating cost than the unpaved road.

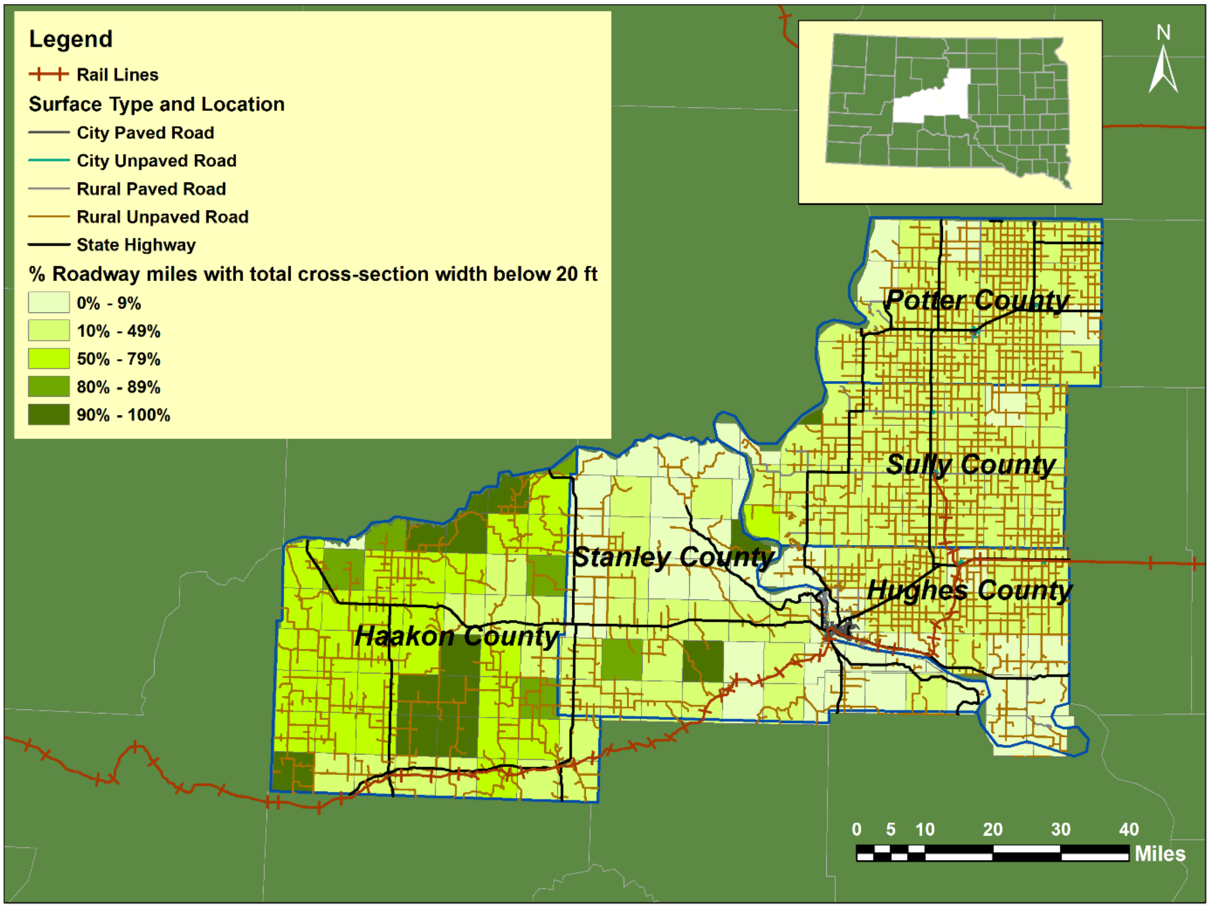
Figure 24 Demonstration Area Map of Percentage Paved Roadway Miles by Township



Source: USDA National 2014 Crop Data Layer (CDL) data, SDDOT and ESRI GIS data. Note: The demonstration area is a five-county region of Haakon, Hughes, Potter, Stanley, and Sully counties.

Figure 25 shows percentage roadway miles that have a total cross-section of less than 20 feet by township in the demonstration area. Narrower roads make it difficult for trucks to maneuver and pass, which is a problem particularly under bad weather conditions. There is a high percentage of these narrow cross-section roads in townships in Haakon County, but most townships in other counties have less than 50% of such roadway miles.

Figure 25 Demonstration Area Map of Percentage Roadway Miles with Total Cross-Section Width less than 20 feet by Township



Source: USDA National 2014 Crop Data Layer (CDL) data, SDDOT and ESRI GIS data. Note: The demonstration area is a five-county region of Haakon, Hughes, Potter, Stanley, and Sully counties.

5.4.2 Agricultural Freight Trip Generation Calculations

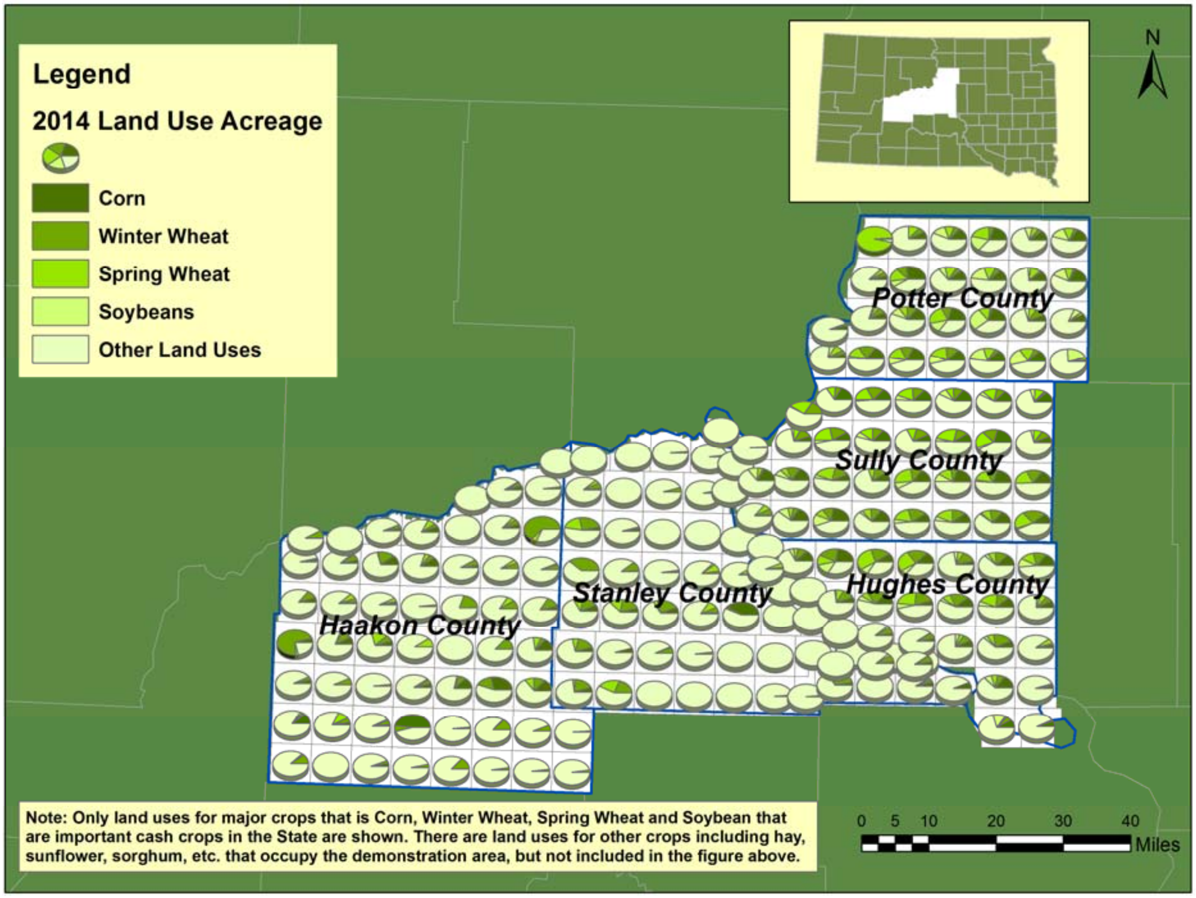
To estimate trips generated for major crops, a CAFO and a livestock auction facility, methods for each of the agricultural freight types using unconventional data sources were developed. The data sources, methods and the illustrative results in terms of trips generated are discussed.

5.4.2.1 Major crops related data sources, methods and trips generated

Figure 26 through Figure 30 show the inputs to estimating major crops related truck trips generated per township by quarter during 2014, while Figure 31 shows the output.

USDA NASS data provides a crop data layer, which is a raster (a colormap) GIS dataset describing agricultural land use in a calendar year. Using GIS software, the colormap for the year 2014 was reduced to a summary of acres by township for major crops (i.e., corn, winter and spring wheat, and soybeans) in the demonstration area. As shown in Figure 26, a majority of corn and soybeans acreage is in the eastern townships (in counties located east of Missouri River), while wheat acreage lies in townships both east and west of Missouri River. When all major crop acreages are combined, eastern townships have a higher share of land use dedicated to production of major crops than the western townships. Several western townships have negligible major crop acreages. Although the acreage summary was made based on a single year's crop data layer in this demonstration, an average estimate for acreage over 5-10 historical years could also be considered.

Figure 26 Demonstration Area Summary of 2014 Land Use Mix by Township

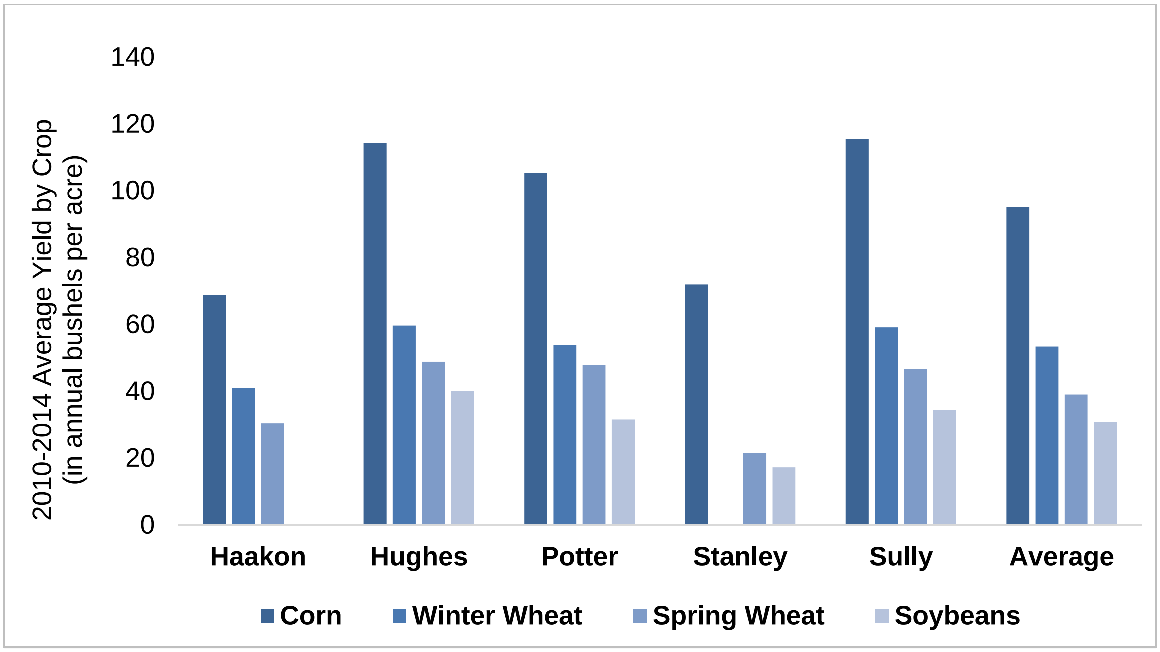


Source: USDA 2014 CDL data, ESRI GIS data, UGPTI's Analysis. Note: The demonstration area is a five-county region of Haakon, Hughes, Potter, Stanley, and Sully counties.

Major crop yield data in 2014 was not available at township level. Instead, USDA's NASS data was used to estimate a five-year (2010-2014) average annual yield for major crops. The major crop acreage by township was multiplied by the average annual crop yield to develop an estimate of annual total production of major crops by township. As shown in Figure 27, average crop yield for major crops in eastern counties of Hughes, Potter and Sully is higher than in western counties of Haakon and Stanley. Data on crop production was missing in NASS data for soybeans in Haakon County and winter wheat in Stanley County between the years 2010 and 2014. In such cases, the average for the demonstration area represented by the rightmost columns in the bar chart was used. Although soil productivity ratings[8] are available as raster dataset and can be used to redistribute crop yield between townships of a county, this was not carried out in this demonstration but can be considered in a future implementation.

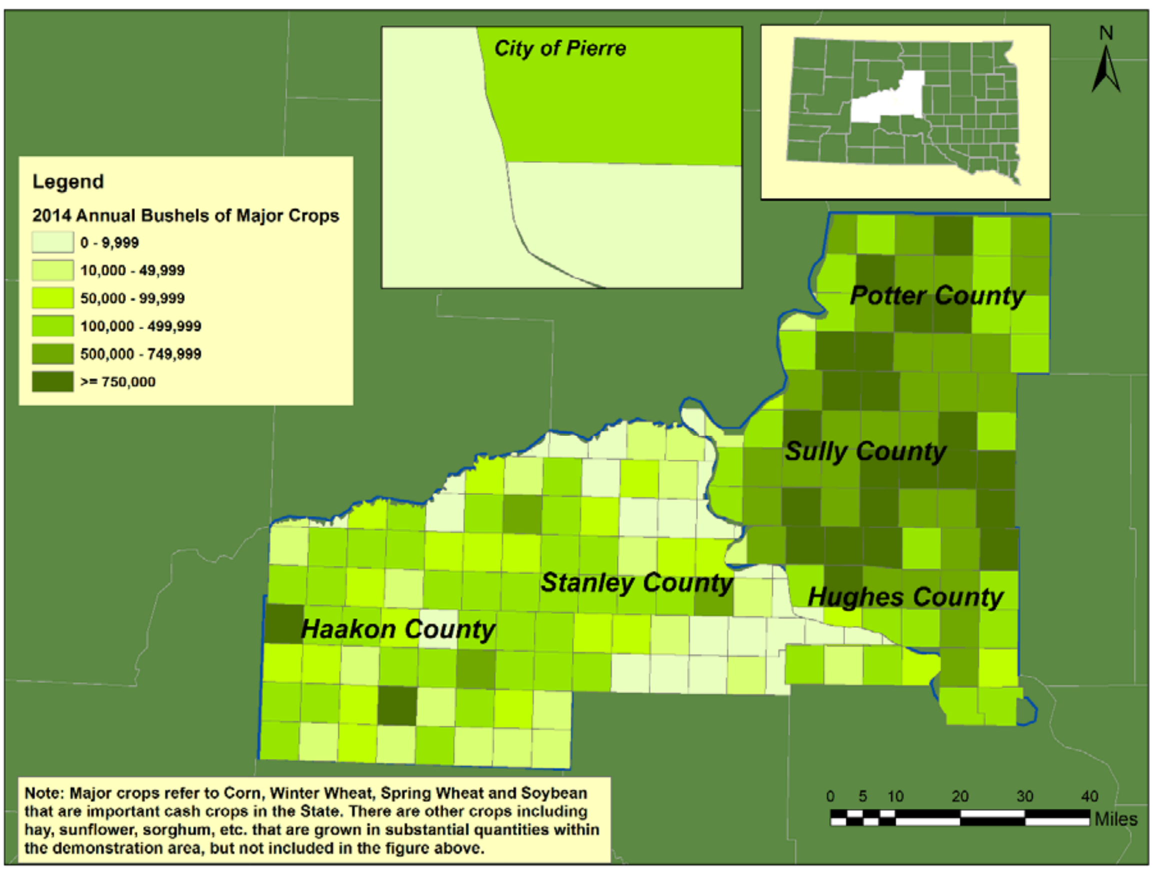
[8] http://www.nrcs.usda.gov/wps/portal/nrcs/main/sd/soils/ (last accessed on September 26, 2015)

Figure 27 Demonstration Area Summary of Average (2010-2014) Major Crop Yield by County



Source: USDA 2010-2014 NASS data

Figure 28 Demonstration Area Summary of 2014 Total Annual Bushels of Major Crops per Township



Source: USDA 2014 CDL data, ESRI GIS data, UGPTI's Analysis, USDA 2010-2014 NASS data

Figure 28 shows the year 2014 estimate for total production in bushels per township. The pattern of bushels is similar to the acreage distribution, and is further intensified for eastern townships due to the greater percentage of corn (major crop with a higher crop yield value) and a higher overall average crop yield than western townships.

USDA's NASS data for South Dakota reports typical harvest periods for major crops and their on-farm and off-farm storage stock levels in bushels by quarter, as shown in Figure 29. The storage stock levels indicate that the harvest periods for corn and soybeans fall within Quarter 4, but within Quarter 3 for wheat. The average stock levels also indicate that a larger portion of corn is stored on-farm, because corn may also be consumed locally as an animal feed ingredient.

This quarterly stock level pattern was generalized to all townships. Further, truck trips in bushels per quarter for a township were generated by assuming that the move from farm to off-farm storage is a one time flow and occurs in the same quarter as the harvest, while the move from on-farm storage to a grain elevator or an end user is a gradual flow, such that quantity of flow by quarter equals the change in on-farm stock levels between the beginning and end of the quarter.

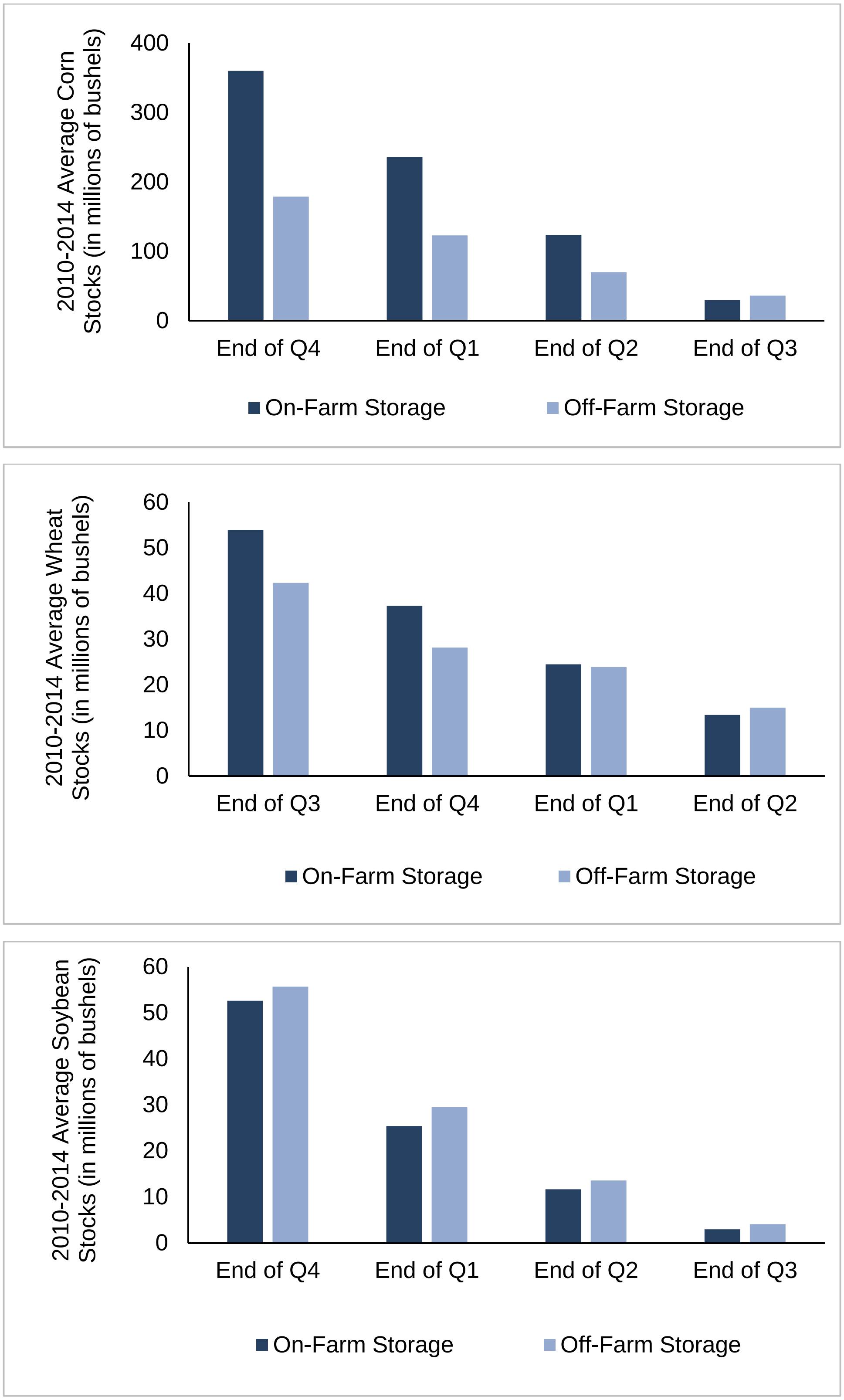
The estimated quarterly bushels per quarter in 2014 were then converted to equivalent single axle loads (ESALs) per quarter, in order that comparisons of the amount of surface damage by payload can be made under alternate truck configuration scenarios (see facility site location discussion in the following section).

This conversion was done using: (a) truck configuration mix built off a conventional data source of a weigh-in-motion station at Agar (Station ID 804) in the demonstration area; (b) assumptions on bushels per truck based on a UGPTI study[9], and (d) assumptions on average payload percentages of a truck and ESALs per truck based on a SDDOT study[10]. The truck configuration mix at Agar WIM in the year 2014 contained a majority of single trailer 5-axle trucks (41% of the total number of trucks), and single unit 2-axle trucks (32% of the total number of trucks), multiple trailer 7-axle trucks (12% of the total number of trucks), and 15% of other truck types. The average bushels per truck in 2014 was estimated about 785, the payload percentages varied between 55% to 70% depending on truck configuration type, and the average ESALs per truck was about 2.2.

[9] UGPTI, North Dakota Strategic Freight Analysis - Truck Size and Weight Issues in North Dakota, Final Report for North Dakota Department of Transportation, July 2007.

[10] David L Huft, Considerations for Imposing Local Load Restrictions, SDDOT, Research Note, last updated on Feb 12, 2014.

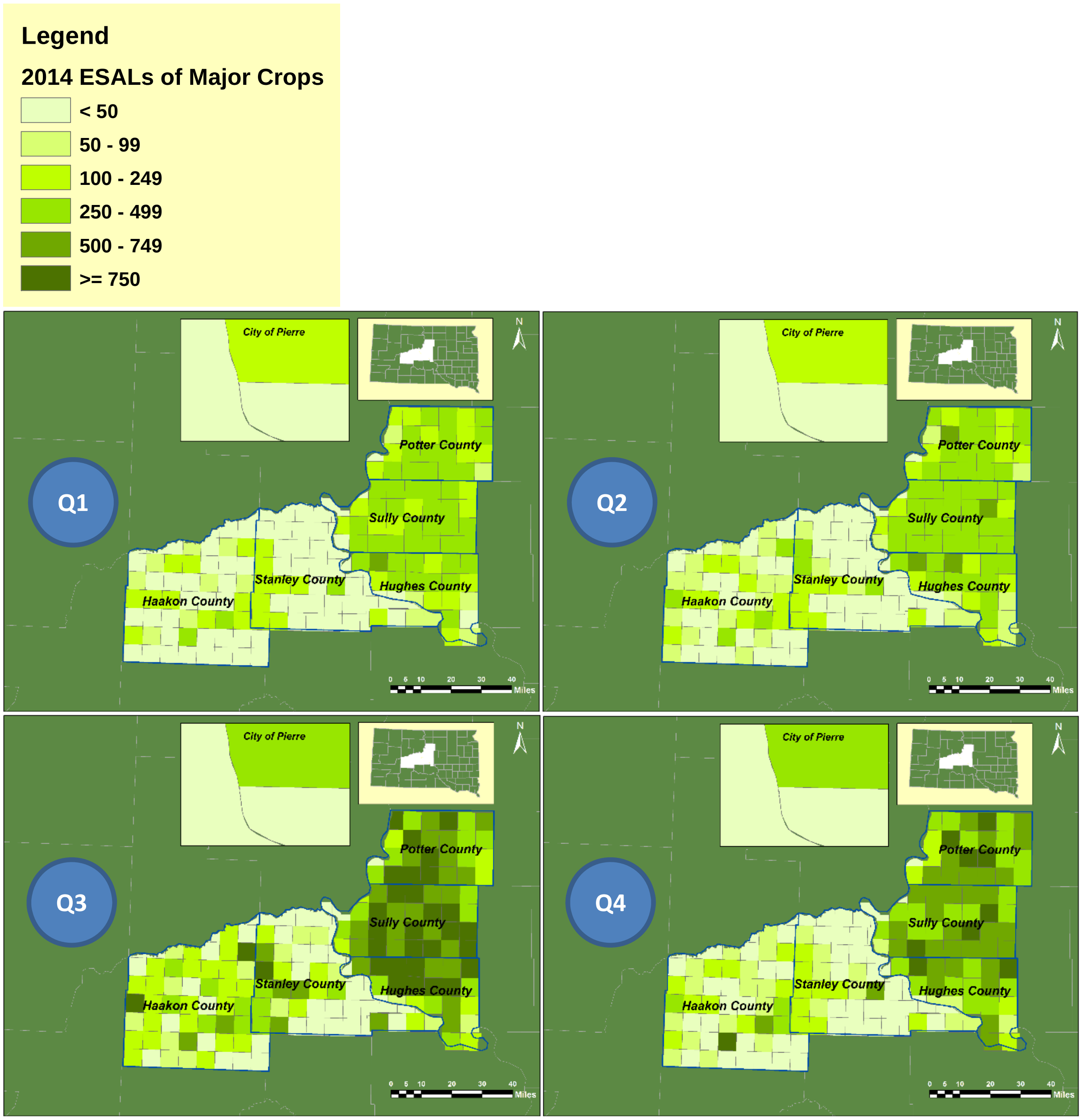
Figure 29 State level Average (2010-2014) Major Crop On-farm and Off-farm Storage Stock Levels



Source: USDA 2010-2014 NASS data

Figure 30 shows major crop related truck trips generated per township by quarter during 2014 in units of ESALs. In the demonstration area, Quarter 3 seems to be the busiest, and Quarter 1 seems to be the least busy.

Figure 30 Demonstration Area Summary of 2014 Total Quarterly ESALs of Major Crops per Township



Source: USDA National CDL data, USDA NASS data, ESRI and SDDOT GIS data, Agar WIM data, UGPTI, North Dakota Strategic Freight Analysis - Truck Size and Weight Issues in North Dakota, Final Report for North Dakota Department of Transportation, July 2007, David L Huft, Considerations for Imposing Local Load Restrictions, SDDOT, Research Note, last updated on Feb 12, 2014, and UGPTI and Cambridge Systematics Analysis.

Note: Major crops refer to corn, winter wheat, spring wheat and soybeans that are important cash crops in the State. There are other crops including hay, sunflowers, sorghum, etc. that are grown in substantial quantities within the demonstration area, but not included in the figure above.

In addition to existing trips generated for major crops, a few 'levers' or "what if" scenarios were also built for future trips generated for major crops in this demonstration. They pertain to cropland use shifts, crop yield growth factors, and truck fleet mix shifts based on SDDOT's prior research note[11] on alternate truck configuration policies.

USDA ERS provides national projections of crop acres, crop yield and crop uses up to 2024. Aside from this, USDA NASS data was used to develop historical trends (since 2006) in crop land use shifts by county in the demonstration area. These provide two ways of projecting crop acres and one way of projecting crop yield. The difference between the cropland use shifts in the national projections and historical trends is that the former projects a decline in acres planted, while the latter indicates a rise in acres planted.

Based on SDDOT's prior research note three scenarios are considered for truck fleet mix shifts—(a) status quo truck fleet mix (same as 2014), (b) use only single trailer 5-axle trucks with weight restriction of 80,000 pounds, and (c) use only multiple trailer 7-axle trucks with no 80,000 pound weight restriction.

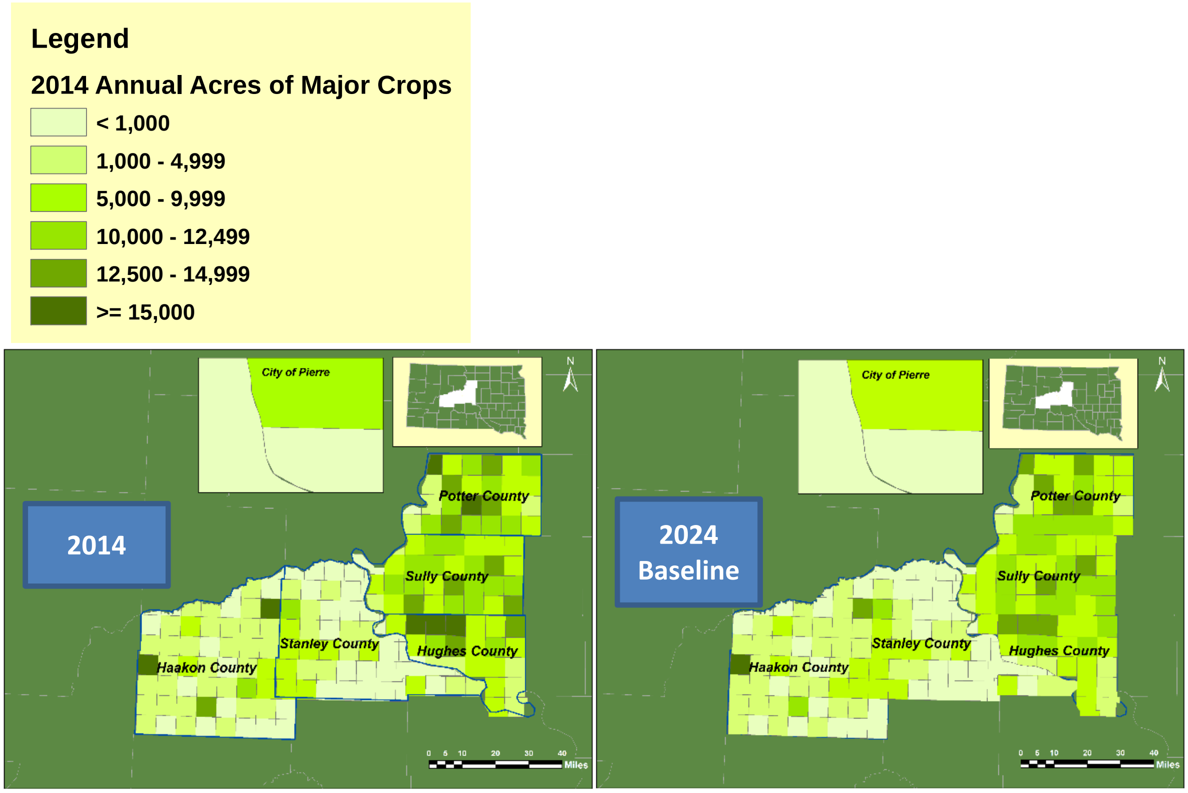
Trips generated for three scenarios for the year 2024 were evaluated in this demonstration as follows:

1. Baseline scenario is defined as the 2024 scenario that involves crop rotation and land use shifts based on USDA ERS' national projections (up to 2024) plus crop yield growth factors using USDA ERS' national projections (up to 2024) plus status quo truck fleet mix.
2. Alternate 1 scenario is a hypothetical scenario defined as baseline scenario minus status quo truck fleet mix plus use only single trailer 5-axle trucks with weight restriction of 80,000 pounds. Under this scenario, on average the bushels per truck increases from 785 to 858, and ESALs per truck increases from 2.20 to 2.28.
3. Alternate 2 scenario is a hypothetical scenario defined as baseline scenario minus status quo truck fleet mix plus use only multiple trailer 7-axle trucks with no 80,000 pound weight restriction. Under this scenario, on average the bushels per truck increases from 785 to 1,318 and ESALs per truck increases from 2.20 to 3.39.

Figure 31 shows a comparison of the crop acres planted per township in 2014 and 2024 baseline scenario, while Figure 32 shows a comparison of trips generated in ESALs per township in 2014, against baseline and alternate scenarios in 2024. Based on the comparison of the maps for 2014 and 2024 baseline scenario it is inferred that although the national projections indicate a decline in acres planted, the projected crop yield growth is sufficiently high to result in some increase in trips generated in ESALs per township from farms by 2024 over 2014 values. Both under Alternate 1 and 2 scenarios, the ESALs per township are lower even than the 2014 values.

[11] Ibid

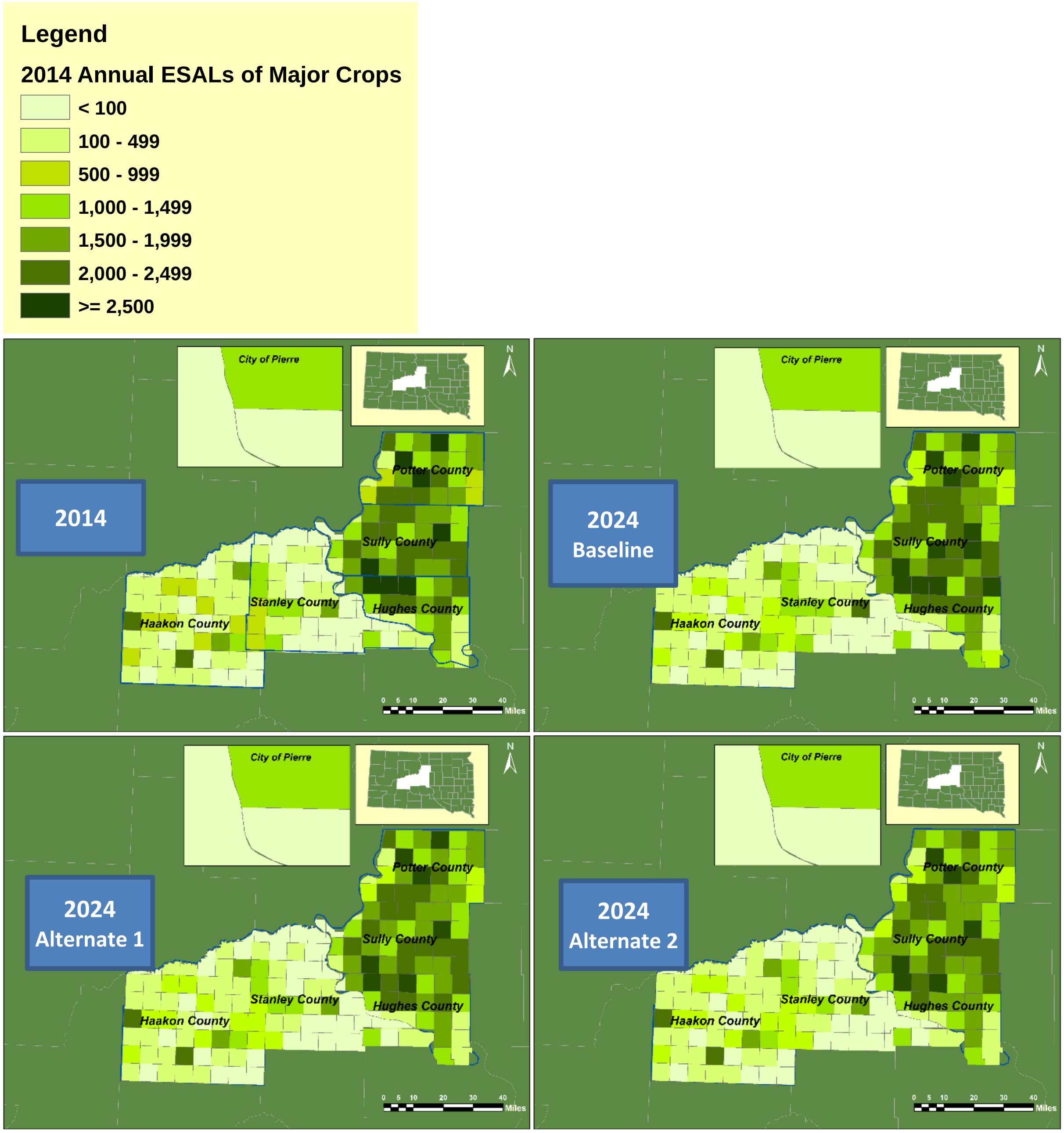
Figure 31 Demonstration Area Comparison of 2014 versus 2024 Baseline Scenario Acres of Major Crops per Township



Source: USDA National CDL data, USDA NASS data, ESRI and SDDOT GIS data, Agar WIM data, UGPTI, North Dakota Strategic Freight Analysis - Truck Size and Weight Issues in North Dakota, Final Report for North Dakota Department of Transportation, July 2007, David L Huft, Considerations for Imposing Local Load Restrictions, SDDOT, Research Note, last updated on Feb 12, 2014, and UGPTI and Cambridge Systematics Analysis.

Note: Major crops are comprised of South Dakota's four primary field crops in terms of volume: corn, winter wheat, spring wheat and soybeans. Other crops including hay, sunflowers, and sorghum, which are grown in significant quantities within the demonstration area, are not included in the above figure.

Figure 32 Demonstration Area Comparison of 2014 versus 2024 Baseline Scenario Acres of Major Crops per Township



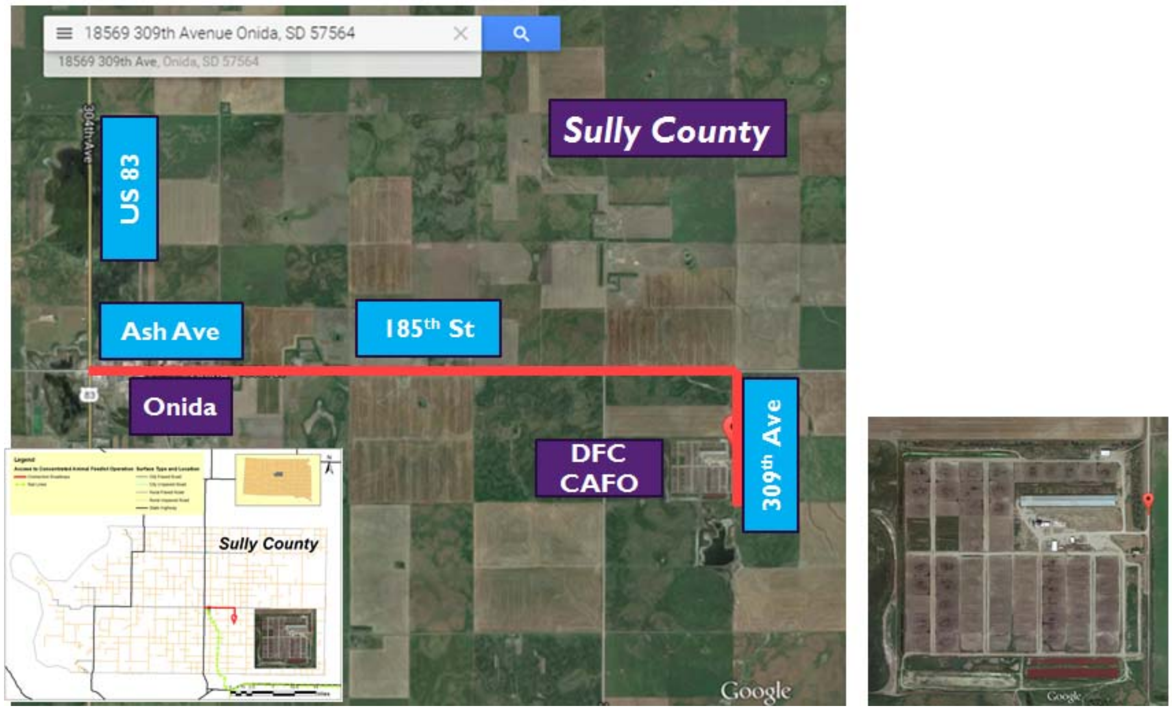
Source: USDA National CDL data, USDA NASS data, ESRI and SDDOT GIS data, Agar WIM data, UGPTI, North Dakota Strategic Freight Analysis - Truck Size and Weight Issues in North Dakota, Final Report for North Dakota Department of Transportation, July 2007, David L Huft, Considerations for Imposing Local Load Restrictions, SDDOT, Research Note, last updated on Feb 12, 2014, and UGPTI and Cambridge Systematics Analysis.

Note: Major crops are comprised of South Dakota's four primary field crops in terms of volume: corn, winter wheat, spring wheat and soybeans. Other crops including hay, sunflowers, and sorghum, which are grown in significant quantities within the demonstration area, are not included in the above figure.

5.4.2.2 CAFO related data sources, methods and trips generated

The CAFO located near Onida in Sully County, South Dakota as shown in Figure 33 was selected. Since site-specific cattle numbers were not available, USDA NASS data for Sully County was collected and assumed to be applicable to this CAFO. According to USDA NASS data, about 5,000 cattle were on feed in Sully County in 2014, and on average (2010-2014), about 60% among them were calves and 40% were cows.

Figure 33 Concentrated Animal Feed Operation (CAFO) near Onida in Sully County, South Dakota



Source: Google Maps

The activity at a CAFO was understood in three steps as shown in Figure 34 and as explained below:

Figure 34 Freight activity diagram for CAFO

Source: Cambridge Systematics

1. **Incoming animal transport**: In South Dakota, animals are moved from ranches and auction facilities to feedlots between February and April. Based on Michigan's livestock trucking guide[12], an average weaned calf is assumed to weigh 700 pounds while an average cow is assumed to weigh 1,000 pounds, and an incoming animal transport truck is assumed to carry about 45 calves or 34 cows. For a given number of cattle and mix of calves and cows, this translates to about 125 animal transport trucks over the period of February to April.

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[12] https://www.michigan.gov/documents/mdard/Livestock_Trucking_Guide_454102_7.pdf (last accessed on September 27, 2015)

2. **Incoming animal feed**: In South Dakota, grain and forage are moved to feedlots between February and October. Calves and cows are assumed to be fed for an average of 270 days and 150 days, respectively. Approximately, 30 pounds per day of feed and supplements are required per animal. Assuming an average payload of 20 tons per truck, and for a given number of cattle and mix of calves and cows, approximately 835 feed trucks are required over the period of February to October. This is also equivalent to about 115 monthly trucks from February to June and about 70 monthly trucks from July to October.

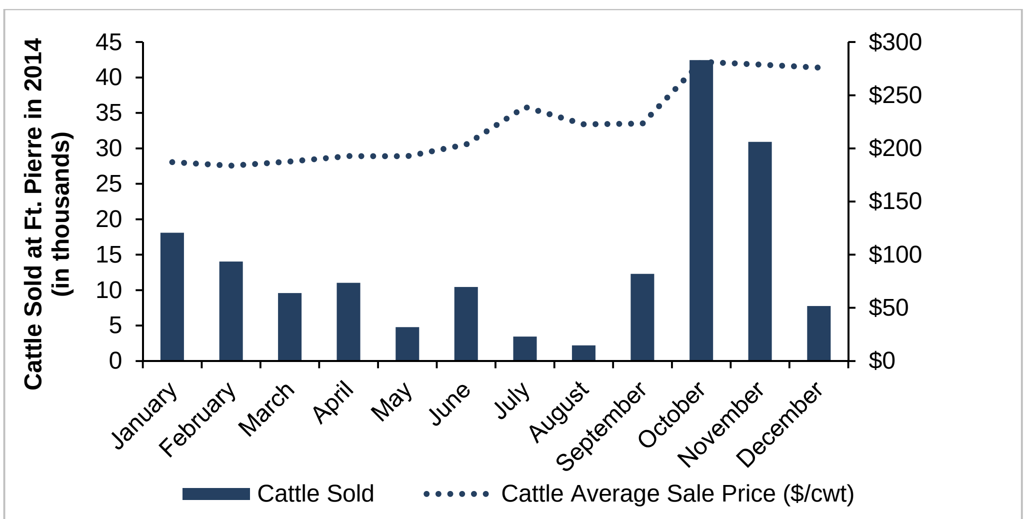
3. **Outgoing animal transport**: In South Dakota, animals are taken from feedlots to auction facilities or processors during the period from July to September for fat cows and October to December for yearling calves. Again, based on Michigan's livestock trucking guide, fat cows are assumed to weigh 1,400 pounds at the time of sale, and yearling calves are assumed to weigh 1,000 pounds at the time of sale, and an outgoing animal transport truck is assumed to carry about 34 calves or 23 cows. For the given mix, this translates to about 180 animal transport trucks over the period of July to December. Of these, about 90 are moved from July to September and 90 are moved from October to December.

5.4.2.3 Livestock Auction Facility related data sources, methods and trips generated

The livestock auction facility located at Ft. Pierre in Stanley County, South Dakota was selected. USDA AMS data on number of cattle, average price, and average weight for Ft. Pierre in 2014 was collected. In terms of agricultural freight activity, a livestock auction facility is very similar to a CAFO. The difference however is that the number of cattle moved in and out of the auction facility is significantly higher and the duration for animal feed activity is much shorter. At Ft. Pierre auction facility, about 167,000 cattle were sold in 2014 and the animal feed activity is on average about two weeks. In addition, incoming and outgoing cattle weights are nearly the same.

Figure 35 shows the number of cattle sold and average price of livestock by month in the year 2014. September to November are peak months for sale of cattle at the auction facility.

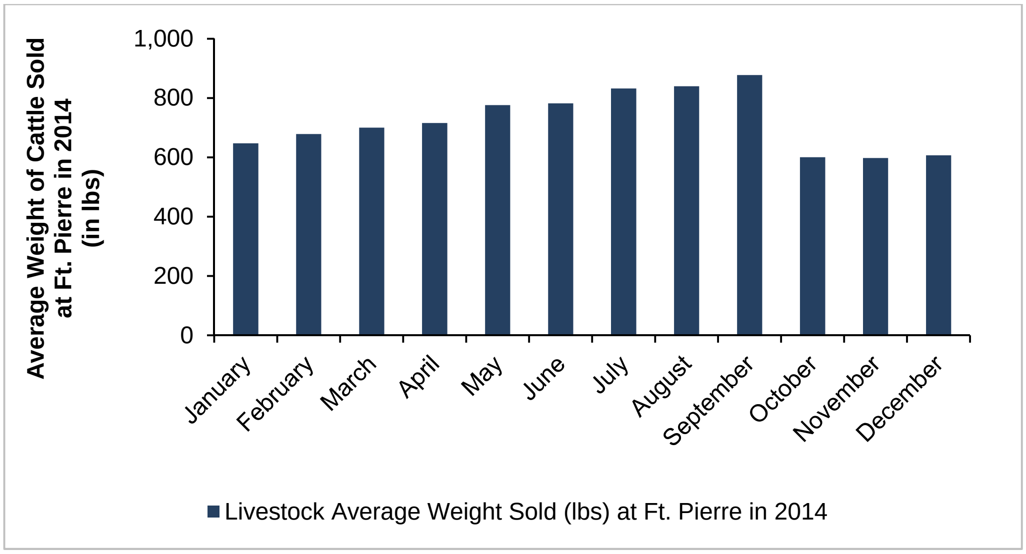
Figure 35 Cattle Sold and Average Price per Hundredweight by Month at Ft. Pierre Livestock Auction Facility at Pierre, South Dakota, 2014



Source: USDA AMS 2014 Data for Ft. Pierre Livestock Auction Facility, Cambridge Systematics Analysis

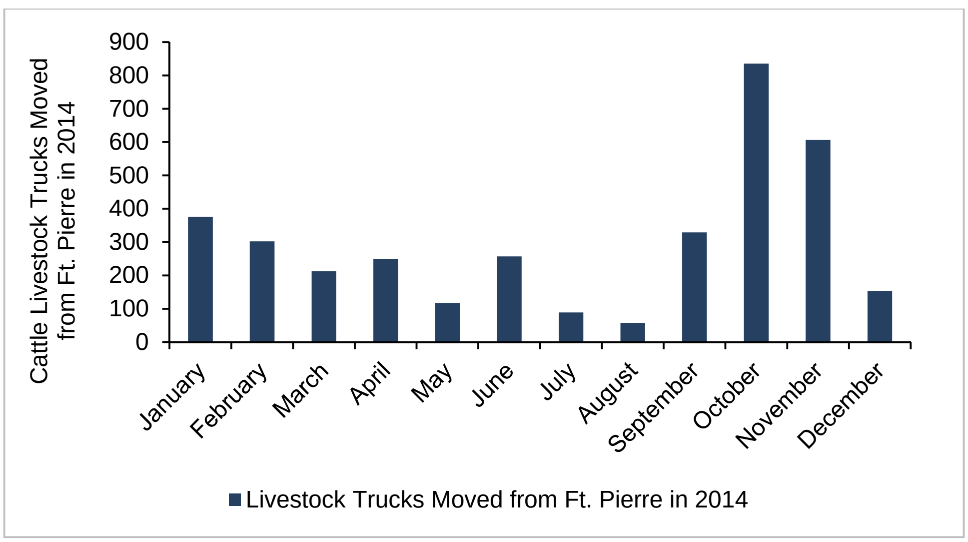
Figure 36 shows the average weight of cattle sold by month. This is combined with Michigan's Livestock Trucking Guide assumptions to estimate animal transport trucks required for one-way transport as shown in Figure 37.

Figure 36 Average Weight of Cattle Sold by Month at Ft. Pierre Livestock Auction Facility at Pierre, South Dakota, 2014



Source: USDA AMS 2014 Data for Ft. Pierre Livestock Auction Facility, Cambridge Systematics Analysis

Figure 37 Average Livestock Trucks Moved One-Way (either to or from) by Month at Ft. Pierre Livestock Auction Facility at Pierre, South Dakota, 2014



Source: USDA AMS 2014 Data for Ft. Pierre Livestock Auction Facility, Cambridge Systematics Analysis

5.4.3 Composite Decision Support Information

Transportation data conventionally collected and maintained by SDDOT is limited to the state highway system and thus provides limited utility for providing insights into agricultural freight activity that produces it. By combining this data with agricultural freight data, state and local agencies can make more informed decisions, particularly by leveraging investment.

By identifying locations of high or spatially concentrated or temporally peaking agricultural freight demand, locations for future data collection, can be identified and prioritized, which in turn helps federal and State agencies strategically expand or optimize a data collection program.

Through an evaluation of "what if" scenarios such as changes in truck configuration mix and establishing typology in terms of agricultural freight activity and intensity, regional, and local agencies can replace data collection with modeled estimates both now and in the future.

The private sector can also benefit from a combining transportation and agricultural data, in areas such as facility location (including permitting), operational management, and marketing.

In this demonstration, illustrative decision support information for a few of the many purposes was developed, as described in the following subsections.

5.4.3.1 Facility Site Location Public and Private Decision Support Information

Facility site location is typically a long-term private sector decision. In the context of locating agricultural facilities that are reliant on field crops or livestock as a principal input, such as grain elevators, animal feedlots, ethanol plants, crop processing plants, etc., proximity to areas of production, and availability of high quality transportation infrastructure are necessary. In this demonstration of grain elevator facility site location, the transportation data summaries presented earlier were considered to serve as a proxy for the quality of available transportation, and total demand for major crops was considered to represent potential demand for locating grain elevators. These were evaluated using the illustrative criteria as shown in Table 9.

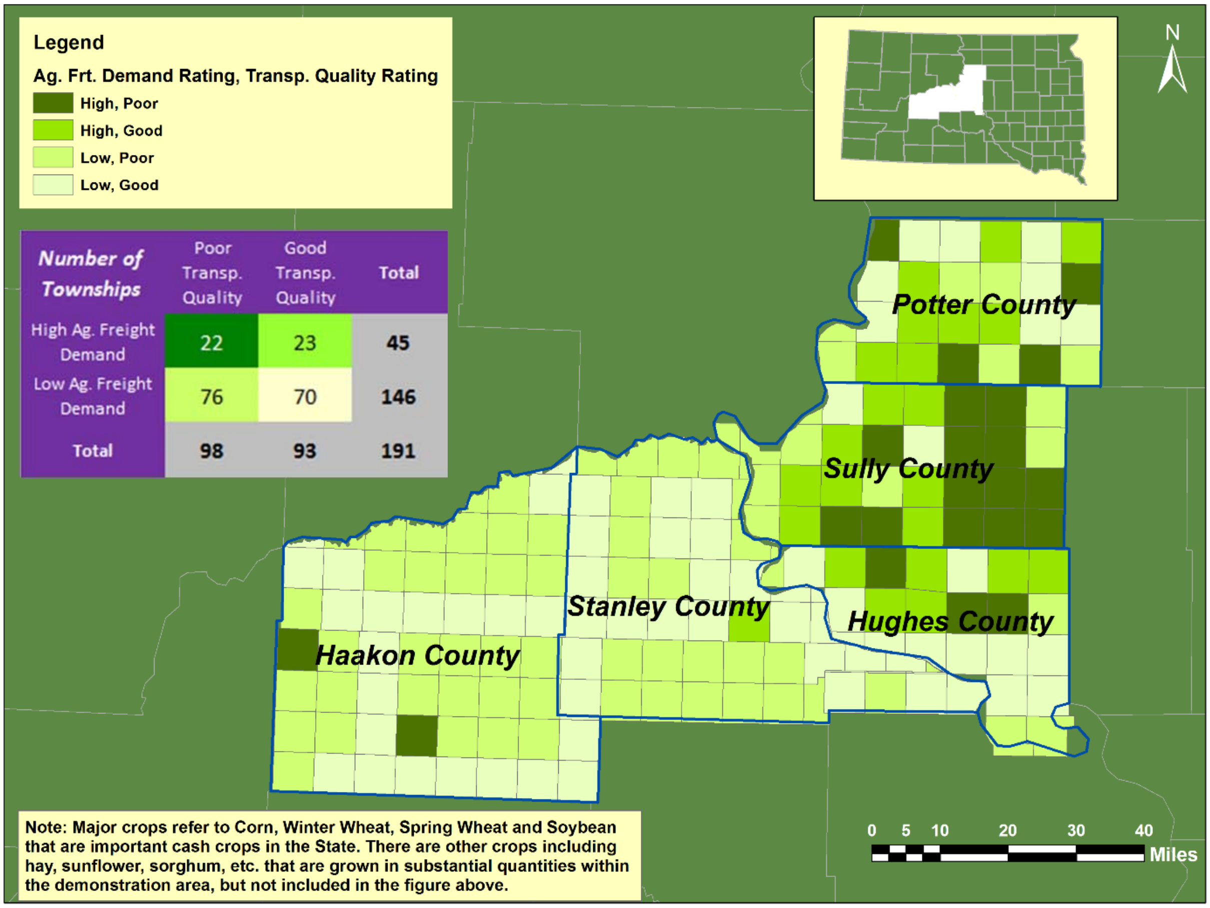
Table 9 Illustrative Criteria for Evaluation of "Greatest Need" or "Greatest Opportunity"

Area of Assessment	Illustrative Criteria
Freight Demand	• **High** when freight demand for at least one of the major crops is above the 80th percentile value; • Otherwise **Low**
Transportation Quality*	• **Poor** when % unpaved is greater than 80% with no direct access to state highway and rail lines, or • **Poor** when % total cross-section width < 20 feet greater than 80%, or • **Poor** when at least one bridge weight limited • Otherwise **Good**

Source: Cambridge Systematics, Inc. Note: *Other important measures of transportation quality (e.g., surface condition) were not considered in this illustration due to data availability.

Based on application of the illustrative criteria, a map and tabulated information at a township level was developed. As shown in Figure 38, the number in the red cell, which is 22 (or about 12% of the total townships in the demonstration area), represents the number of townships that have high agricultural freight demand but poor transportation quality. The number in the yellow cell, that is 76 (or about 40% of the total townships in the demonstration area), represent the number of townships that have low agricultural freight demand and poor transportation quality, and so on. This type of map and table provides information to public decision-maker on the townships with the "greatest need" or "greatest opportunity."

Figure 38 Evaluation of Agricultural Freight Demand and Transportation Quality* for Facility Site Location Decision in the Demonstration Area



Number of Townships	Poor Transp. Quality	Good Transp. Quality	Total
High Ag. Freight Demand	22	23	45
Low Ag. Freight Demand	76	70	146
Total	98	93	191

Source: USDA National CDL data, USDA NASS data, ESRI and SDDOT GIS data, Agar WIM data, UGPTI, North Dakota Strategic Freight Analysis - Truck Size and Weight Issues in North Dakota, Final Report for North Dakota Department of Transportation, July 2007, David L Huft, Considerations for Imposing Local Load Restrictions, SDDOT, Research Note, last updated on Feb 12, 2014, and UGPTI and Cambridge Systematics Analysis.

Note: *Other important measures of transportation quality were not considered in this illustration due to data availability (e.g., surface condition).

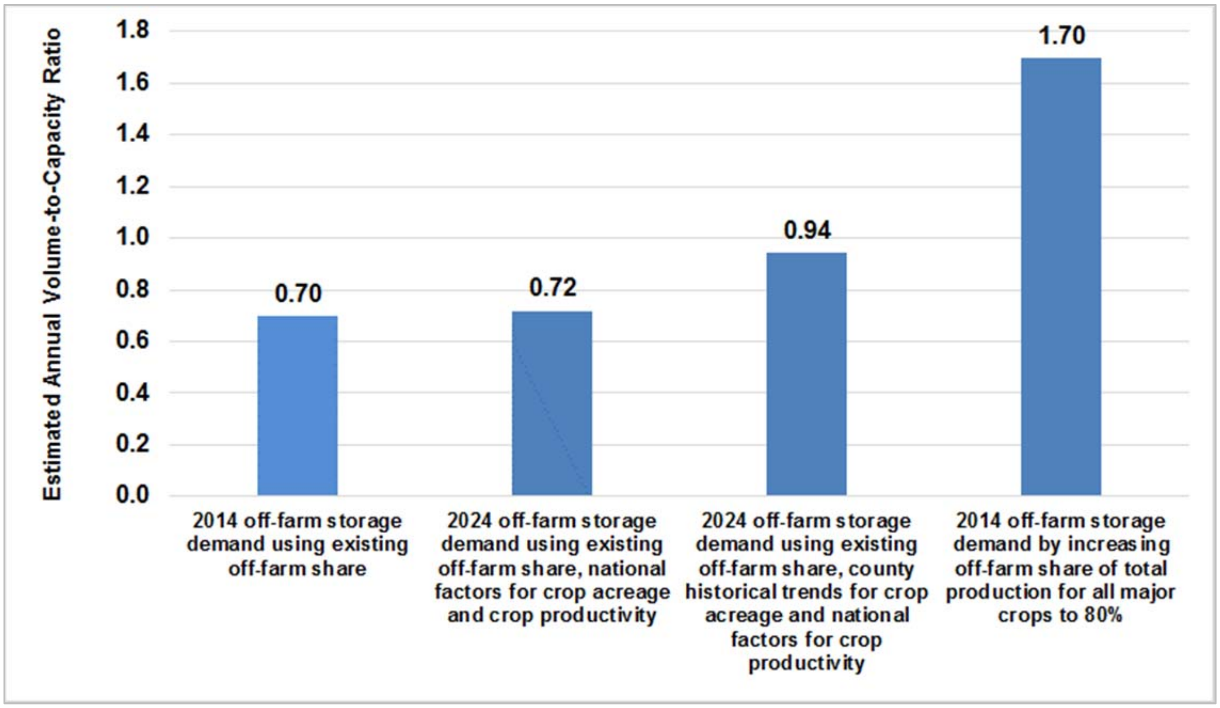
Other criteria to consider in grain elevator site selection require additional data and / or analysis as follows:

- **Demand for additional service**: This is dependent on the current and projected off-farm storage demand and available off-farm storage capacity. In the demonstration area, based on licensed capacity of off-farm storage facilities, the existing total available storage capacity is 28.5 million bushels per year.

  On average (2010-2014), statewide off-farm share of total production by crop are: corn—15%, wheat—45% and soybeans—75%. The low off-farm storage of corn may be due to corn's use for on-farm animal feed use or increased availability of on-farm storage.

  Figure 39 shows that under current demand and off-farm shares scenario, the demand is about 70% of available capacity. Under two hypothetical demand scenarios that call for increased crop acreage but with the off-farm storage share being kept constant, the demand will still remain below capacity. Demand will exceed capacity under a scenario of current demand but with off-farm storage share of all major crops reaching 80%.

Figure 39 Evaluation of Agricultural Freight Demand and Transportation Quality* for Facility Site Location Decision in the Demonstration Area



Source: USDA NASS data, USDA FSA data, Cambridge Systematics Analysis.

- **Accessibility, that is, distance and travel time to markets**: In this demonstration, a preliminary accessibility index was developed for grain elevators with rail access by taking an average distance for townships to all grain elevators as shown in Figure 40.

  The accessibility index measure can be improved further by weighting the distance with farm production and elevator capacity to identify townships with the greatest grain elevator accessibility need.

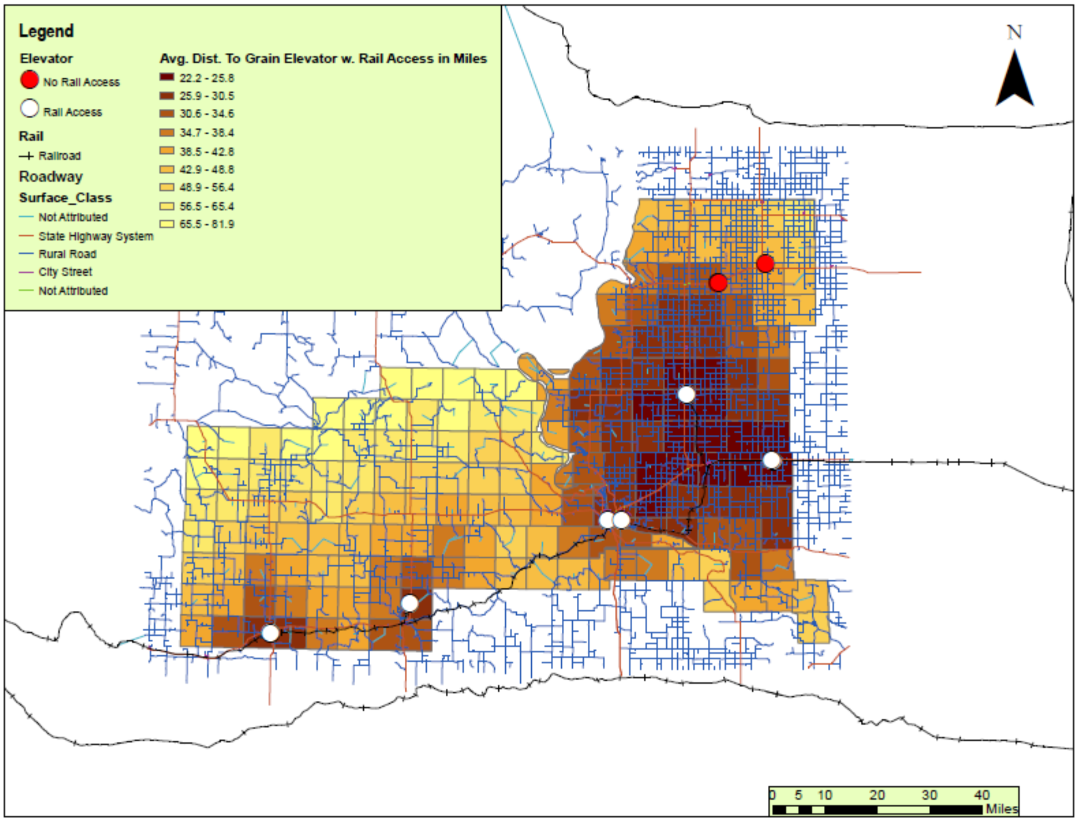
- **User transportation cost**: In this demonstration data on transportation costs was not collected, but it is an important data element for understanding availability and mode choice of agricultural freight;

- **Surface and bridge type and condition**: Vehicle operating costs are dependent on surface and bridge type and condition. Figure 41 shows that in the State on average gravel roads impart higher vehicle operating costs than hot-mix asphalt (HMA) paved roads, which holds especially true when both types of roads are well maintained. Therefore, grain elevator facilities are far more likely to locate on paved roads; and

- **Geometric constraints**: Aside from the cross-section width, there are other geometric constraints such as sight distance, turning radius, etc. that may result in delays or safety costs.

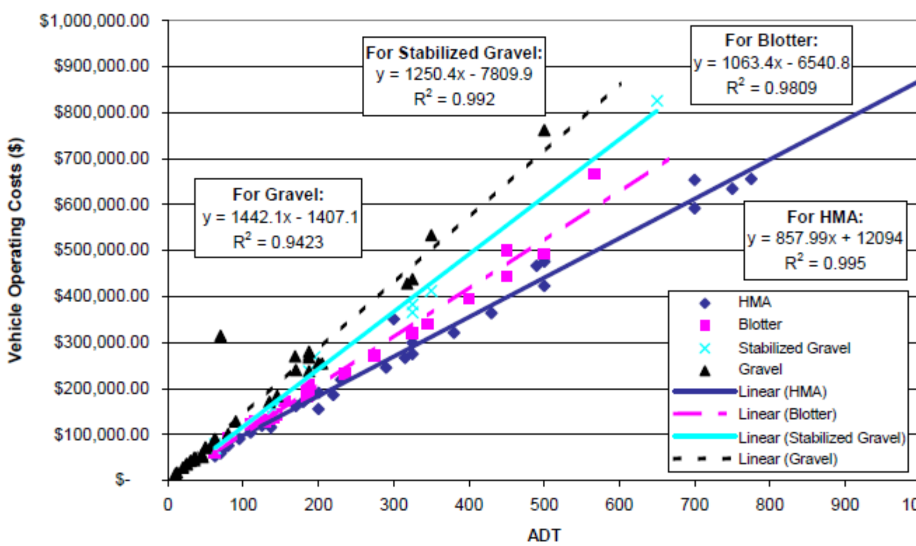
The public sector may also consider these types of criteria in approving and permitting conditional use or leveraging private investments on "last mile" connectors to a site.

Figure 40 Accessibility Index (Average Distance) to Grain Elevators with Rail Access from Townships



Source: ESRI and SDDOT GIS data, UGPTI's Analysis.

Figure 41 Vehicle Operating Costs by Roadway Type by Average Daily Traffic in South Dakota



Source: K.A. Zimmerman and A.S. Wolters, Local Road Surfacing Criteria Research Study, Final Report No. SD2002-10, Prepared for South Dakota Department of Transportation, Office of Research, June 2004.

5.4.3.2 CAFO Local Public and Private Decisions Support Information

CAFO site location decisions are similar to a grain elevator site location decisions, however with the difference that the input and output to a CAFO is a livestock unit instead of a grain unit. Hence, the related site location decisions are not discussed here. Once conditional use permits are established and a CAFO site is built, the decisions are made on a daily or seasonal basis by local public agencies and the owner and operator of the CAFO.

A CAFO for cattle can be converted into a standard typology by estimating approximate annual trip generation rates based on trip generation calculations for the CAFO near Onida in Sully County. The trip generation rates are summarized by step of CAFO activity as follows:

1. **Incoming animal transport**: Approximately, 0.0257 loaded transport trucks per animal
2. **Animal feed transport**: Approximately, 0.1665 loaded feed trucks per animal
3. **Outgoing animal transport**: Approximately, 0.0354 loaded transport trucks per animal

The rates above could be scaled to go from a single inventory or placement of cattle on feed to a number of "turns" or times that cattle are placed into feedlots within a year. The seasonality of movement of cattle from or to a CAFO in one part of South Dakota may not differ much from another part of South Dakota, however it may change when moving to another State in the U.S. with different seasonal weather patterns.

Trip generation rates such as the above in general help public agencies make quick demand estimates and analyze impacts of new or expanded facilities.

Aside from the trip generation rates, by studying the transportation data elements of "last mile" access roads connecting to a State highway similar to as shown in Table 10, the impacts of agricultural freight trips throughout a year can be determined. Surface condition data would enhance the daily and seasonal decision-making. Since the demand is small but distributed over a long period of time in a year, the surface maintenance needs are also likely to be small but distributed over a long period of time in a year.

Table 10 Roadway Characteristics on Connector Roadways to CAFO for Cattle near Onida in Sully County, South Dakota

	Ash Ave	185th St	309th Ave
Distance Traveled	1.0 mile	4.0 miles	1.5 miles
Surface Width	48 ft	24 ft	14-24 ft
Surface Type	Bituminous	Bituminous	Gravel or Crushed Rock
Shoulder Type	No shoulder	Concrete shoulder	No shoulder

Source: Google Maps, ESRI ArcGIS, Cambridge Systematics

5.4.3.3 Livestock Auction Facility Local Public Decision Support Information

A livestock auction facility for cattle can also be converted into a standard typology by estimating approximate annual trip generation rates based on trip generation calculations for the livestock auction facility at Ft. Pierre in Stanley County, South Dakota. Unlike a CAFO, a livestock auction facility has heavy peaking, so the peak month and season factor is more important.

The livestock auction facility is located next to an urban area of Pierre. Peaking in traffic in combination and the urban location result in both increased surface maintenance and traffic management needs during the peak month and season. Due to high volumes of truck flow in and out of the livestock auction facility, truck-car and truck-pedestrian conflicts could be a concern. The researchers learned that Pierre has developed a traffic management plan during peak sales period that tries to minimize traffic conflicts. Aside from the peak month traffic, during spring time as frost leaves the roadbeds urgent surface maintenance needs may arise, which reduces serviceability of the traffic entering or leaving the livestock auction facility.

Similar traffic management issues may exist with other agricultural facilities that are located in urban areas, such as dairy plants near Brookings, South Dakota.

5.4.3.4 Road and Bridge Temporary Closure related State and Local Public Decisions Support Information

Due to a significant percentage of unpaved roadway miles, states such as South Dakota are seasonally impacted by weather effects. The weather effects are severe on unpaved roads that lose some of their strength during wet weather conditions and thus have a lower load bearing capacity than when weather conditions are dry. The vehicle operating costs on average are higher on unpaved roads than on paved roads.

On the other hand, unpaved roads also have an advantage that they can repaired easily, and take less time and expense to restore to full strength than paved (hot mix asphalt or concrete) roads. For the same traffic level, the cost of maintaining unpaved roads is also lower, and blading is a typical maintenance need.

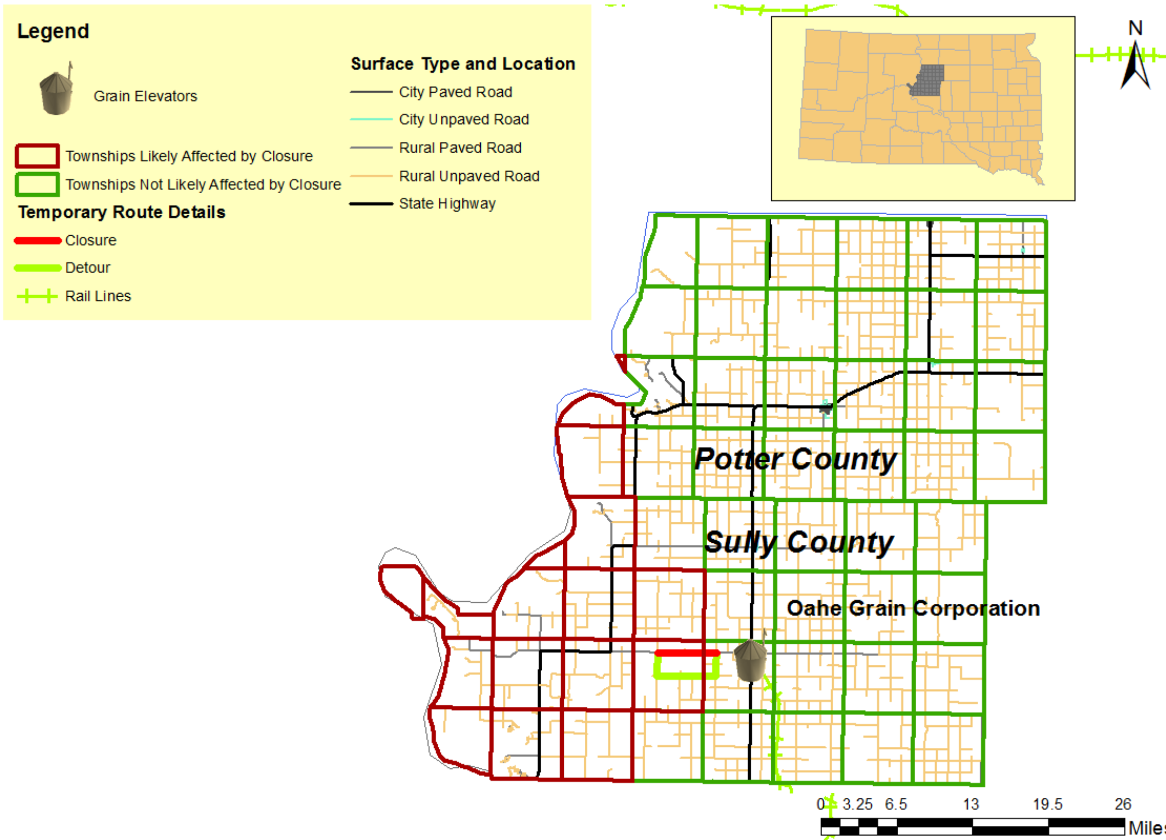
Like roads, bridges have routine maintenance needs, and occasionally fail. Because bridges are costly to replace, replacement is often deferred, and sometimes load restrictions are placed on bridges to prolong their life.

In Sully County, a bridge at Sully Lake was declared unpassable and the road, 185th Street from 301st Avenue to 295th Avenue, was closed in July 2015. As a result, some of the farm traffic that accessed major grain elevators at Onida were forced to detour. Figure 52 shows the location of temporary closure, the townships affected, and the detour route during the closure.

Assuming that 50% of the production in major crops in the townships is affected by the road and bridge closure, and assuming changes in agricultural freight demand between 2014 and 2015 to be small, an estimated 1700 ESALs are likely to be diverted during 2015 Q3. This type of estimation was made possible due to the availability of agricultural freight demand at the granularity of townships.

To estimate the traffic diversion impacts on surface maintenance, transportation data elements for original and detour routes were also collected and summarized as shown in Table 11. Surface condition data would enhance the decision-making on this sudden closure.

Figure 42 Location Map of Road and Bridge Closure in Sully County, Affected Townships and Detour Route



Source: ESRI and SDDOT GIS Data, UGPTI and Cambridge Systematics Analysis

Table 11 Roadway Characteristics on Original and Detour Routes for Sully County Road and Bridge Closure in July, 2015

	Original	Detour
Distance Traveled	5.01 miles	8.94 miles
Surface Type	Bituminous	Gravel or Crushed Rock
Shoulder Type	Concrete shoulder	No shoulder

Source: Google Maps, ESRI ArcGIS, Cambridge Systematics

6 RECOMMENDATIONS

On the basis of the findings of this research, five recommendations have been proposed for further action by the South Dakota Department of Transportation. These recommendations are made within three categories: Monitor Agricultural and Transportation Industry Trends, Incorporate Agriculture Resources in Transportation Decision-making, and Local Transportation Data Development. The recommendations are described below.

6.1 Monitor Agricultural and Transportation Industry Trends

SDDOT should actively monitor agricultural and transportation industry trends.

As shown in the research, while the word "dynamic" is often used to describe the agricultural industry, given the number of variables and uncertainty, that word does not quite do the industry justice. And, for public agencies throughout the State, including the South Dakota Department of Transportation (SDDOT), regional planning agencies, tribes, counties, townships and others that plan, design, invest, and operate transportation system infrastructure, keeping pace with ongoing changes in agricultural production in particular regions may seem difficult at best.

This research identified data that reflect agricultural production and demand for transportation systems and services in various dimensions. The principal production measures consist of cultivated land by township (acres), cultivated land by crop (acres), and crop yield (bushels per acre). Through a series of hypothetical examples, we demonstrated how varying production data could influence truck demand and transportation system use.

SDDOT should actively monitor these data and observe how they trend over time for several purposes.

- Cultivated land by township will inform if actively farmed land is expanding, contracting, or shifting to different regions of the state. This information can be used to determine, generally, the level of truck demand by region over time.
- Cultivated land by crop will inform decision makers on trends in the types of crops planted (e.g., corn, wheat, soybeans, etc.) by region of the state. Through their varying physical and market characteristics, crop type has a direct bearing on the type of transportation services and handling that are required, and is useful to estimate truck demand by area of the state over time.
- Crop yields will indicate changes in productivity over time, and, combined with other data, the causes of these changes, such as improving plant genetics, weather, and other external conditions. This information can be used to estimate the volume of truck and other transportation system demand in various regions throughout the state.

By compiling these data and monitoring trends over time, the DOT, and other South Dakota transportation stakeholders, can maintain an ongoing understanding of field crop production and productivity. At the most basic level, transportation stakeholders can use this information to characterize existing transportation demand, and how it is changing over time.

6.2 Incorporate Agriculture Resources in Transportation Decision-making

SDDOT should incorporate available agricultural resources including knowledge of agricultural production, and agricultural and transportation industry trends into short- and long-term transportation decision-making.

As shown in the research, purposes for improved agricultural freight data were identified through outreach to a variety of public and private sector, agriculture and transportation stakeholders. These purposes reflect a mix of short- and longer-term, low- and higher-dollar investment decisions that are regularly considered by these stakeholders. Generally, these decisions relate to 1) determining if there is a need, 2) defining the need, 3) selecting a course of action and timing for that action, and 4) funding and generating revenue to implement the action. To make any of these decisions, an understanding of current and future truck demand is required at the onset. During interviews conducted with SDDOT staff from various offices, stakeholders echoed that a positive outcome of this research would be a means for estimating truck trips (demand) based on agricultural patterns and trends. In addition, a method of projecting these trips into the future based on select variables would allow the state to improve investment and maintenance decisions.

This research established a methodology and conducted a demonstration to show that through the synthesis of transportation and agricultural data sources, estimates of current and future truck demand at the township level can be generated based on agricultural production. Alternative future estimated demand can also be derived by altering inputs. In doing this, the research illustrated that there is potential, significant value in using agricultural production to estimate truck demand and that the results could be used as an input into DOT decision-making. However, this research merely started this process, as there is still work to be done before the data can be operationalized within SDDOT and made available to support decision making.

SDDOT should take two specific actions to begin to incorporate agricultural resources in state and local transportation decision-making.

6.2.1 Institutionalize the Spreadsheet Tool within SDDOT

The spreadsheet evaluation tool created during this research is a resource that SDDOT should continue to develop and enhance over time. This tool, which serves to consolidate agricultural and transportation data sources and assumptions, should become the responsibility of a specific functional group within SDDOT. This group should be given the responsibility to continue exploring, enhancing, and evaluating the capabilities of the tool. Potential activities would include incorporating additional data, such as soil productivity ratings to redistribute crop yield between townships of a county, establishing standardized methodologies for evaluating facility impacts, etc.

6.2.2 Assess Evaluation Tool Outputs for Planning

As shown in the research, the spreadsheet evaluation tool is designed to be flexible; myriad scenarios can be crafted using the tool and an almost endless array of outputs can be generated. For the purposes of this study, the tool was developed simply to demonstrate that agricultural data can be used to estimate current and future truck demand. While an attempt was made during the research to show how this demand could translate into identifying needs (and fulfill the short- and long-term purposes identified), there is still much thought required to use the tool outputs and to make decisions with those outputs. As described above, SDDOT should specifically evaluate how the tool may be used to:

- Determine if there is a transportation system need,
- Define the need,
- Determine a course of action and timing for the action to address the need,
- Determine funds required to implement the action, and
- Determine potential revenue generated by the action.

The tool should never be considered the "final answer" to any investment question, but rather one of several inputs. SDDOT should continue evaluating the capabilities of the spreadsheet evaluation tool and assess how the outputs could be used in the day–to-day activities of local governments and SDDOT.

6.3 Local Transportation Data Development

SDDOT should lead data development efforts in partnership with regional and local transportation agencies.

As noted in the research, the 4-step transportation planning and modeling framework was used to structure the analysis. This framework relies on a range of base data, much of which was not available at a level of detail to conduct the demonstration as initially intended. For example, instead of being able to ask "how many trucks are on roadway X?" we asked "how many trucks are in Township Y?" due to lack of truck count information on local roadways. Fortunately, the framework (and spreadsheet evaluation tool developed during this research) is flexible and allowed for the incorporation of supplemental data and assumptions where data did not exist. However, it is important to remember that data inputs for Steps 2 through 4 of the framework rely on the outputs of previous steps; as more assumptions are made early in the process the results will be less precise. So, more, better data is a preferred approach in using the tool.

The largest data gap identified was found to be related to local roadways—that is, essentially all roads that are not under State jurisdiction. The gaps included a lack of truck counts (AADTT), truck classification counts, and surface condition information. Had truck count information been available, the Research Team could have tested truck routing assignments to ascertain how production relates to truck volumes on specific roadways. Absent truck count information on study area roadways, there was no means to validate the results of the demonstration. Truck classification information, linked to truck counts, would have provided insight into the types of trucks using the roadways and potentially the commodities carried.

While not an input into the 4-step framework, data on surface condition was also identified as a gap. This data, when combined with truck demand, can be used to determine and prioritize road improvement needs. For example, on a road segment where truck use is heavy, a surface redesign may be more cost-effective than a repaving job. Both truck count and surface information is valuable to planners for managing the transportation system whether the tool is applied, or not.

SDDOT should take two specific actions related to improving local transportation system data. These are as follows:

6.3.1 *Field Data Collection*

Throughout the research effort SDDOT and transportation stakeholders acknowledged the data needs in the State, but also that a robust data collection program at the local level may be expensive and may not yield benefits commensurate with the cost and effort involved. SDDOT is currently exploring options to enhance local data. If field data collection aimed at better understanding agricultural movements is a focus of SDDOT and local transportation agency stakeholders, this research provides an opportunity to focus on those areas where data collection will be most beneficial. This research has identified several factors that drive increased transportation system use by trucks including areas of high production and the presence of major aggregators and facilities. And, the demonstration made an attempt to highlight townships in the study area that may have the greatest need as reflected by crop production and a proxy for infrastructure condition (absent surface condition data). SDDOT should coordinate with local agencies to pursue spot collection of local data—including truck counts, truck classification counts, and surface condition information—and use proximity to agricultural activity and need as a consideration in determining collection locations.

6.3.2 *Monitor and Incorporate New Sources of Transportation Data*

To supplement or perhaps eventually supersede the spot local data collection described above, innovative sources of data should be monitored and adopted when found appropriate. Forthcoming transportation data sources have the potential to provide statewide coverage with high geographic granularity at relatively low cost.

One promising new means of data collection are smart phone applications that crowd-source information on roadway conditions. These applications, which include Waze (owned by Google), leverage the GPS in smartphones to identify system chokepoints, road hazards and other real-time traffic information. Future development that incorporates the accelerometers and microphones that are commonplace in mobile phones may allow crowd-sourcing of surface conditions as well. Once such applications are broadly adopted, it may become possible for South Dakota to acquire surface and roadway condition data at a far lower cost than is possible through conventional methods.

A second innovative data collection method entails the use of Unmanned Aerial Vehicles (UAV, also referred to as Unmanned Aerial Systems, or UAS) to monitor bridge and surface conditions. Research to date indicates that remote sensing using these aircraft may allow the characterization of unpaved road conditions. Unlike the smartphone applications noted above, where data is crowd sourced and relatively inexpensive to acquire, the significant cost of deploying UAVs could be borne by SDDOT and other potential stakeholders. The principal benefit of UAVs is their lower cost compared to other traditional options such as ground-based data collection and overflights by manned aircraft, and has the potential to provide wide area coverage in a short amount of time, with little or no disruption to the traffic stream. Presently, Federal Aviation Administration (FAA) regulations regarding UAVs and these types of applications are still in flux. Thus far, the FAA has developed a UAV integration roadmap, and has issued a proposed rulemaking for regulation of small commercial UAVs weighing less than 55 pounds[13].

Both of these data innovations have the potential to enable SDDOT and local transportation stakeholders to better understand system operations and needs. SDDOT should monitor the development of these and other innovative sources of transportation system data and incorporate them in traffic monitoring and data collection programs, once they have proven their utility and cost-effectiveness.

Other innovations such as use of private farm data recording tools such as FarmLogs and remotely sensed data using satellites should be considered for adoption once privacy and cost considerations have been addressed.

[13] U.S. Government Accountability Office. *Unmanned Aerial Systems – FAA continues progress toward integration into the National Airspace*. Report to Congressional Committee, GAO-15-610, Available at: http://www.gao.gov/assets/680/671469.pdf (last accessed on November 30, 2015)

7 RESEARCH BENEFITS

In line with the goal of the SHRP2 Program, the freight modeling data and tools developed in this project will have substantial value to a wide range of agricultural and transportation stakeholders in South Dakota, other states that have agricultural interests, and the freight transportation community as a whole. Several benefits expected from this project, include:

- **Better understanding of agriculture and transportation trends.** As noted throughout the research, the agricultural industry is very dynamic and subject to numerous external factors. Through knowledge of those factors that drive agricultural freight demand, DOTs and others are better equipped to understand freight movements on their transportation systems and how they may change in the future.
- **Awareness of agricultural data sources.** In an agricultural state like South Dakota, system demand is driven by agricultural production. Knowledge of "what" is grown "where" and in "what quantity" is power. National agricultural data resources, provided free to the public through the USDA, are very robust in terms of spatial and temporal granularity, and they are updated annually. These data sources are available now to improve agricultural awareness.
- **Methodology to knit together agricultural and transportation data sources.** The research describes a process for combining and aligning the many existing, disparate data sources developed by numerous agricultural and transportation entities to achieve a common baseline for analysis. A spreadsheet evaluation tool has also been developed. As the focus of this research was to craft a methodology using low- or no-cost data available in the public realm, others are easily able to recreate the demonstration from scratch, or plug-and-play using the existing spreadsheet tool with their own data.
- **Consistent approach to calculate freight demand from agriculture.** The methodology and results provided in this research can provide guidance and a consistent approach to estimating current and future agricultural freight demand throughout the U.S. In one case study, related to a livestock auction, trip generation rates were developed for the facility.
- **Scalable approach.** While methods and data sources developed in this research are specific to South Dakota, the approach is scalable and may also be used in other regions, statewide, and by other regions in the U.S. regardless of agricultural commodity or geography.

8 Appendix A: Stakeholders Interviewed and Questions

8.1 Stakeholders Interviewed

The following table provides a listing of stakeholders interviewed.

Stakeholder Type	Affiliation
Dairy	Farmer
Ethanol	Glacial Lakes Energy, LLC
Ethanol	Poet, LLC
Farmer/Producer	Farmer
Farm-oriented Trucking	Farmer
Grain Elevator Operator/Co-op	South Dakota Wheat Growers
Grain Handling, Processing and Agronomy	Dakota Mill and Grain
Livestock Auction	Ft. Pierre Livestock Auction
Local Transportation Agency	Brookings County
Local Transportation Agency	Hughes County
Local Transportation Agency	McCook County
Local Transportation Agency	South Eastern Council of Governments (SECOG)
Private 110+shuttle	BNSF
State Department of Agriculture	SD Department of Agriculture
State Department of Transportation	SDDOT Air, Rail & Transit
State Department of Transportation	SDDOT Investment Decisions
State Department of Transportation	SDDOT Transportation Inventory Management Program
Tribal Transportation Agency	Crow Creek Indian Agency

8.2 Interview Guides

Interview guides were developed to provide consistency in the line of questioning asked by multiple interviewers. Unique questions were developed for the two types of stakeholder groups—agriculture-focused and transportation-focused.

8.2.1 Agricultural Stakeholder Questions

General Questions

Describe your organization and your role in the organization

Provide a simple description of the various process stages of a typical facility such as yours

How important are transportation and storage activities to your business operations?

What are some of the advantages or disadvantages of your location of business? How can this be improved?

If better information on truck demand (current and future) were available, how would you use it?

Questions Related to Trade, Transportation and Storage Decisions

Describe the key commodities shipped and received by your business

What are the key markets for commodities shipped from your business, and how do you transport and store?

What are the key markets for commodities received by your business, and how do you transport and store?

What portion of your transportation is rail vs truck? Has this changed over time? Why?

What size of trucks do you use - weight or axle distribution? Has this changed over time? Why?

What is current grain storage mix - on-site, aggregator site, rail served elevator, etc.? Why do you choose to store in this way? Has this changed over time? Why?

Questions Related to Transportation and Storage Data Resources

Do you use SDDOT's transportation and storage system GIS data? If yes, do you think it is accurate for your purpose?

What other types of transportation and storage facilities location data does your business have? Would you be willing to share some of this data with the State?

What are your key transportation and storage system needs and issues? What data resources do you have to identify and quantify them and apply for local, tribal and state funding? Would you be willing to share some of this data with the State?

Has your business location collected any traffic counts or storage inventory, or conducted any market assessment and financial feasibility studies in the past decade? Would you be willing to share some of this data with the State?

Has your organization applied for a conditional use permit at any of its business locations? If yes, what type of traffic volume, route, and pavement and environmental impact restrictions are stipulated in the conditional use permits?

Questions Related to Future Agricultural Production and Attraction

What factors and data resources do you use for deciding the size and location of a new facility? Would you be willing to share some of this data?

What are some of the major market, sourcing, mode, productivity and technology changes that you expect to affect your business? How do you measure and monitor their trends?

Concluding General Questions

Are you aware of any relevant research, study, plan or other documents and websites that can help us with our research?

Can you suggest any names of relevant people with in-depth knowledge on our research topic that we can speak to?

8.2.2 Transportation Stakeholder Questions

General Questions

Describe your organization and your role in the organization.

What are some of your key investment and policy programs and decision processes? What transportation and storage related data do you currently use for these purposes?

How does your organization use the freight transportation system in South Dakota? Do you actively quantify and monitor this?

If better information on truck demand (current and future) were available, how would you use it?

Questions Related to Transportation and Storage Decisions

Can you talk about what transportation data and information your business or agency relies on regularly? Do you currently use any data or information from SDDOT or other public sources in your operations? Do you subscribe to any private data services or use related software?

Do you use SDDOT's transportation and storage system GIS data? If yes, does it suit your needs?

Do you maintain your own data regarding transportation and/or agriculture related facilities? If so, would you be willing to share it for the purposes of this project? Do you use third-party data on transportation and/or agriculture related facilities?

What are your key transportation and storage system needs and issues? What data resources do you have to identify and quantify them to develop projects and programs, plans and grant applications? Would you be willing to share some of this data with the State?

Has your agency collected any traffic counts or storage inventory or historical and tribal preservation sites inventory, or conducted any freight project related traffic impact or economic feasibility or policy studies in the past decade? Would you be willing to share some of this data with the State?

If a tribal or local agency, has your organization approved a conditional use permit to any business locations? If yes, what type of traffic volume, route, and pavement and environmental impact restrictions are stipulated in the conditional use permits?

Questions Related to Future Agricultural Economic Development, Agricultural Freight Investment and Policy Decisions

Are there data and resources that could benefit your business/agency and support economic development? Can better transportation and storage data resources can be incorporated into your future agricultural economic development, freight investment and policy decision processes?

Are you aware of business incentives in your jurisdiction? Are there any restrictive policies that inhibit economic growth? What are the taxes and fees that businesses have to pay in your jurisdiction? Can you express these quantitatively, e.g. per square foot of land or facility?

What are some of the major national and state policy changes and changes in the business atmosphere that you expect to affect future economic development opportunities, agricultural freight program levels and decision processes? How do you measure and monitor their trends?

Concluding General Questions

Are you aware of any relevant research, study, plan or other documents and websites that can help us with our research?

Can you suggest any names of relevant people with in-depth knowledge on our research topic that we can speak to?

How could this project best benefit your organization, if at all?

9 Appendix B: Data Sources and Assessment

The following tables identify the required data for each step of the 4-step framework used in this demonstration. The tables identify the most appropriate source of information to fulfill the input requirement and whether or not the data has the desired spatial, temporal or collection frequency attributes desired.

Table 12 Step 1—Generation Inputs

Step	Required Data	Available Data, Source	Does data meet requirements?			Can data be adjusted?
			Spatial	Temporal	Frequency	
Step 1 - Generation	**Available land for planting** (acreage per area)	USDA CropScape	Yes, as user-defined area	Yes, Annual	No	Further temporal adjustment may not be required as changes in available land are slow
	Corn crop yield (bushels per acre)	USDA NASS	Partially Yes, Projections are national, although historical data exists at state and county level	Yes, Annual	No	Further spatial and temporal adjustment may not be required as GMO improvements are slow and steady; Also, no adjustments being made for climate changes (drought, snow, etc.)
	Facility locations (by commodity)	Grain elevators (with / without rail access), Ethanol facilities, Other ag. businesses	Mostly Yes, geocoded addresses	No	No	Missing year established data, this can however be determined
	Facility total demand (by commodity)	Private company interviews, USDA NASS	No	Partially Yes, quarterly on- and off-farm storage stock levels at state level	No	Additional data collection or estimation effort would be needed to reach required spatial and temporal granularity

Table 13 Step 2—Distribution Inputs

Step	Required Data	Available Data, Source	Does data meet requirements?			Can data be adjusted?
			Spatial	Temporal	Frequency	
Vector of **bushels of crop produced by area**		**Step 1 - Generation**				
Vector of **demand for bushels of crop by area** or facility		**Step 1 - Generation**				
Step 2 - Distribution	**Commodity use** (feed, ethanol, export, etc.)	Private company interviews, USDA NASS, FAF3	Partially Yes, global, domestic & local trade partners	Partially Yes, likely annual comm. uses at state level	No	Additional data collection or estimation effort would be needed to reach required spatial and temporal granularity
	Facility capacity (bushels per facility)	Location capacity of Grain elevators in bushels per year; Capacity of Ethanol facility in million gallons per year	Mostly Yes, capacity for geocoded address locations	Yes, Annual average month	Yes	Further temporal adjustment may not be required as increase in facility capacity or facility closure can be explicitly handled
	Price per crop per facility ($ per bushel)	USDA AMS, SDDOT Ag Dept Data	No	Partially Yes, likely quarterly comm. sold at state level	Yes	If public data is insufficient, empirical data or assumptions to be identified.
	User Cost of transportation between O-Ds ($ per bushel)	May be simplified	No	No	No	As public data is unavailable, empirical data or assumptions to be identified

Table 14 Step 3—Mode Choice Inputs

Step	Required Data	Available Data, Source	Does data meet requirements?			Can data be adjusted?
			Spatial	Temporal	Frequency	
O-D matrix of bushels moved between locations		**Step 2 - Distribution**				
Step 3 - Mode Choice	**Available transportation network**	Road network by functional class and rail system and sidings/yards	Yes	Static	Yes	Temporally may not be required as changes in network can be explicitly handled
	Cost of transp. by mode ($ per mode, by location pairs)	May be simplified	No	No	No	As public data is unavailable, empirical data or assumptions to be identified.
	Vehicle capacity (bushels per truck, bushels per railcar)	Best practice assumption, Truck size trends from SDDOT traffic data	No	Yes	Yes	Spatially may not be required as variance is likely to be small

Table 15 Step 4—Assignment Inputs

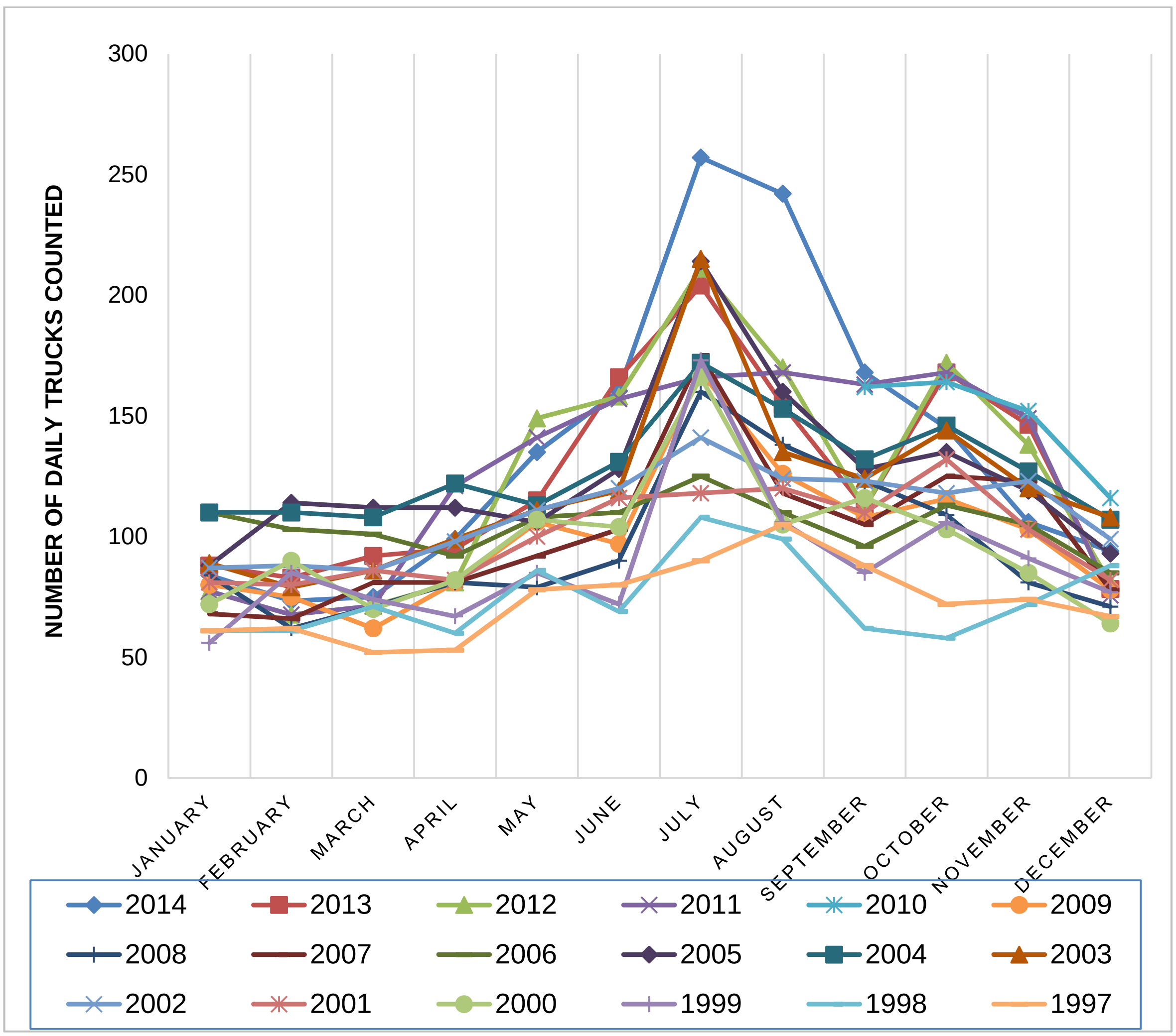
Step	Required Data	Available Data, Source	Does data meet requirements?			Can data be adjusted?
			Spatial	Temporal	Frequency	
Matrices of number of trucks between each O-D pair		**Step 3 - Mode Choice**				
Step 4 - Assignment	**Route between each O-D pair**	Estimate but may be simplified, SDDOT traffic data based truck fleet mix and variations by roadway type and/or by time of year	Route assignment based on available connections between cropland, facilities and markets using roadway functional class as impedance	Timing based on estimated monthly on- and off-farm storage stock levels at local level	No	Cropland centroids may need to be identified; Traffic counts to be used for estimation of background truck traffic and validation of agricultural freight truck flows
	Proportion of each road type within an area that is available for truck movements (% of each road type, by area)	Assigned agricultural freight truck flows by time of year, SDDOT surface roughness index by roadway segment	Aggregation of truck miles by roadway functional class and surface type (paved/ unpaved)	Estimated monthly truck miles	No	Adjust contribution of agricultural freight trucks to surface roughness by roadway segment

10 Appendix C: Example Graphical Summaries of Input and Output Characteristics in Demonstration

The following figures show some example graphical summaries of total transportation demand output and some inputs to agricultural freight demand estimation. These summaries are not meant to provide comprehensive understanding of these characteristics, but to serve as examples for demonstrating the variations in agricultural freight demand at some locations in the demonstration areas and at the state level.

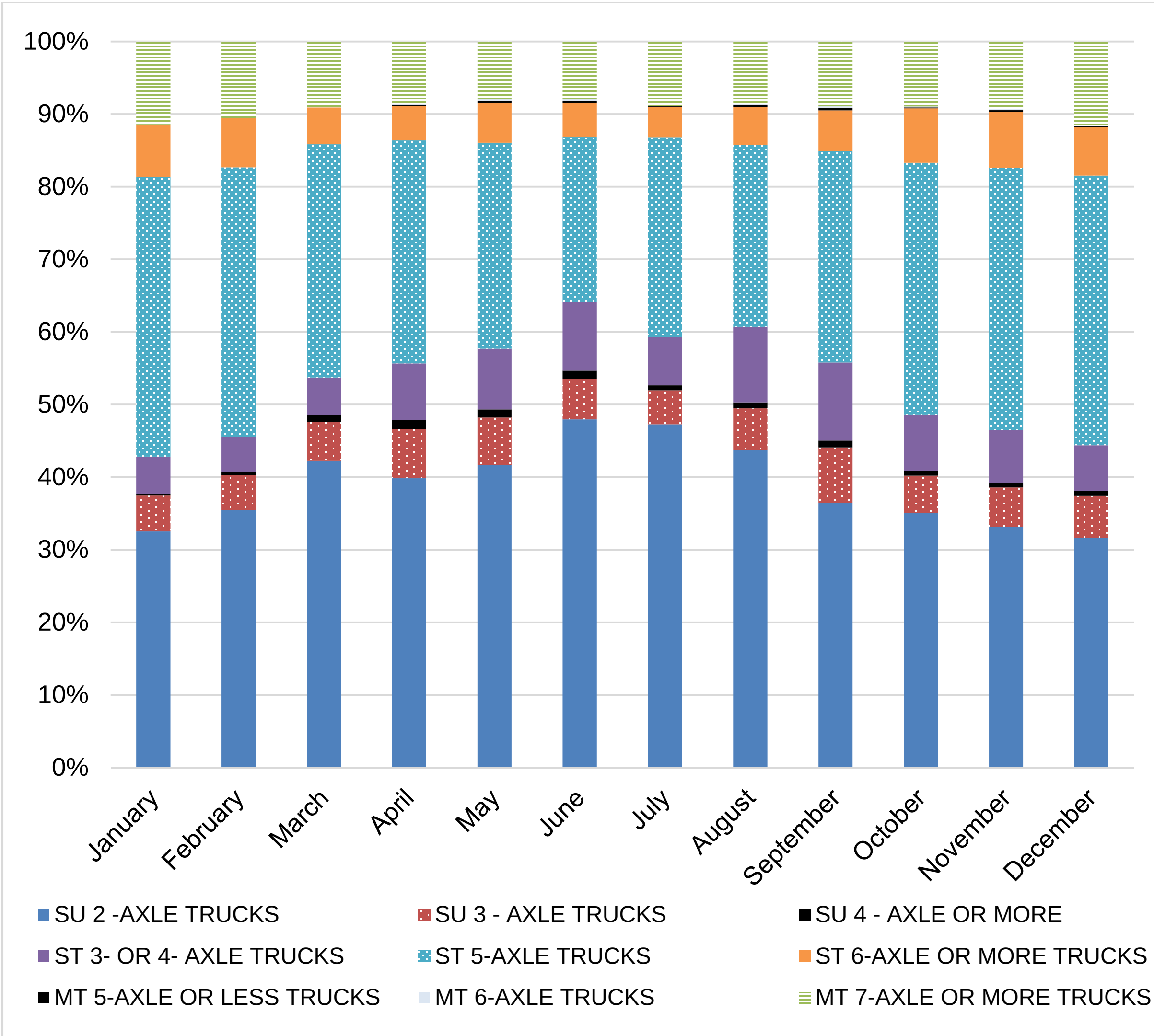
Figure 43 and Figure 44 show the monthly average total daily trucks and truck size distribution at the weigh station at Ft. Pierre, SD. Peak truck traffic occurs around July. The percentage of single unit trucks appears to increase around the same time of the year. If it were true that the non-agricultural freight truck volumes are much smaller than agricultural freight truck volumes, then the agricultural freight demand estimates on the transportation link at or near the Ft. Pierre weigh station should match the pattern.

Figure 43 Yearly Variations in Monthly Average Total Daily Trucks at Pierre Weigh Station, 1997-2014



Source: SDDOT Weigh Station Data

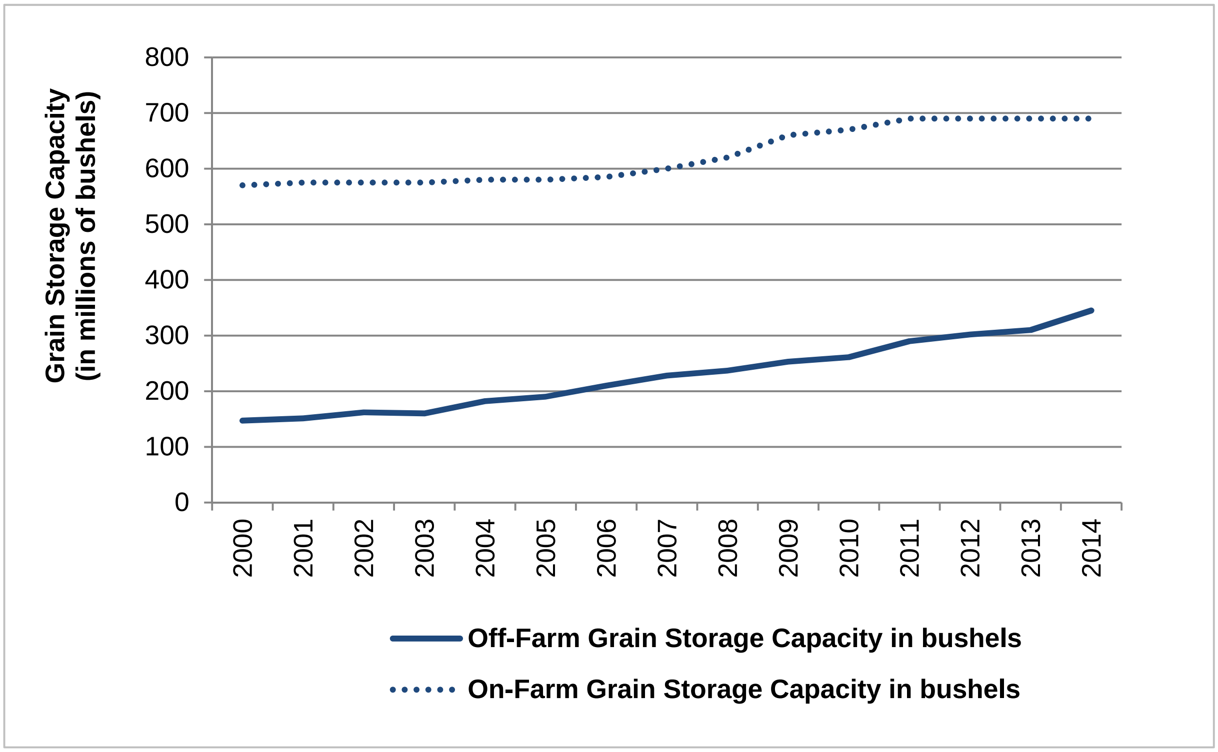
Figure 44 Mean of Monthly Average Truck Axles Distribution at Pierre Weigh Station, 1997-2014



Source: SDDOT Weigh Station Data

Figure 45 shows that there is a significantly higher on-farm storage capacity than off-farm storage capacity. Off-farm storage capacity is growing at a faster pace than on-farm storage capacity which is reducing the gap between them. These trends may also likely be true in the demonstration locations.

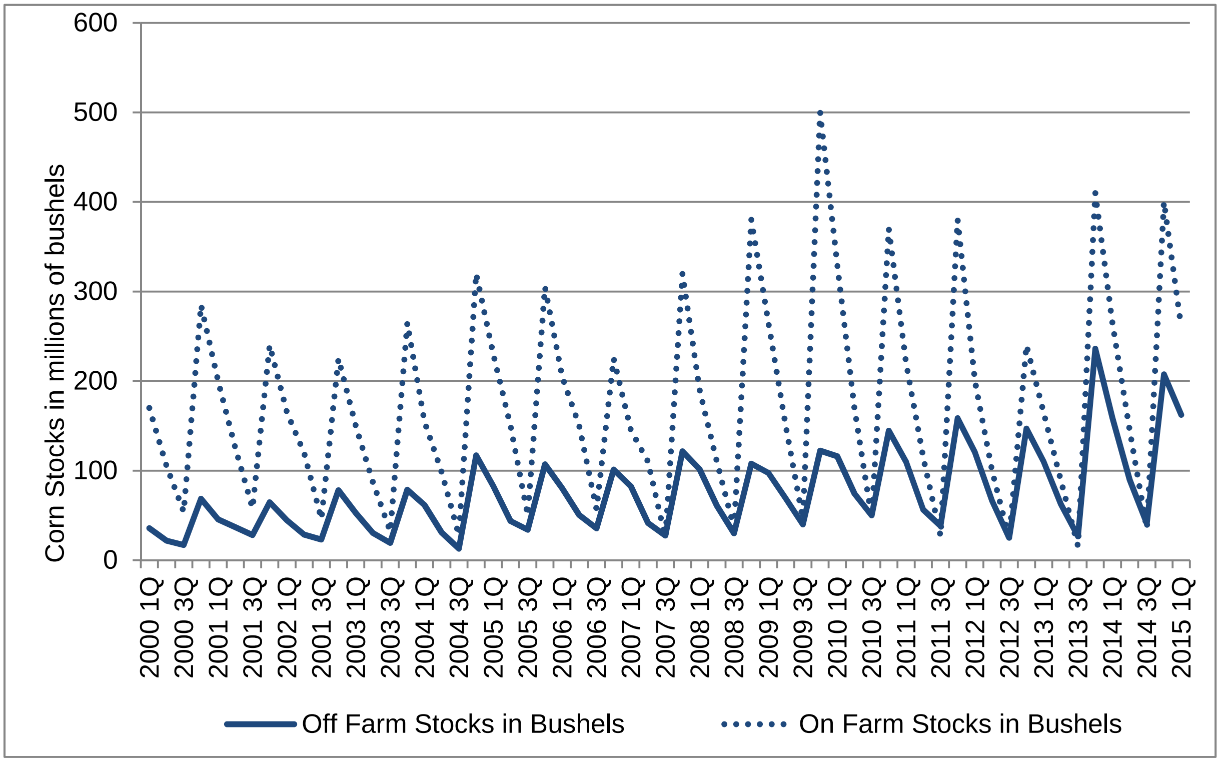
Figure 45 Statewide Annual On-Farm and Off-Farm Storage Facility Capacities, 2000-2014

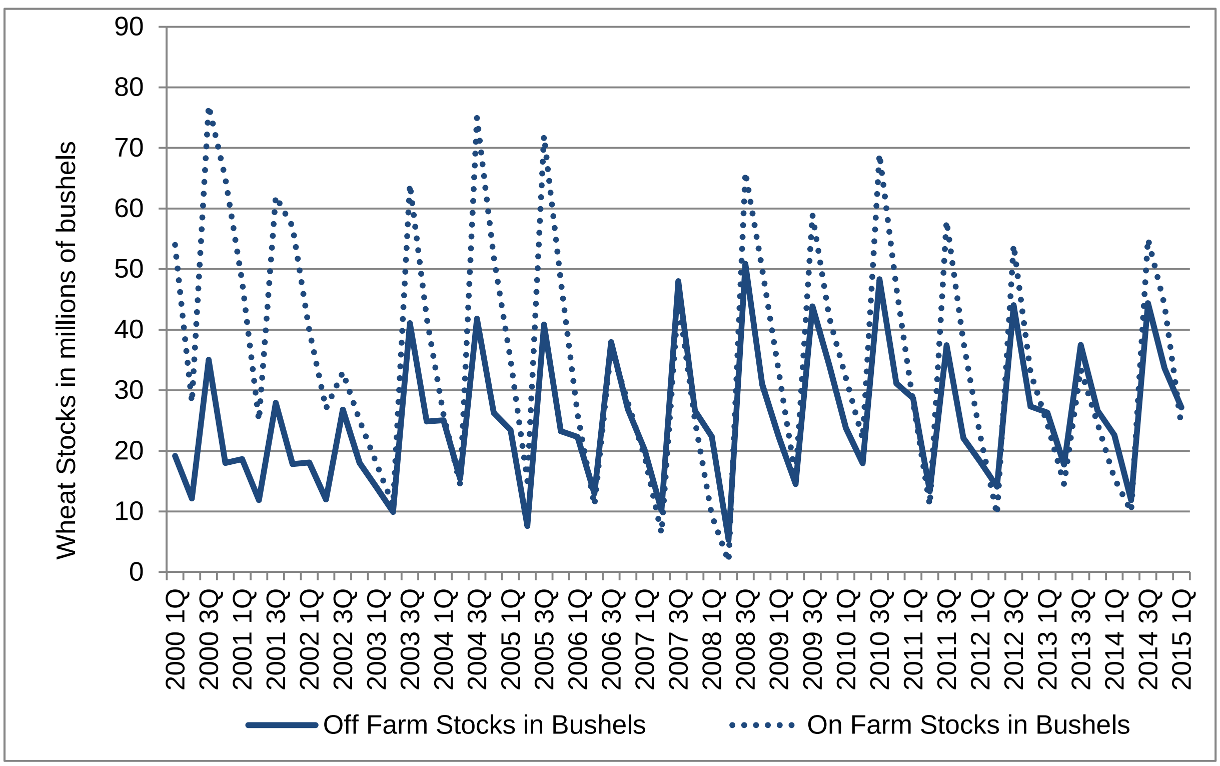


Source: USDA National Agricultural Statistics Service (NASS) Data

Figure 46 shows some differences in crop storage practices of corn and wheat. While corn has a much higher percentage of on-farm storage than off-farm storage, wheat has about an even percentage split between on-farm and off-farm storage. On a bushels basis, corn is stored in much higher quantity compared to wheat. The amount of storage by quarter tells how quickly or slowly the grain moves from the farms to grain elevators, and how quickly or slowly the grain is moved to customers located both locally and globally.

Figure 46 Statewide Quarterly variations in Corn versus Wheat stocks in millions of bushels, 2000-2014

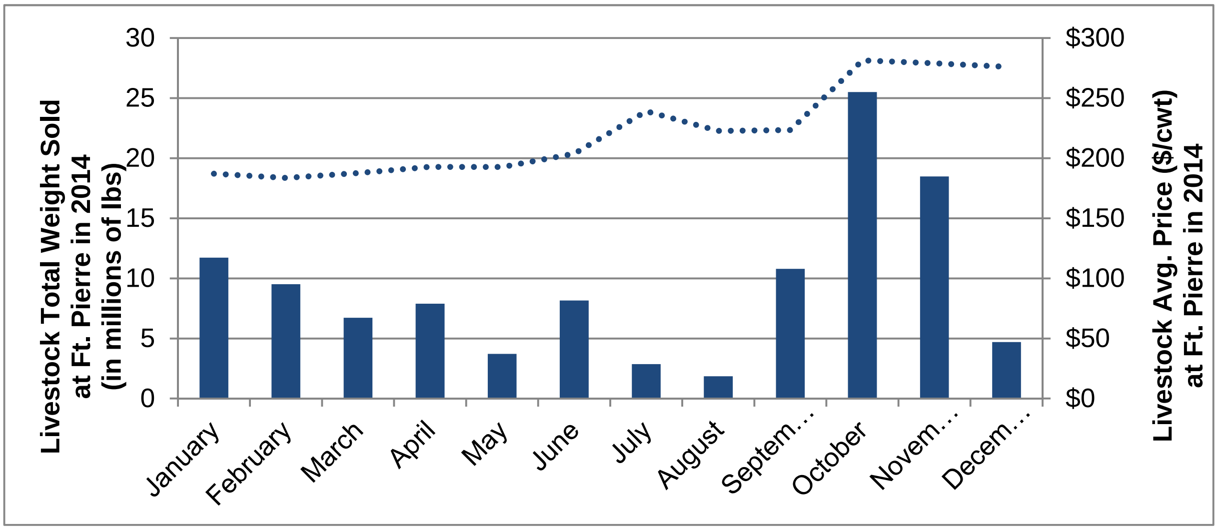




Source: USDA National Agricultural Statistics Service (NASS) Data

Figure 47 shows that the monthly livestock sales in pounds and monthly average price of livestock on a hundredweight basis vary within a year. The peak sales in pounds occur in October, which coincides roughly with peak monthly average price. This indicates the livestock transportation demand is likely to be skewed towards the end of the year.

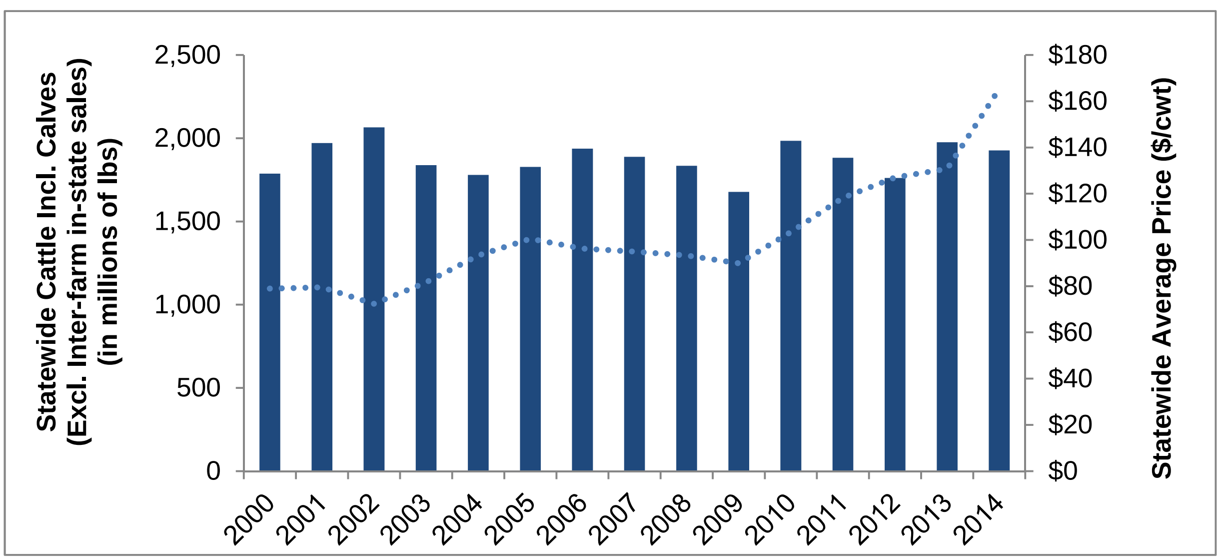
Figure 47 Monthly Livestock Sale (in millions of pounds) and Average Price (in $ per hundredweight) at Fort Pierre Livestock Auction Facility, 2014



Source: USDA Agricultural Marketing Service (AMS) Data

Figure 48 shows the annual variation in the livestock sales in pounds and annual average price of livestock on a hundredweight basis in the State. The average prices of livestock have been rising steadily, but livestock sales in pounds have been cyclical, there is no trend visible in steady growth or decline in the demand. As a result, the net revenue for auction facilities in the State are likely increasing.

Figure 48 Statewide of Cattle Including Calves (Excluding Inter-Farm In-State Sales) (in millions of pounds) and Average Price (in $ per hundredweight) by Year, 2000-2014



Source: USDA National Agricultural Statistics Service (NASS) Data

11 Appendix D: Summary of Agricultural and Transportation-Related Trends and Potential Application

Table 16 Summary of Agricultural and Transportation-Related Trends and Potential Application

Research Framework (4-Step Transportation Model Components)	Key Questions on Trend Application	Agriculture Practice Trends			Land Use Trends		Weather Trends		Modal Trends					Pricing & Revenue Trends		Agriculture Demand Trends				
		Continual advances in plant genetics and agricultural practices	Fertilizer Use	Animal Feed Use	Expansion of cultivated land	Expansion of grazing land	Precipitation	Climate Change	Truck Size & Weight on Local Roadways	Service Prices and Competition	Service Quality and Availability	System Constraints	Grain Elevator and Storage Capacity	Commodities Prices/Basis	Hedging Practices	Population Increase	Macroeconomic Conditions	Ethanol Industry	Crop Processing Industries	Livestock Processing Industries
Freight Generation (Production/ Attraction)	What crops will be grown?	X		X	X		X	X		X			X	X	X	X	X	X	X	
	What inputs are needed for crop growth?	X	X				X					X	X					X		
	Where will crops be grown in South Dakota?	X		X	X		X						X					X		
	What is the crop yield (bushels/acre) or soil productivity?	X	X		X		X						X	X	X					
	When will the crops be harvested?	X		X								X	X							
	Where will the harvest be stored?			X									X	X	X			X		
	What livestock are reared?			X		X	X	X			X							X		X
	What inputs are needed for rearing animals?			X		X							X					X	X	
	Where will animals be reared in South Dakota?			X		X														

Table 16 Summary of Agricultural and Transportation-Related Trends and Potential Application

Research Framework (4-Step Transportation Model Components)	Key Questions on Trend Application	Agriculture Practice Trends			Land Use Trends		Weather Trends		Modal Trends					Pricing & Revenue Trends		Agriculture Demand Trends				
		Continual advances in plant genetics and agricultural practices	Fertilizer Use	Animal Feed Use	Expansion of cultivated land	Expansion of grazing land	Precipitation	Climate Change	Truck Size & Weight on Local Roadways	Service Prices and Competition	Service Quality and Availability	System Constraints	Grain Elevator and Storage Capacity	Commodities Prices/Basis	Hedging Practices	Population Increase	Macroeconomic Conditions	Ethanol Industry	Crop Processing Industries	Livestock Processing Industries
	When will the livestock bred?																			
Freight Distribution	Who will harvest be sold to? Local, regional, international?		X	X	X			X	X				X			X	X	X	X	X
	When will the harvest be shipped?			X	X			X			X		X			X	X	X	X	X
	Who will the livestock be sold to? Market locations			X		X				X	X									X
	When and where will the livestock be sold?			X		X											X			X
Freight Mode Choice	What mode(s) and specialized services will be used?								X	X	X	X	X							
Freight Route Choice	What route(s) will be used?						X	X	X	X	X	X	X				X	X	X	X

12 Appendix E: Agricultural and Transportation-Related Decision Data Matrix (Purposes of Improved Agricultural Freight Data)

Table 17 Purposes of Improved Agricultural Freight Data

Sub-Application Type				State of Economy			Direct Data Type										Derived Data Type						
Sub-Application Type				Funding Availability			Ag. Production/ Attraction-related Data and Trends (Crop Acreage, Yield, Storage Capacity, etc.)	Route and Fleet Choice related data and trends (shortest route by distance/time, truck fleet mix by truck configuration, rail car equipment mix, etc.)	Current Infrastructure Condition / Performance			Current Operational Restrictions			Current Weather Conditions	Current Transportation Service and Commodity Prices	Near-Future (a week to a month) Transportation Service and Commodity Prices	Current Daily / Seasonal Demand *(sometimes also a Direct Data)*			Future Daily or Seasonal Demand		
Temporal Resolution	Decision-Maker	Spatial Resolution	Decisions	Local Public	State Public	Private	Sub-Area	Sub-Area	Local	State	Sub-Area	Local	State	Sub-Area	Sub-Area	Market	Market	Local	State	Sub-Area	Local	State	Sub-Area
Daily / Seasonal / Event-based [Based on Best Practices and Issues as they appear]	Public	Local / State	Install temporary signage for road / bridge closure due to inclement weather or poor infrastructure condition / performance (with or without alternate route information)	X			X	X	X						X			X					
			Perform emergency maintenance of surface / bridge	X		X	X	X	X														
		State	Install temporary signage for road / bridge closure due to inclement weather or poor infrastructure condition / performance (with or without alternate route information)		X		X	X		X					X				X				
			Perform emergency maintenance of surface / bridge		X	X	X	X															
		Sub-Area	Provide information services for roads / bridges closure due to inclement weather or poor infrastructure condition / performance	X	X	X	X	X			X				X					X			
			Gather performance data, needs and issues and provide information services on the economic importance of agricultural freight and best practices.	X	X	X	X	X			X									X			
	Private	Public (state or local) or Private Infrastructure	Select a route or divert to an alternate route.			X	X	X				X		X	X	X							
			Select or change a fleet mix - use small or large trucks.			X	X	X				X			X	X		X					
			Select or substitute mode of transportation - use truck-to-rail or truck only.			X	X	X		X		X			X	X		X					
			Delay commodity movement - Use Storage Capacity			X	X	X	X			X			X	X	X						
		Market	Provide information services for prices of commodities and their transportation services			X	X	X								X	X						
			Source Inputs			XX	X	X							X	X							
			Sell Commodities			X	X	X								X	X						
Annual Maintenance and Minor Operational Improvements	Public	Local	Repair / Rehabilitate damaged surface on local roadway, including blading of gravel roads	X	X	X	X	X	X												X		
			Repair / Rehabilitate local bridge or grade separation structures	X	X	X	X	X	X												X		
		State	Repair / Rehabilitate damaged surface on local roadway, including blading of gravel roads		X	X	X	X	X												X		
			Repair / Rehabilitate local bridge or grade separation structures		X	X	X	X	X												X		
	Private	Private Infrastructure	Repair / Rehabilitate private driveways and private roads			X	X	X	X									X			X		

Table 17: Purposes of Improved Agricultural Freight Data

Sub-Application Type				State of Economy			Direct Data Type										Derived Data Type						
Sub-Application Type				Funding Availability			Ag. Production/ Attraction-related Data and Trends (Crop Acreage, Yield, Storage Capacity, etc.)	Route and Fleet Choice related data and trends (shortest route by distance/time, truck fleet mix by truck configuration, rail car equipment mix, etc.)	Current Infrastructure Condition / Performance			Current Operational Restrictions			Current Weather Conditions	Current Transportation Service and Commodity Prices	Near-Future (a week to a month) Transportation Service and Commodity Prices	Current Daily / Seasonal Demand *(sometimes also a Direct Data)*			Future Daily or Seasonal Demand		
Temporal Resolution	Decision-Maker	Spatial Resolution	Decisions	Local Public	State Public	Private	Sub-Area	Sub-Area	Local	State	Sub-Area	Local	State	Sub-Area	Sub-Area	Market	Market	Local	State	Sub-Area	Local	State	Sub-Area
Short-Term (4-year) Transportation Improvement Programs	Public	Local	Replace surface and/or subgrade and/or improve drainage on local roadway	X	X	X	X		X		X	X		X				X		X	X		X
			Improve alignment or add lanes to existing or construct new local roadway	X	X	X	X		X		X	X		X				X		X	X		X
			Retrofit / Replace local bridge or grade separation structures	X	X	X	X		X		X	X		X				X		X	X		X
			Widen existing or construct new local bridge or grade separation structures	X	X	X	X		X		X	X		X				X		X	X		X
			Modify operational restrictions and install signals and signage on local roadways	X	X		X		X		X	X		X							X		X
		State	Repair / rehabilitate damaged surface on state highway		X	X	X			X												X	
			Replace surface and/or subgrade and/or improve drainage on state highway		X	X	X			X	X		X	X					X			X	
			Improve alignment or add lanes to existing or construct new state highway		X	X	X			X	X		X	X					X			X	
			Repair / rehabilitate / retrofit state highway bridge or grade separation structures		X	X	X			X												X	
			Replace state highway bridge or grade separation structures		X	X	X			X	X		X	X					X			X	
			Widen existing or construct new state highway bridge or grade separation structures		X	X	X			X	X		X	X					X			X	
			Install signals and signage on state highway mainline and intersections		X		X			X												X	
			Install Intelligent Transportation Systems for travel time information and emergency response to incidents		X	X	X			X												X	
			Modify operational restrictions on state roadways		X		X			X	X		X	X					X	X		X	X
			Rent/Buy rolling stock for state-owned rail system		X		X			X									X			X	
			Repair / Rehabilitate rail tracks to 110-lb rail on state-owned rail system		X	X	X			X	X		X	X					X	X		X	X
			Repair / Rehabilitate rail bridges to 286K-lb car capability rail on state-owned rail system		X	X	X			X	X		X	X					X	X		X	X
			Improve alignment or add rail mainline track on state-owned rail system		X	X	X			X	X								X	X		X	X
		Sub-Area	Conduct final design studies and identify project mitigation measures.	X	X	X	X		X	X	X							X	X	X	X	X	X
			Select a location and construct emergency response services		X		X				X												
			Improve access and eliminate conflicts with community for newly constructed commodity storage / handling / processing facilities		X		X				X												X
			Construct rail sidings/spurs/yards on state-owned rail system	X	X	X	X		X	X	X							X	X	X	X	X	X
			Install signals and signage on rail mainlines and yards belonging to state-owned rail system	X	X		X		X	X	X							X	X	X	X	X	X

Table 17: Purposes of Improved Agricultural Freight Data

Sub-Application Type				State of Economy			Direct Data Type										Derived Data Type						
Sub-Application Type				Funding Availability			Ag. Production/ Attraction-related Data and Trends (Crop Acreage, Yield, Storage Capacity, etc.)	Route and Fleet Choice related data and trends (shortest route by distance/time, truck fleet mix by truck configuration, rail car equipment mix, etc.)	Current Infrastructure Condition / Performance			Current Operational Restrictions			Current Weather Conditions	Current Transportation Service and Commodity Prices	Near-Future (a week to a month) Transportation Service and Commodity Prices	Current Daily / Seasonal Demand *(sometimes also a Direct Data)*			Future Daily or Seasonal Demand		
Temporal Resolution	Decision-Maker	Spatial Resolution	Decisions	Local Public	State Public	Private	Sub-Area	Sub-Area	Local	State	Sub-Area	Local	State	Sub-Area	Sub-Area	Market	Market	Local	State	Sub-Area	Local	State	Sub-Area
Long-Term (8-year) Transportation Improvement Programs	Public	State	Repair / rehabilitate damaged surface on state highway		X	X	X			X												X	
			Replace surface and/or subgrade and/or improve drainage on state highway		X	X	X			X	X		X	X					X			X	
			Improve alignment or add lanes to existing or construct new state highway		X	X	X			X	X		X	X					X			X	
			Repair / rehabilitate / retrofit state highway bridge or grade separation structures		X	X	X			X												X	
			Replace state highway bridge or grade separation structures		X	X	X			X	X		X	X					X			X	
			Widen existing or construct new state highway bridge or grade separation structures		X	X	X			X	X		X	X					X			X	
			Install signals and signage on state highway mainline and intersections		X		X			X												X	
			Install Intelligent Transportation Systems for travel time information and emergency response to incidents		X	X	X			X												X	
			Modify operational restrictions on state roadways		X		X			X	X		X	X					X	X		X	X
			Rent/Buy rolling stock for state-owned rail system		X		X			X									X			X	
			Repair / Rehabilitate rail tracks to 110-lb rail on state-owned rail system		X	X	X			X	X		X	X					X	X		X	X
			Repair / Rehabilitate rail bridges to 286K-lb car capability rail on state-owned rail system		X	X	X			X	X		X	X					X	X		X	X
			Improve alignment or add rail mainline track on state-owned rail system		X	X	X			X	X								X	X		X	X
		Sub-Area	Conduct planning, scoping, feasibility, preliminary design and environmental clearance studies.	X	X	X	X		X	X	X							X	X	X	X	X	X
			Select a location and construct emergency response services		X		X				X												
			Improve access and eliminate conflicts with community for newly constructed commodity storage / handling / processing facilities		X		X				X												X
			Construct rail sidings/spurs/yards on state-owned rail system	X	X	X	X		X	X	X							X	X	X	X	X	X
			Install signals and signage on rail mainlines and yards belonging to state-owned rail system	X	X		X		X	X	X							X	X	X	X	X	X

Table 17: Purposes of Improved Agricultural Freight Data

Sub-Application Type				State of Economy			Direct Data Type										Derived Data Type						
Sub-Application Type				Funding Availability			Ag. Production/ Attraction-related Data and Trends (Crop Acreage, Yield, Storage Capacity, etc.)	Route and Fleet Choice related data and trends (shortest route by distance/time, truck fleet mix by truck configuration, rail car equipment mix, etc.)	Current Infrastructure Condition / Performance			Current Operational Restrictions			Current Weather Conditions	Current Transportation Service and Commodity Prices	Near-Future (a week to a month) Transportation Service and Commodity Prices	Current Daily / Seasonal Demand *(sometimes also a Direct Data)*			Future Daily or Seasonal Demand		
Temporal Resolution	Decision-Maker	Spatial Resolution	Decisions	Local Public	State Public	Private	Sub-Area	Sub-Area	Local	State	Sub-Area	Local	State	Sub-Area	Sub-Area	Market	Market	Local	State	Sub-Area	Local	State	Sub-Area
Business Plan (1-5 years)	**Private**	Private Infrastructure	Construct driveways and private roads			X	X	X	X									X			X		
			Construct precautionary storage / handling capacity			X		X	X						X	X							
			Rent/Buy rolling stock for privately-owned rail system		X		X			X												X	
			Repair / Rehabilitate rail tracks to 110-lb rail on privately-owned rail system		X	X	X			X	X		X	X					X	X		X	X
			Repair / Rehabilitate rail bridges to 286K-lb car capability rail on privately-owned rail system		X	X	X			X	X		X	X					X	X		X	X
			Improve alignment or add rail mainline track on privately-owned rail system		X	X	X			X	X								X	X		X	X
			Install signals and signs on rail mainlines and yards belonging to privately-owned rail system			X	X		X	X	X							X	X	X	X	X	X
		Market	Locate and construct input storage / handling facility			X	X		X		X										X		X
			Locate and construct commodity storage storage / handling facility			X	X		X		X										X		X
			Construct rail sidings/spurs/yards on privately-owned rail system	X	X	X	X		X	X	X							X	X	X	X	X	X