Montana Weigh-in-Motion (WIM) and Automatic Traffic Recorder (ATR) Strategy

Report for Task 3
Data Collection, Analysis, and Presentation

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ABSTRACT

This report characterizes a) the basic traffic data that the Traffic Data Collection and Analysis (TDCA) Section of the Montana Department of Transportation (MDT) is collecting on Montana's highways, b) the analyses being performed on this data, and c) the various delivery formats and venues subsequently being used. Additionally, initial efforts were made to identify and characterize various potentially significant temporal and areal traffic flows on the state's highways from agriculture, natural resource extraction and tourism activities. This report is the third task report prepared for a major research project being conducted by MDT on assessing the efficacy of its traffic data collection program.

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INTRODUCTION

This report characterizes a) the basic data that the Traffic Data Collection and Analysis (TDCA) Section of the Montana Department of Transportation (MDT) is collecting on Montana's highways, b) the analyses being performed on this data, and c) the various delivery formats and venues subsequently being used. Large local/regional fluctuations in traffic volumes and in the composition of the traffic stream are encountered on many of Montana's highways both temporally and spatially, as the state's economy is agriculture, natural resource extraction and tourism intensive. Whether the data that are being collected capture all of the important traffic flows on the state's highways can only be fully determined if the existence of these flows (and if appropriate, their causative factors) is known. Therefore, and as possible, such flows are also identified in this report, including vehicle movements associated with grain harvests, off-season farm-to-market movements, logging, energy development, and ore processing.

This report is the third task report prepared for a major research project being conducted by MDT on assessing the efficacy of its traffic data collection program. Other task reports that have been completed to-date describe the state-of-the-practice in traffic data collection (Qi, Forsythe, et al. 2013) and the basic composition of MDT's traffic data collection program (Qi, Stephens, et al. 2014).

SUMMARY OF BASIC TRAFFIC DATA COLLECTED

Currently the Montana Department of Transportation (MDT) continuously monitors traffic at 99 locations across the state using permanent Automatic Traffic Recorder (ATR) and Weigh-in-Motion (WIM) installations. Based on the various segments of the highway system they are located on, these installations are actively collecting data on 9.4 percent of the estimated 11,858 million vehicle miles travelled (VMT) in 2012 on the state highway system. Data collection at these permanent sites is augmented by short-term counts (typically 36 to 48 hours in duration) conducted at approximately 5,000 sites around the state, with approximately one third of the short-term counts being done in any given year. In general, the data that are being collected can be grouped in three broad categories, namely, volume, configuration, and weight. The following sub-sections of this report describe the data that are collected from the permanent/continuous ATR and WIM sites, and from the short-term count sites.

Data from Permanent ATR Sites

Montana's permanent ATR sites (62 locations around the state) are capable of collecting vehicle volume or vehicle volume and configuration data. The ATR systems fundamentally detect the passage of each vehicle/vehicle axle. To determine vehicle classification, it is usually necessary to also collect speed data to permit calculation of axle spacing and/or vehicle length, which is done based on the time required for an axle to pass two consecutive sensors at a known distance apart. Data are collected in binary format at the site, and are subsequently processed either using software from the ATR manufacturer, or third party general purpose traffic data analysis software. For further analysis of the traffic data, it is also necessary that the data records include the time and date of the recorded event(s). Further information on analyses of this data is presented in a subsequent section of this report. Individual vehicle records (IVR) are only available from a limited number of ATR sites (17 sites). Otherwise, data are aggregated (also referred to as "binned") in one hour blocks. The IVR data available from selected sites is reported in Table 1. Similar information is available for data aggregated into one hour blocks.

TABLE 1 Typical ATR Data (MDT 2014)

Field	Description
Date	Date of record
Time	Time of record
Lane	Lane number
Speed	Speed of vehicle
Axles	Number of axles on the vehicle
Length	Total length of vehicle
Ax	Axle class – vehicle classification
Sp	Speed class
Ln	Length class
Gp	Gap class – not being used
Hd	Headway class – not being used
1-2	Space between axles
2-3	Space between axles

* Spacing between axles continues for up to 13-14 axles

Data from Permanent WIM Sites

Generally WIM sites are capable of collecting all of the data that ATR sites collect with the addition of weight data for each axle that crosses the site. Dependent upon the type of WIM installation, it is possible to collect the weight of the left and right side of each axle individually or to collect only each axle's weight. That being said, MDT primarily utilizes quartz-piezoelectric WIM systems that measure the weight of each tire assembly and combine the left and right sides of the vehicle into one weight for the whole axle. Axle weight typically is the parameter recorded and used in subsequent analyses. All WIM data from the 37 sites around the state are in the form of individual vehicle records. The axle weight data is used to determine the weight of each axle group (i.e., single, tandem, tridem, quadrum) and the gross vehicle weight (GVW). Table 2 presents the data collected and parameters calculated at a typical WIM installation for each individual vehicle.

TABLE 2 Typical WIM Data (MDT 2014)

Field	Description
MO	Month
DA	Day
YE	Year
HO	Hour
MI	Minute
SE	Second
VHNUM	Sequential vehicle number
SN	Station number
LN	Lane number
Viol	Sensor violation (vehicle did not hit sensor properly)
CA	Vehicle Scheme F Class
GR81	Axle arrangement
Spee	Vehicle Speed
Leng	Total Vehicle Length
ESAL	Equivalent single axle load
TODT	Length from first axle to last
TWT3	Total Vehicle Weight
WT1	Weight of first axle
DT12*	Distance between first and second axle
WT2*	Weight of second axle

*Weight and Distance pairs are repeated for as many axles as are detected

Data from Short-term Sites

Short-term counts are performed using portable devices such as pneumatic road tubes or video equipment. The type of data collected in short-term counts is often limited by the capabilities of the data collection device. Data collected can be as simple as the total number of axles to cross a given point, or as complex as the speed and axle spacing of each vehicle. Portable WIM systems also exist. That being said, MDT does not utilize portable WIM systems due to the low accuracy and high labor costs associated with use and calibration of these devices.

Table 3 presents the data typically collected from short-term counts. In addition to those items in Table 3, information on the station setup is included with the raw data. This information includes the type of counting device, serial number of the counting device, and the settings used for the count. While data are captured for every vehicle that passes the counting device, the data that are stored on the device and later collected are grouped into 1-hr blocks or bins. Since short-term sites are mainly used to collect traffic volume, storing binned data does not cause any reduction in accuracy, and it is less memory intensive than retaining every vehicle record.

TABLE 3 Typical Short-term Data (MDT 2014)

Field	Description
Date	Date of count
Time	Time of count
Lane 1	Number of vehicles (two-hose setup) or number of axles (single-hose setup)

DATA ANALYSES

The basic data described above are analyzed to determine various characteristics of the traffic on the state highway system which are then used across a broad spectrum of planning and design activities at both the project-specific and network levels. Basic traffic characteristics of interest include traffic volume, classification, and weight, and associated metrics that can then be calculated from this information, such as average-annual-daily-traffic (AADT), vehicle-miles-of-travel (VMT) and equivalent single axle loads (ESALs). Since an essential part of any such analyses is an assessment of basic data quality, the principal quality control measures used by MDT are discussed first below, followed by descriptions of the various data analyses that are subsequently performed.

Quality Control

In order to obtain reliable information from the data that are collected by the ATR/WIM systems throughout Montana, MDT utilizes quality control procedures that screen the data automatically and/or manually for erroneous and missing entries.

Automated quality control checks are performed by software and consist of the items shown in Table 4. Referring to Table 4, many of these automated checks are tests of the "reasonableness" of the data collected as judged based on physical limits and historical values of the phenomena being measured or calculated. For example, a warning is issued if a vehicle is classified as having 14 or more axles, with an error assessed if the number of axles is at or greater than 20. As another example, records with a vehicle speed of greater than 90-mph are flagged with a warning message, with a recorded speed in excess of 155 mph resulting in an error message. Another test checks hourly lane volume, with values in excess of 3,500-veh/hr generating an error message. Traffic volumes in excess of this value are physically unreasonable at even moderate speeds. Any records that are found to be in error are simply removed from the final data sets. Individual vehicle records that result in a warning message are reviewed by an MDT technician, and a decision on the validity of the data is made based on the experience of the technician.

Relative to comparative checks against historical operations, if the reported AADT, for example, varies by more than a pre-determined percentage from the historic AADT at a given site (a value of 90 percent often is used), a warning message is issued.

In addition to the checks listed in Table 4, all outcomes of the data analysis process are scrutinized by experienced personnel for possible anomalies not detected by the automated screening process. For example, the percentage of heavy vehicles determined on a segment of highway may appear to have significantly increased over the previous year, with no other changes to the traffic stream. This situation would not be flagged for further investigation by the automated quality control checks, but it would be seen as a concern by an experienced traffic data technician as being possibly caused by a problem with the data collection and analysis process.

If the data are missing for many days at a given site, it is possible that the missing data could result in mischaracterization of the traffic operations at that site. To prevent this from happening, MDT requires that at least one full day of data exist for each day-of-week for each month. If, for example, all Saturdays in a given month had no data, no traffic adjustment factor would be calculated for Saturdays in that month.

TABLE 4 Data Quality Control (MDT 2014)

Data Quality Error	Description	Error	Warning	Units
AADT vs History	Current AADT differs from historic AADT by more than given percentage	-	90	Percent
Annual ADT Threshold	Annual average day-of-week (DOW) traffic volumes must be available for every day of the week (total of seven values), if annual AADT is to be determined	6	-	Days
Annual Day-of-week threshold	Average DOW traffic volumes must be available for at least eight and preferably nine months, if average annual DOW traffic volume is to be determined	7	8	Months
Annual High Hour Threshold	Data must be available for at least 250 and preferably 300 days, if annual high hour peak volume is to be determined	249	299	Days
Annual Weekday Threshold	Average annual traffic must be available for at least four individual weekdays, if average annual weekday traffic volume is to be determined	3	-	Days
Annual Weekend Threshold	Average annual traffic must be available for at least one individual weekend day, if average annual weekend traffic volume is to be determined	1	-	Days
Axle Count High	Maximum number of axles comprising a credible vehicle	20	14	Axles
Axle Count Low	Minimum number of axles comprising a credible vehicle	1		Axles
Axle Spacing High	Maximum credible spacing between consecutive axles	99	50	Feet
Axle Spacing Low	Minimum credible spacing between consecutive axles	2	3	Feet
Axle Weight <> GVW	Sum of reported axle weights and GVW are within 90 percent of one another	90		Percent
Axle Weight High	Maximum credible single axle weight	500	-	100’s of lbs
Axle Weight Low	Minimum credible single axle weight	5		100’s of lbs
Axles vs Spaces	Axles minus one must equal spaces	On As Error	-	Axles
Axles vs Total Axles	Axles counted does not equal total axles	On As Error	-	Axles
Bumper/Axle1 High	Not used	-	-	-
Bumper/Axle1 Low	Not used	-	-	-

Consecutive Hourly Zeroes	Maximum credible number of hours with no traffic	12	6	Hours
Consecutive Identical Number	Maximum credible number of hours with the same traffic volume	8	4	Hours
Direction Data Missing	No direction data	On As Error	-	-
Directional Split	Maximum credible directional split	80	60	Percent
High 9/11 First Axle Weight	Maximum credible steer axle weight for class 9 and 11 vehicles	400	150	100’s of lbs
High Volume vs History	Check if current calculated AADT is at least 90 percent of historical AADT		20	Percent
Hours Collected	Number of hours collected per day exceeds	23	-	Hours
Invalid Date	Date is invalid	On As Error	-	Date
Length < Wheelbase	Vehicle length is less than wheelbase	On As Error	-	Feet
Length = Wheelbase	Vehicle length equals wheelbase	-	On As Warning	Feet
Low 9/11 First Axle Weight	Minimum credible steer axle weight for class 9 and 11 vehicles	5	70	100’s of lbs
Low Volume vs History	Current calculated volume is at least 80 percent of historical volume	-	80	Percent
Maximum Hourly Volume Directional	Maximum credible hourly volume in one direction	14000	-	Volume
Maximum Hourly Volume Lane	Maximum credible hourly volume in one lane	3500	-	Volume
Missing Data	Data entry check	On As Error		-
Monthly ADT Threshold	Average DOW traffic must be available for at least six days of the week, if monthly ADT is to be determined	5	-	Days
Monthly DOW Threshold	Data from a least one DOW during the month must be available to calculate the average traffic for that DOW in that month	0	-	Days
Monthly Weekday Threshold	Average DOW traffic must be available for at least four individual weekdays of that month, if average monthly weekday per month is to be determined	3	-	Days
Monthly Weekend Threshold	Average DOW traffic must be available for at least one individual weekend day of that month, if average monthly weekend traffic volume is to be determined	1	-	Days
No Class Code	Vehicle not classified	On As Error	-	-
Speed 0	Speed equals zero	On As Error	-	mph
Speed High	Speed exceeds given value	155	90	mph
Speed Low	Speed is lower than given value	9.9	39.9	mph
Split Counter Files	Counter file split		On As Warning	-
Too Many Invalid	Number of invalid records exceeds value	30	-	Percent

Measures of Traffic Volume

Data collected at permanent ATR/WIM sites is used to determine traffic volume over various time intervals. The average daily traffic volume by day-of-week for each month is obtained by averaging the weekday (Monday through Thursday), Friday, Saturday, and Sunday traffic for a given month. This averaging is done to help eliminate possible bias in the day-of-week results due to random variations in traffic volumes across the month. As a minimum requirement, data for at least one day for each day-of-week must be collected for a given month. If this requirement is not met, the data for that month is not used in any further analysis.

Determination of AADT is done using an average of averages method as recommended by the Traffic Monitoring Guide (FHWA 2013). The basis for this calculation is the values determined for the average daily volume of traffic by day-of-week for each month. The average daily traffic volumes by DOW are averaged across the year (i.e. average of twelve values, one from each month), as indicated in Equation 1. This approach, reportedly, is a simple but relatively robust approach to minimizing potential bias from missing data (FHWA 2013).

$$AADT = \frac{1}{7}\sum_{i=1}^{7}\left[\frac{1}{12}\sum_{j=1}^{12}\left(\frac{1}{n}\sum_{k=1}^{n} VOL_{ijk}\right)\right] \qquad (1)$$

Where,

VOL	=	Daily traffic for day k, of day-of-week i, and month j,
i	=	Day-of-the-week,
j	=	Month-of-the-year,
k	=	1 when the day is the first occurrence of that day of the week in a month, 4 when it is the fourth day of the week, and
n	=	The number of days of that day-of-the-week during that month (usually between one and five depending on the number of missing data).

Configuration

Vehicle configuration (classification) is determined using computer algorithms acting on overall vehicle length and/or axle spacing. Length based classification simply assigns vehicles to one of two classifications, over 47-ft and less than 47-ft in total length. This threshold length was selected based on the lengths of common heavy vehicles. If supported by the basic data collected and stored, a more refined classification can be performed using algorithms that act on axle spacing to sort vehicles by their FHWA Scheme F classification. FHWA Scheme F recognizes 13 fundamental vehicle types, which have been customized in Montana with various subgroups to better capture specific types of vehicles commonly observed on the state's roadways. The set of vehicle classification algorithms typically used with ATR data is presented in Table 5, while the classification scheme generally used with WIM data is shown in Figure 1. In addition to the 13 configurations given in FHWA Scheme F, two other "configurations" are used to report erroneous data, namely Class 14 and Class 99. Class 14 vehicles are those that were reported to be vehicles, but upon further scrutiny of the data are believed in error, for example, a record with a vehicle speed of zero miles per hour. Class 99 vehicles are those that have been reviewed by TDCA personnel and found to be legitimate, but do not fall within any established classification. If FHWA classified data needs to be evaluated in length based terms, vehicles in Classes 5 through 13 are assumed to correspond to vehicles over 47 feet in length. Further, many elements of traffic data (e.g., AADT) are reported in various aggregations of vehicle classifications. Vehicle configurations are often aggregated into the broad categories of commercial vehicles (Class 5-13), or small and large trucks (Class 5-7 and Class 8-13, respectively) and busses (Class 4). Further information on the classification and presentation of data is presented in the Data Dissemination section of this report.

TABLE 5 MDT Configuration Definitions (MDT 2014)

Definition	FHWA Scheme F Classification	Number of Axles	Spacing Between Sequential Axles (ft)
1	Type 1	2-3	1-6.5,2-8
2	Type 2	2-3	6.6-9.9,6.1-19.5
3	Type 2	4	6.6-9.9, 6.1-18, 1-10
4	Type 3	2-3	10-14.9, 6.1-23
5	Type 3	4	10-14.9, 6.1-40, 1-13
6	Type 3	5	10-14.9,*,*,1-5
7	Type 4	2-3	20-40,3-6
8	Type 5	2	15-19.9
9	Type 5	4	15-19.9, 6.1-40, 1-10.5
10	Type 5	5	15-19.9,*,*,1-5
11	Type 6	3	*, 3-6
12	Type 7	4	*, 3.3-6, 3.3-6
13	Type 8	3	*, 6.1-42
14	Type 8	4	*, 3.3-42, 3.3-42
15	Type 9	5	*, 3.3-6, *, 3.3-23
16	Type 9	5	*, *, *, *
17	Type 10	6	*, 3.3-8, 3.3-6, *, 3.3-11
18	Type 10	6	*, 3.3-6, *,*, 3.3-11
19	Type 10	7	*, 3.3-8, 3.3-6, *, 3.3-6, 3.3-6
20	Type 10	8	*, 3.3-8, 3.3-6, *,3.3-6, 3.3-6, 3.3-6
21	Type 11	5	*,13.3-27,4-16.7,10-26.7
22	Type 12	6	*, 3.3-6, 13.3-27, 6.7-13.3, 10-27
23	Type 12	6	*, 10-40, 3.3-6, 8-20, 10-30
24	Type 13	7	*, 3.3-8, *, *, *, *
25	Type 13	7-10	*, *, *, *, *, *, *, *, *

* Any distance between axles

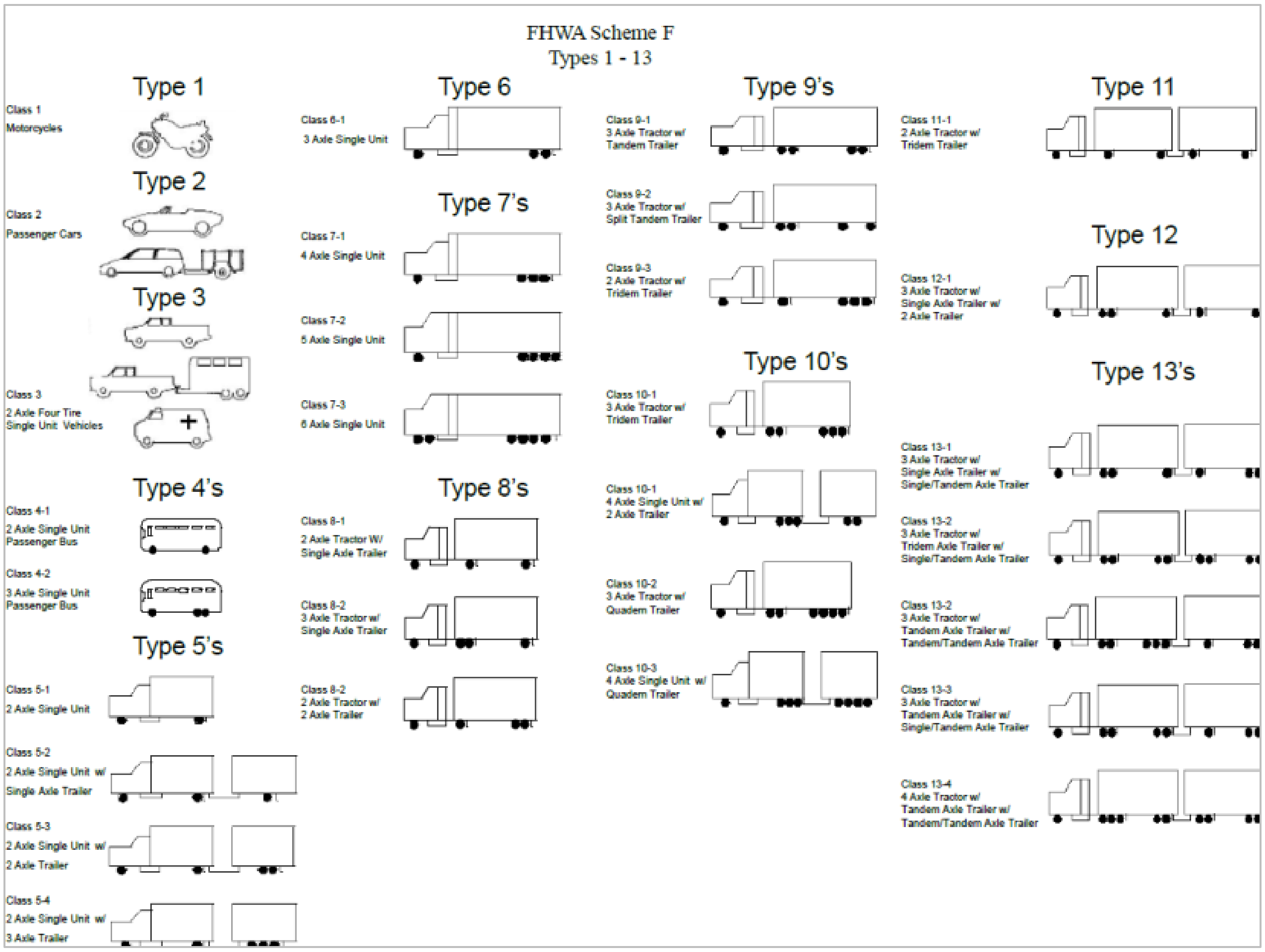

FIGURE 1 FHWA Scheme F

Traffic Factors

Traffic Factors are generated for use in determining AADT at a given location by expanding the results of short-term traffic counts conducted at that location for just a few days during the year. The ADT during the short-term count is multiplied by a factor determined from data collected at permanent ATR/WIM sites expected to have a similar composition of vehicles. Two sets of factors are generated, one for expanding single-hose volume counts, and one for expanding two-hose classification counts. In the former case, the traffic factor simply needs to account for variations in traffic operations at various times throughout the year, while in the latter case it must also address the expected number of combination vehicles in the traffic stream. These factors vary by the time interval during the year when the short-term count was conducted, as well as by the functional class of roadway the count was taken on. Table 6 presents the functional classifications used by MDT. MDT currently determines factors for each functional

TABLE 6 Functional Classifications used by MDT

Abbreviation	Classification
RI	Rural Interstate
UI	Urban Interstate
RPA	Rural Primary Arterial
UPA	Urban Primary Arterial
RMA	Rural Minor Arterial
UMA	Urban Minor Arterial
RMC	Rural Major Collector
UC	Urban Collector
REC	Recreational

class (total of eight classes), for weekdays (Monday through Thursday), Fridays, Saturdays, and Sundays, for each month of the year. Thus, a total of 384 individual factors are determined (MDT 2013). Although traffic factors are generated for Fridays, it is the policy of MDT to not perform short-term counts on Fridays due to the atypical nature of the traffic.

Traffic factors are generated for each ATR/WIM site using Equation 2. Next, for a given functional class, the factors from all of the ATR/WIM systems within that functional class are averaged. Further, to address possible short-term variations in traffic operations from year-to-year, these values are averaged over a three-year period. Those averages are the final factors that are published. Factors for single-hose configurations simply use the number of axles instead of the number of vehicles in calculating traffic factors. Further information on the format in which the factors are published can be found in the Data Dissemination section of this report.

$$Factor_{i,j} = \frac{AADT_j}{ADT_i} \quad (2)$$

Where,

$Factor_{i,j}$ = Traffic factor for time interval i at site j,
ADT_i = Average daily traffic for time interval i for two-hose configurations or average number of axles for time interval i for single-hose configurations, and
$AADT_j$ = Average annual daily traffic for site j.

Weight Data

All weight data are collected by WIM systems, with the primary use of this data being in pavement design. Currently in Montana, vehicle demands for pavement design need to be quantified in terms of ESALs, which are calculated from the weight carried on the individual axle groups comprising each vehicle in the traffic stream. An alternate pavement design process uses axle load spectra rather than ESALs in quantifying vehicle demands for pavement design, and while not currently used in Montana, programs are in place that can generate these spectra from the data collected at WIM sites. WIM data are also used to support Montana's weight enforcement efforts, as described below.

ESALs

Design ESALs are a cumulative traffic load applied to a pavement during its design life, expressed in terms of the equivalent number of passages of an 18,000-lb single axle over that pavement. Notably, ESALs serve to convert a mixed stream of traffic of different axle loads and axle configurations to a common unit of structural demand. Following the AASHTO-Pavement Design Guide (AASHTO 1993), roadways are designed to carry the total number of ESALs that they are projected to experience across their design life, often 20 years. Design ESALs are a function of the volume, classification, and weight of the traffic traveling on a given roadway. Derived through empirical testing, design ESALs vary a) as a fourth order of axle weight, b) by axle configuration, i.e., single, tandem, tridem and quadrum, c) by roadway strength, and d) by terminal level of pavement condition assumed at its failure. For a given roadway strength and level of terminal serviceability, equations are available to calculate ESAL factors for each vehicle based on axle configuration and weight.

ESAL values are first calculated for each individual vehicle record by the TDCA, and then aggregated across functional system and vehicle classification based on their intended use. For network level analyses, ESAL factors are aggregated across the categories of interstate highways as well as minor and major arterials for the broad vehicle classifications of small trucks (Class 5-7), large trucks (Class 8 -13), and busses (Class 4). For project level work, ESAL factors are determined for each vehicle classification for the functional class of roadway consistent with the project location. All factors are calculated as an average of the ESAL factors for the individual vehicles captured at corresponding WIM sites over the past year. The ESAL factors are applied to the traffic count of interest to estimate total ESALs of demand on a particular network or at a specific project site.

To ensure accuracy, the ESAL factors are visually checked by a TCDA staff member for any abnormal values based on the staff member's experience. These checks include reviewing the number of erroneous vehicle classifications within the data set being used, i.e. types 14 and

99; scale, validation, and speed errors; and the percentage of type 14 vehicles to total commercial vehicles. These checks are performed on a per lane basis and a total quantity per site. In addition to the aforementioned checks, general trends in vehicle classification, volume, and weight are compared with those observed historically and at other similar sites to further identify possible anomalies in the results

Axle Load Spectra

Axle Load Spectra are used to quantify vehicle weight related pavement demands in the Mechanistic-Empirical Pavement Design Guide (ARA 2004). Currently MDT does not use this approach, but it is possible to generate load spectra from the WIM data being collected and the software that is being utilized. Axle Load Spectra, as the label implies, provide frequency distributions of axle group loads by vehicle configuration.

Weight Enforcement

A decade ago MDT developed the State Truck Activities Reporting System (STARS) that included the Measurement of Enforcement Activity Reporting System (MEARS) (Stephens and Carson 2005). The MEARS software was specifically configured to use WIM data to identify where and when overweight vehicles were operating on the state highway network. This functionality is now available to MDT as part of the commercial software package Traffic Count Database System (TCDS), a subscription based software and database service offered by Midwestern Software Solutions (MS2, Ann Arbor, MI). This and other features of this software are described in more detail in subsequent sections of this report.

Expansion of Short-term Counts

Short-term traffic counts are performed for 36 to 48-hr. These counts are then expanded to an estimated AADT for the site using the Traffic Factors for the given functional class and time-of-year. The appropriate factor that corresponds to the type of short-term count (single hose, volume only or two-hose, classification) must be used. Equation 3 presents the method employed to expand a short-term count.

$$AADT = Factor_{i,j} * ADT_i \tag{3}$$

Where,

AADT	=	Estimated average annual daily traffic,
$Factor_{i,j}$	=	Traffic factor corresponding to time i for functional class j, and
ADT_i	=	Average daily traffic for time i as determined by the short-term count.

VMT

Vehicle miles traveled (VMT) are determined by multiplying the length of a roadway section by the number of vehicles that travel the section in a given time, most often one year. The estimated or actual AADT for a roadway section is multiplied by the number of days in the year to determine the total vehicles that traveled the section within the given year. The end result of this calculation can be used to create traffic flow maps, estimate vehicle emissions, etc. Approximately 10 percent of the VMT in Montana are captured by permanent ATR/WIM sites (based on traffic flow and data collection in 2012). The remaining VMT on the state system is estimated based on short-term counts.

DATA DISSEMINATION

The following section presents the various reports that MDT publishes to disseminate traffic data. These reports typically are available online as downloadable files. In addition to reports, MDT also has an online interactive map-based GIS application available on their website that incorporates a variety of traffic data. MDT is also testing an online traffic data management tool, MS2, for internal use. To improve readability of this section of this report, website addresses for the cited data items have been collected in Appendix A.

Traffic by Sections

The Traffic by Sections (TBS) report is published annually and includes traffic data for all of the highway sections that are monitored by the TDCA section. This report includes referencing and description information, AADT, and the daily vehicle miles travelled (DVMT) for all vehicles (Classes?), with sub-breakdowns by various vehicle groupings (e.g., commercial vehicles (Class 5 -13), small trucks (Class 5-7) and large trucks (Class 8-13), etc.). The road sections used are based on a) major intersections that cause changes in traffic, b) political boundaries such as county lines, and c) for interstates, every interchange.

The 2012 TBS report is 833 pages in length. Table 7 shows a sample of the data that are available in the TBS report by specific route segments. Table 8 presents a sample of the data available for AADT/DVMT aggregated by route.

TABLE 7 Sample of Traffic by Sections

2012					Location		County	Truck Percentages				Weighted AADT			
Dept Route	Reference Point Beg	Reference Point End	Sctn Length	Section Description				Small (5 7)	Large (8 13)	Comm (5 13)	Traffic Type	2010	2011	2012	DVMT
N-1	119+0.622	120+0.114	0.504	JCT N-109 (KALISPELL ALT ROUTE)	KALISPELL	CITY	FLATHEAD	1.3	1.1	2.4	All Vehicles		11530	16460	8296
											Commercial		336	389	196

TABLE 8 Sample of Weighted AADT/DVMT Summary by Route

Secondary			Average Annual Daily Traffic (AADT)							Daily Vehicle Miles Traveled (DVMT)						
Dept Route	Rural/ Urban	Miles	MC (1)	Pass Vehicles (2-3)	Buses (4)	Small Trucks (5-7)	Large Trucks (8-13)	Comm (5-13)	All Vehicles (1-13)	MC (1)	Pass Vehicles (2-3)	Buses (4)	Small Trucks (5-7)	Large Trucks (8-13)	Comm (5-13)	All Vehicles (1-13)
S-442	Rural	8531		154	4	4	4	8	170		1315	34	34	34	68	1452
	Urban															
	Route Total	8531		154	4	4	4	8	170		1315	34	34	34	68	1452

Vehicle Miles Traveled

Two reports exist summarizing VMT on state roads in Montana. The first report is the Annual VMT report; the second, Montana's Estimated Monthly VMT report. The Annual VMT report, presented for illustrative purposes in Figure 2, is simply a table presenting the VMT for interstate, non-interstate National Highway System (NI-NHS), primary, secondary, urban, on-system total, off-system total, and statewide total for every year from 1966 to the present.

The second report is a table presenting the VMT for each month of the year from 2010 to present. The monthly report is further broken down into urban and rural components. Figure 3 presents an illustration of the monthly VMT table.

Annual Vehicle Miles of Travel
All Systems, Urban & Rural
(in Billions)

Year	Interstate	NI-NHS	Primary	Secondary	Urban	On-System Total	Off-System Total*	Statewide Total
1966	0.800		1.510	0.429		2.739		3.838
1967	0.852		1.581	0.453		2.886		4.080
1968	Unavailable							
1969	0.875		1.734	0.489		3.098		4.439
1970	0.958		1.842	0.544		3.344		4.867
1971	1.043		2.007	0.565		3.615		5.079
1972	1.181		2.095	0.602		3.878		5.373
1973	1.181		2.117	0.630		3.928	1.761	5.689
1974	1.174		1.930	0.472	0.430	4.006	1.817	5.823
1975	1.184		1.933	0.471	0.434	4.022	1.701	5.723
1976	1.290		2.202	0.362	0.532	4.386	1.742	6.128
1977	1.393		2.350	0.372	0.622	4.737	1.774	6.511
1978	1.497		2.427	0.423	0.610	4.957	2.064	7.021
1979	1.442		2.635	0.428	0.602	5.107	1.596	6.703
1980	1.410		2.359	0.405	0.639	4.813	1.794	6.607
1981	1.443		2.552	0.433	0.645	5.073	1.930	7.003
1982	1.435		2.518	0.417	0.631	5.001	1.667	6.668
1983	1.487		2.661	0.440	0.671	5.259	1.920	7.179
1984	1.525		2.685	0.469	0.705	5.384	1.982	7.366
1985	1.599		2.695	0.472	0.626	5.392	2.178	7.570
1986	1.632		2.709	0.486	0.637	5.464	2.273	7.737
1987	1.719		2.743	0.510	0.664	5.636	2.398	8.034
1988	1.788		2.787	0.517	0.651	5.743	2.372	8.115
1989	1.899		2.890	0.531	0.677	5.997	2.252	8.249
1990	1.986		2.934	0.541	0.683	6.144	2.187	8.331
1991	1.962		2.892	0.531	0.677	6.062	2.253	8.315
1992	2.114		3.113	0.558	0.719	6.504	1.997	8.501
1993	2.115		3.195	0.578	0.770	6.658	2.048	8.706
1994	2.156		3.256	0.605	0.809	6.826	2.291	9.117
1995**	2.281	2.409	1.183	0.632	0.775	7.280	2.119	9.399
1996	2.308	2.361	1.169	0.639	0.784	7.261	2.159	9.420
1997	2.350	2.339	1.141	0.653	0.802	7.285	2.037	9.322
1998	2.427	2.337	1.175	0.679	0.832	7.450	2.043	9.493
1999	2.417	2.401	1.202	0.704	0.832	7.556	2.228	9.784
2000	2.436	2.434	1.214	0.722	0.835	7.641	2.214	9.855
2001	2.480	2.508	1.205	0.733	0.822	7.748	2.263	10.011
2002	2.736	2.638	1.303	0.717	0.889	8.283	2.203	10.486
2003	2.737	2.733	1.342	0.741	0.902	8.455	2.442	10.897
2004	2.829	2.774	1.363	0.763	0.908	8.637	2.540	11.177
2005	2.814	2.776	1.362	0.768	0.916	8.636	2.491	11.127
2006	2.833	2.761	1.367	0.766	0.910	8.637	2.628	11.265
2007	2.905	2.776	1.381	0.770	0.930	8.761	2.545	11.306
2008	2.686	2.592	1.303	0.753	0.916	8.250	2.532	10.782
2009	2.787	2.681	1.322	0.770	0.941	8.501	2.509	11.010
2010	2.750	2.723	1.326	0.804	0.944	8.547	2.638	11.185
2011	2.810	2.706	1.326	0.814	0.945	8.602	3.064	11.666
2012	**2.954**	**3.346**	**1.172**	**0.771**	**0.582**	**8.824**	**3.034**	**11.858**

FIGURE 2 Annual Vehicle Miles Traveled, in millions

Montana's Estimated Monthly Vehicle Miles Traveled (Millions)*

		Rural						Urban				Statewide
		Rural Interstate	Rural Other Arterial	Other Rural	Total Rural			Urban Interstate	Urban Other Arterial	Other Urban	Total Urban	All Systems
Rural '10	Jan	145	202	150	497	Urban '10	Jan	21	87	52	160	657
	Feb	154	211	155	521		Feb	22	92	54	166	689
	Mar	175	239	177	591		Mar	26	104	60	189	780
	Apr	188	246	183	617		Apr	26	107	65	198	815
	May	207	282	209	698		May	29	121	73	223	921
	Jun	246	337	248	832		Jun	35	154	82	271	1,102
	Jul	299	422	308	1,029		Jul	45	194	101	341	1,370
	Aug	291	395	297	982		Aug	42	188	98	328	1,310
	Sep	224	318	226	767		Sep	33	142	73	248	1,015
	Oct	218	288	207	713		Oct	31	129	73	233	946
	Nov	189	254	184	627		Nov	25	112	69	205	833
	Dec	179	240	182	600		Dec	26	101	61	188	789
	AVMT	***2,515***	***3434***	***2,526***	***8,474***		***AVMT***	***361***	***1,531***	***861***	***2,750***	***11,227***
Rural '11	Jan	148	198	149	495	Urban '11	Jan	21	88	55	164	659
	Feb	151	201	152	504		Feb	22	91	57	169	674
	Mar	171	231	172	575		Mar	25	101	58	184	759
	Apr	186	236	186	608		Apr	26	106	68	200	808
	May	204	276	212	692		May	29	121	78	228	920
	Jun	250	325	249	825		Jun	35	154	86	275	1,085
	Jul	304	409	315	1,028		Jul	45	195	106	347	1,375
	Aug	299	390	302	991		Aug	43	191	107	341	1,332
	Sep	231	316	235	782		Sep	34	145	77	255	1,038
	Oct	223	280	210	713		Oct	31	130	77	238	951
	Nov	198	256	186	639		Nov	27	114	72	213	852
	Dec	189	255	185	629		Dec	27	106	60	192	821
	AVMT	***2,554***	***3,373***	***2,553***	***8,481***		***AVMT***	***365***	***1,542***	***901***	***2,806***	***11,274***

FIGURE 3 Montana's Estimated Monthly Vehicle Miles Traveled

Annual and Monthly ATR/WIM Reports

The Annual ATR/WIM Report contains data collected by the permanent ATR/WIM sites throughout Montana on daily and hourly traffic volumes. Provided as an introduction to these reports, are tallies of the ATR/WIM sites sorted by functional class and urban versus rural (see Table 9). The following descriptions are provided of the specific information contained in these reports:

The Yearly ATR Profile includes:

- The average daily traffic for each day of week and for each month (i.e. the average traffic for Sunday in January versus a Sunday in July),
- The average daily traffic for the week (Sunday through Saturday),
- The average daily traffic for the weekday for each month (weekday is defined as Monday through Thursday for traffic reporting purposes),
- Percentage, by month, of average daily traffic (Sunday through Saturday) as compared to the average weekday traffic (Monday through Thursday),
- Percentage, by month, of average daily traffic (Sunday through Saturday) as compared to the yearly average daily traffic is shown on the Yearly Peak Hourly Volumes Report,

- The traffic mix (Passenger vehicles, small trucks, and large trucks) as percent of the total AADT. This is only displayed for sites that are capable of collecting FHWA 13 class data, and
- The directional distribution of vehicles.

The Yearly Peak Hour Volume report includes:

- The current and historical AADT, and
- The 10th, 20th, 30th (generally used as the design hour volume -DHV), 50th and 100th peak hour traffic volumes, shown as percentages of the daily traffic.

TABLE 9 ATR Distribution by Functional Class

Functional Class	Urban	Rural
1. Principal Arterial (Interstate)	4	20
2. Principal Arterial (Other)	5	34
3. Minor Arterial	3	18
4. Collector (Urban); Major Collector (Rural)	2	9
5. Minor Collector (Rural)	0	0
6. Local	0	1
Total	14	82

In addition to the above descriptions of the data, the introduction includes a map presenting the location of the ATR/WIM sites throughout Montana and an FHWA Scheme F vehicle classification chart.

Figures 4 and 5 present examples of the Yearly ATR Profile and the Yearly Peak Hour Volume tables, respectively, for an ATR site.

Montana Department of Transportation
MDT

Yearly ATR Profile
For Year: 2012
Jefferson County
Station A-002
Ascending Direction: East

Location ID: 22-2-2
Functional Class: Principal Arterial - Rur
Traffic Factor Group: RPA
US-287/US-12 near Claysoil, 9 miles east of Helena N-8 (C000008) RP 55.3
Traffic Mix: Pass: 93.89% Sm Truck: 0.94% Lg Truck: 5.03%
Directional Split E: 50% / W: 50%

(YATRPROF)

	Average Daily Number of Vehicles Day of the Week							Avg. Day (Entire Week)	Avg. Weekday (Mon-Thu)	% Avg. Day is of Avg. Weekday	% Avg. Day is of Yearly Avg.
	Sun	Mon	Tue	Wed	Thu	Fri	Sat				
JAN	4,053	4,868	5,052	4,767	5,030	5,933	4,696	4,914	4,929	99.70%	81.09%
FEB	4,338	5,285	5,188	5,195	5,439	6,371	4,745	5,223	5,277	98.98%	86.19%
MAR	5,010	5,239	5,385	5,661	5,966	6,864	5,449	5,653	5,563	101.62%	93.28%
APR	5,414	6,076	5,943	6,166	6,406	6,830	5,737	6,082	6,148	98.93%	100.36%
MAY	5,608	6,202	6,318	6,352	6,705	7,819	6,290	6,471	6,394	101.20%	106.78%
JUN	6,328	6,681	6,394	6,720	7,181	8,072	6,648	6,861	6,744	101.73%	113.22%
JUL	7,039	7,018	6,927	6,784	7,489	8,190	6,673	7,160	7,055	101.49%	118.15%
AUG	6,526	6,644	6,536	6,734	7,186	7,979	6,561	6,881	6,775	101.56%	113.55%
SEP	5,683	6,226	6,272	6,303	6,631	7,738	6,325	6,454	6,358	101.51%	106.50%
OCT	5,805	5,976	5,818	5,996	6,360	7,544	6,235	6,248	6,038	103.48%	103.10%
NOV	4,891	5,528	5,911	6,332	5,334	5,905	4,925	5,547	5,776	96.04%	91.53%
DEC	4,216	4,962	4,989	5,519	5,704	6,294	4,913	5,228	5,294	98.75%	86.27%
Year	5,409	5,892	5,894	6,044	6,286	7,128	5,766	6,060	6,029	100.51%	

** NOTES:*
UNDER CONSTRUCTION IN 2000

FIGURE 4 Sample of Yearly ATR Profile

Montana Department of Transportation
MDT

Yearly Peak Hourly Volumes
For Year: 2012
Jefferson County
Station A-002
Ascending Direction: East

Location ID: 22-2-2
Functional Class: Principal Arterial - Rur
Traffic Factor Group: RPA
US-287/US-12 near Claysoil, 9 miles east of Helena N-8 (C000008) RP 55.3

(YATRPHV)

		Highest Hour		10TH		20TH		* DHV 30TH		50TH		100TH	
YEAR	AADT	Volume	%	Volume	%	Volume	%	Volume	%	Volume	%	Volume	%
1991	3,433	570	16.60%	483	14.10%	458	13.30%	448	13.00%				
1992	3,660	570	15.60%	491	13.40%	479	13.10%	464	12.70%				
1993	3,782	581	15.40%	510	13.50%	496	13.10%	483	12.80%	472	12.50%	438	11.60%
1994	4,043	594	14.70%	547	13.50%	529	13.10%	511	12.60%	493	12.20%		
1995	4,300	592	13.80%	559	13.00%	536	12.50%	528	12.30%	506	11.80%	476	11.10%
1996	4,416	689	15.60%	599	13.60%	565	12.80%	551	12.50%	539	12.20%		
1997	4,439	698	15.70%	574	12.90%	562	12.70%	542	12.20%	527	11.90%	499	11.20%
1998	4,861	657	13.50%	617	12.70%	603	12.40%	588	12.10%	565	11.60%	535	11.00%
1999	5,190	769	14.80%	657	12.70%	632	12.20%	614	11.80%	595	11.50%	561	10.80%
2001	5,230	833	15.90%	647	12.40%	621	11.90%	608	11.60%	570	10.90%	532	10.20%
2002	5,376	731	13.60%	653	12.10%	638	11.90%	627	11.70%	595	11.10%	561	10.40%
2003	5,444	728	13.40%	672	12.30%	650	11.90%	637	11.70%	615	11.30%	577	10.60%
2004	5,730	784	13.70%	695	12.10%	674	11.80%	657	11.50%	641	11.20%	606	10.60%
2005	5,650	749	13.30%	672	11.90%	661	11.70%	650	11.50%	627	11.10%	581	10.30%
2006	5,860	728	12.40%	689	11.80%	669	11.40%	656	11.20%	632	10.80%	598	10.20%
2007	6,182	795	12.90%	746	12.10%	723	11.70%	704	11.40%	676	10.90%	640	10.40%
2008	5,899	1,063	18.00%	750	12.70%	712	12.10%	696	11.80%	667	11.30%	624	10.60%
2009	6,538	877	13.40%	811	12.40%	780	11.90%	770	11.80%	744	11.40%	701	10.70%
2010	6,809	916	13.50%	860	12.60%	836	12.30%	816	12.00%	791	11.60%	760	11.20%
2011	6,010	788	13.10%	729	12.10%	697	11.60%	682	11.30%	656	10.90%	624	10.40%
2012	6,060	797	13.20%	739	12.20%	722	11.90%	704	11.60%	679	11.20%	637	10.50%

** NOTES:*
UNDER CONSTRUCTION IN 2000

FIGURE 5 Sample of Yearly Peak Hourly Volumes

Four types of reports are available with monthly ATR/WIM data. Three of the reports are similar in presentation and provide traffic data on different vehicle groupings: commercial vehicles, large truck, and all vehicles. These three reports provide monthly ADT and the change in traffic volume from year to year sorted by ATR/WIM site. The fourth report type is the Monthly Calendar Report which presents the traffic volume in calendar format by day, direction, and month for each ATR/WIM site. Figure 6 and 7 show an example of each report type.

Montana Department of Transportation
MDT

Monthly Commercial (Class 5-13) Comparison

(Class Sites Only) (MATRC)

January 2012

Site#	Sys Desc	Location	County	Year	Monthly ADT	% Change from same month last year	Monthly Average Weekday Traffic	% Change from same month last year	Monthly Average Weekend Traffic	% Change from same month last year	Number of days monitored this month
A-002	NHS	US-287/US-12 near Claysoil, 9 miles east of Helena N-8 (C000008) RP 55.0	Jefferson	2012	291	-8.78%	367	-9.38%	132	7.32%	31
				2011	319		405		123		31
A-003	INT	I-15, 0.5 miles south of Helena (C000015) RP 191.8	Lewis and Clark	2012	573	-1.72%	630	-4.98%	451	7.13%	30
				2011	583		663		421		31
A-005	PRI	MT-7, 1 mile south of Wibaux P-27 (C000027) RP 79.2	Wibaux	2012	90	9.76%	113	11.88%	48	41.18%	30
				2011	82		101		34		31
A-008	NHS	US 93, 0.5 miles south of Ravalli N-5 (C000005) MP 26.3	Lake	2012	315	0.32%	393	-1.75%	135	8%	30
				2011	314		400		125		28
A-010	NHS	US-2, 2 miles east of Wolf Point N-1 (C000001) RP 592.7	Roosevelt	2012	146	8.96%	189	9.25%	62	47.62%	29
				2011	134		173		42		31
A-014	SEC	S-278, 7 miles southwest of Dillon (C000278) RP 3.4	Beaverhead	2012	22		29		12		30
				2011							29
A-017	INT	I-15, 6.8 miles north of Lima (C000015) RP 22.3	Beaverhead	2012	766	-1.79%	843	-3.66%	621	3.33%	31
				2011	780		875		601		31
A-027	NHS	US-191, 3 miles north of US-191/MT-19 junction N-61 (C000061) RP 69.6	Fergus	2012	41	20.59%	51	21.43%	19	18.75%	31
				2011	34		42		16		31
A-028	STH	State Highway X-07611, 7 miles west of Great Falls (C007611) RP 3.8	Cascade	2012	50		66		19		31
				2011							
A-038	NHS	MT-200, 1 mile west of Jordan N-57 (C000057) RP 209.8	Garfield	2012	41	2.5%	47	-2.08%	28	16.67%	30
				2011	40		48		24		31
A-056	NHS	US-93, 1.5 miles north of Hamilton N-7 (C000007) RP 50	Ravalli	2012	135	-15.09%	173	-16.43%	46	-6.12%	31
				2011	159		207		49		31
A-059	INT	I-90, East of south Billings Blvd Int. (C000090) RP 447.8	Yellowstone	2012	2337	0.95%	2495	-1.11%	1929	8.68%	29
				2011	2315		2523		1775		31
A-061	INT	I-15, north side of Marias Int (C000015) RP 359.6	Toole	2012	742	5.25%	809	2.66%	594	13.14%	31
				2011	705		788		525		30
A-063	NHS	US-212, 13 miles east of Ashland N-37 (C000037) RP 76.7	Powder River	2012	320	1.27%	293	-2.33%	371	8.8%	31
				2011	316		300		341		31
A-072	PRI	US-287 South of Ennis P-13 (C000013) RP 39.5	Madison	2012	179	-2.72%	215	-4.02%	115	10.58%	31
				2011	184		224		104		31

FIGURE 6 Sample of Monthly Commercial Comparison

Montana Department of Transportation
MDT

Monthly Traffic Calendar
For Month: January 2012
Lewis and Clark County
Station A-003
Ascending Direction: North

Location ID: 25-7C-1
Functional Class: Principal Arterial - Int - Urb
Traffic Factor Group: UI
I-15, 0.5 miles south of Helena (C000015) RP 191.8
Directional Split S: 51% / N: 49%

	SUN	MON	TUE	WED	THU	FRI	SAT
North-Bound South-Bound Roadway	1 3,615 3,757 7,372	2 4,967 4,995 9,962	3 5,966 6,272 12,238	4 6,192 6,418 12,610	5 6,346 6,380 12,726	6 6,701 6,835 13,536	7 5,228 5,207 10,435
North-Bound South-Bound Roadway	8 4,306 4,363 8,669	9 5,847 6,143 11,990	10 5,515 5,359 10,874	11 5,577 5,806 11,383	12 5,850 6,142 11,992	13 6,512 6,559 13,071	14 4,805 5,152 9,957
North-Bound South-Bound Roadway	15 3,784 4,034 7,818	16 4,959 5,154 10,113	17 5,606 5,867 11,473	18 4,732 3,886 8,618	19 4,748 4,748 9,496	20 5,384 5,465 10,849	21 4,556 4,718 9,274
North-Bound South-Bound Roadway	22 3,955 4,003 7,958	23	24 5,782 5,941 11,723	25 5,660 5,829 11,489	26 5,844 6,020 11,864	27 6,380 6,547 12,927	28 4,984 5,345 10,329
North-Bound South-Bound Roadway	29 4,262 4,318 8,580	30 5,676 5,940 11,616	31 5,853 6,042 11,895				
North-Bound South-Bound Roadway							
North-Bound South-Bound Roadway	Avg SUN 3,984 4,095 8,079	Avg MON 5,362 5,558 10,920	Avg TUE 5,744 5,896 11,641	Avg WED 5,540 5,485 11,025	Avg THU 5,697 5,823 11,520	Avg FRI 6,244 6,352 12,596	Avg SAT 4,893 5,106 9,999
North-Bound South-Bound Roadway		Avg Weekday 5,586 5,691 11,277					Avg Weekend 4,439 4,601 9,039

Monthly Traffic Summary

Avg Daily Traffic		Days Reported		High Volumes	
North-Bound	5,352	All Days	30	High Day	Day 06, Count 13536
South-Bound	5,474	Weekday Days	17	High Hour	Day 04, Hour 17, Count 1258
Roadway	10,826	Weekend Days	9		

* NOTES– None

FIGURE 7 Monthly Traffic Calendar

Traffic Factor Tables

Two Traffic Factor Tables are published each year. One of the tables can be used to expand short-term volume counts to AADT, while the other table does the same for short-term vehicle classification counts. Each table, regardless of whether it is for volume or classification counts, gives a factor for weekdays, Friday, Saturday, and Sunday for each functional classification for each month of the year (total of 384 individual factors). Due to a low number of segments fitting the functional classes of Urban Minor Arterial and Urban Collector, the two classes are combined into the class Urban Minor Collector. As previously mentioned, reported values are a three-year average.

ESAL Factors

ESAL factors are only made available internally to the party requesting them, typically for pavement design (project level work) or planning (network level analyses).

Traffic Maps (GIS)

The online interactive map-based GIS tool made available by MDT allows users to select a highway section and retrieve selected traffic data for it. The map allows a user to select a route segment using a mouse, or to search by address, route name, or place. Figure 8 shows the screen shot when a user first visits the online map. Figure 9 shows the data presented after a site has been selected by the user. The following data are made available when a site has been selected:

- Description (route number, route (mile) post, general physical location),
- Site ID,
- County,
- MDT Departmental Route ID,
- MDT Corridor Route ID,
- Owner of Traffic Counter,
- ATR/WIM ID,
- Vehicle Classification Site,
- 2008 AADT,
- 2009 AADT,
- 2010 AADT,
- 2011 AADT,
- 2012 AADT,
- Section Length, and
- % commercial vehicles 2012

The AADT data can be presented in a graphical form as shown in Figure 10. Additionally, when the user zooms in on a region, the roads are symbolized using color and line weight to represent traffic volumes; this feature can be observed in Figure 11.

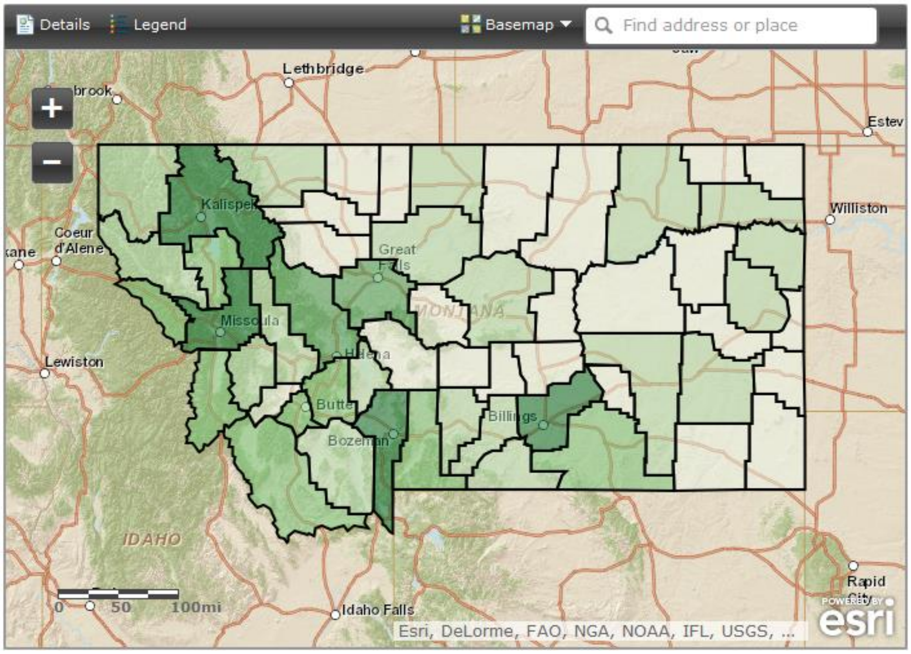

FIGURE 8 Interactive Online GIS (color reflects annual VMT)

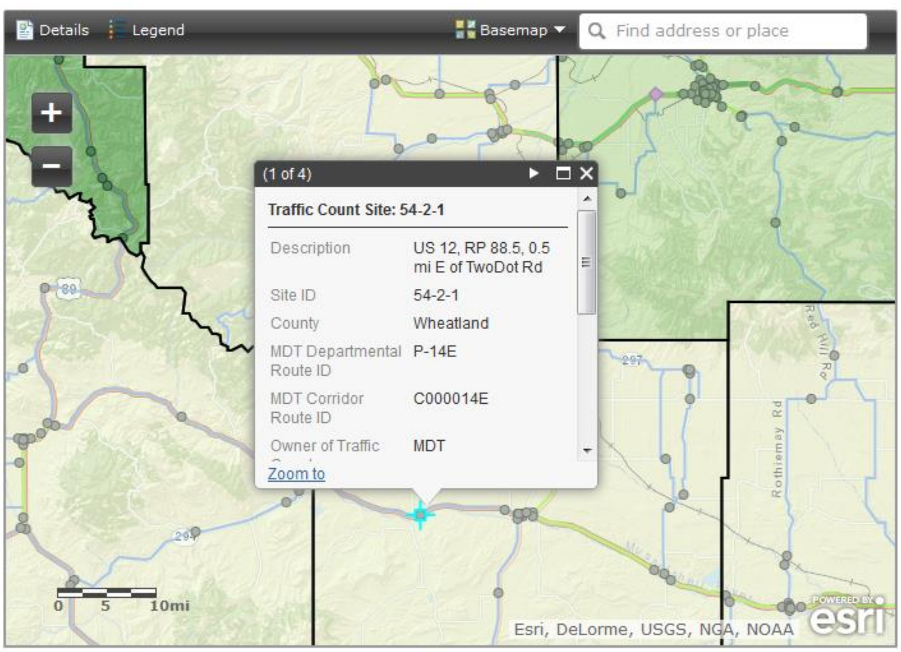

FIGURE 9 Typical Data from Selected Site

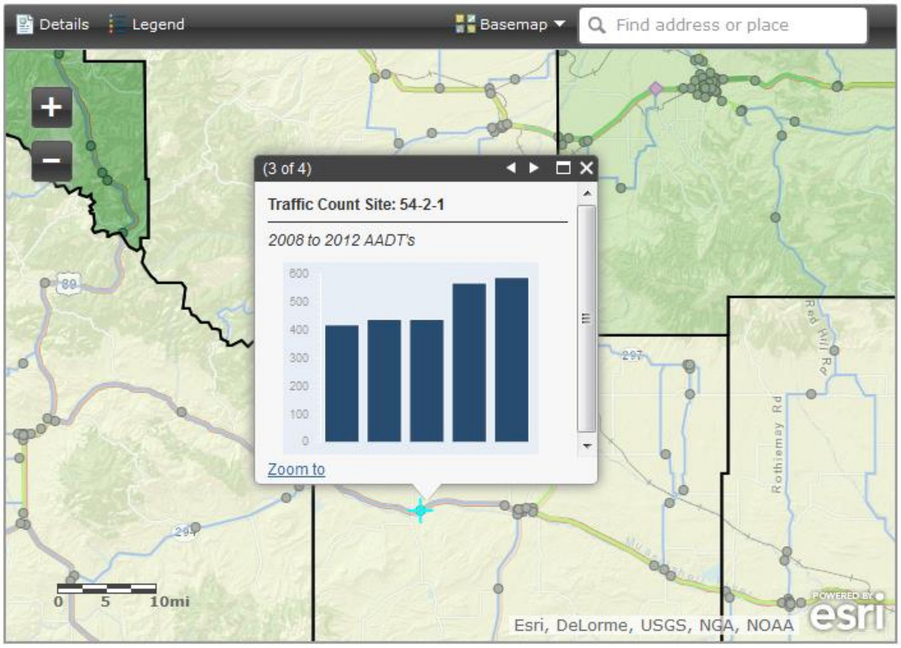

FIGURE 10 Typical Graphical Presentation of AADT Data for a Site

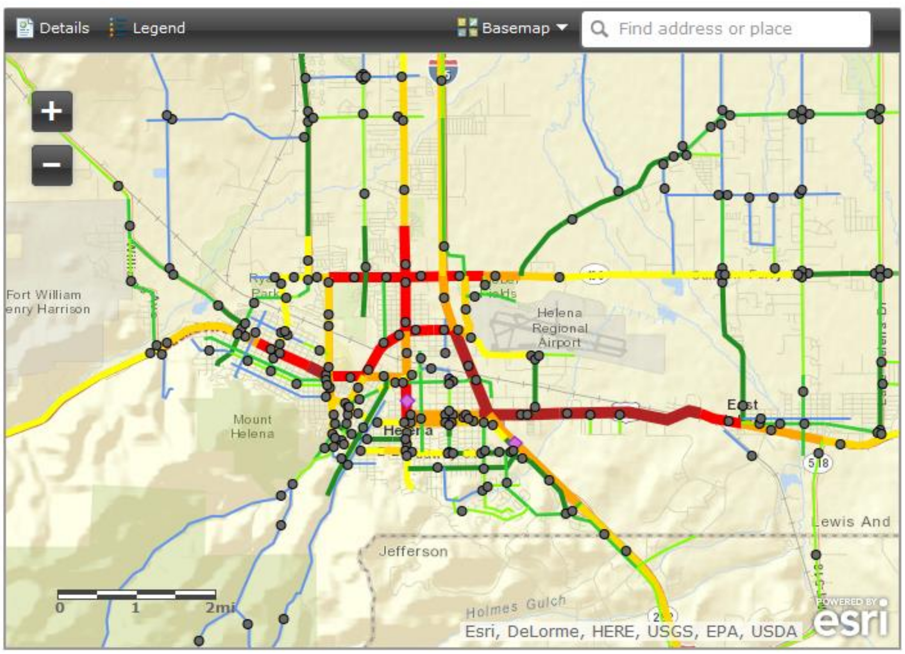

FIGURE 11 Symbolized Roads ("dots" are traffic data collection sites, color of route reflects annual volume of traffic)

Also available in an online interactive GIS format is a map presenting the location of current and proposed permanent ATR and WIM sites throughout the state (see Figure 12). The information presented when a site is selected is similar to the data from the aforementioned GIS system with the exception of including a link to the yearly ATR/WIM report for the selected site.

Also available is an overlay presenting the MDT maintenance districts; this information can be used to help to determine which sites are the responsibilities of which maintenance crew.

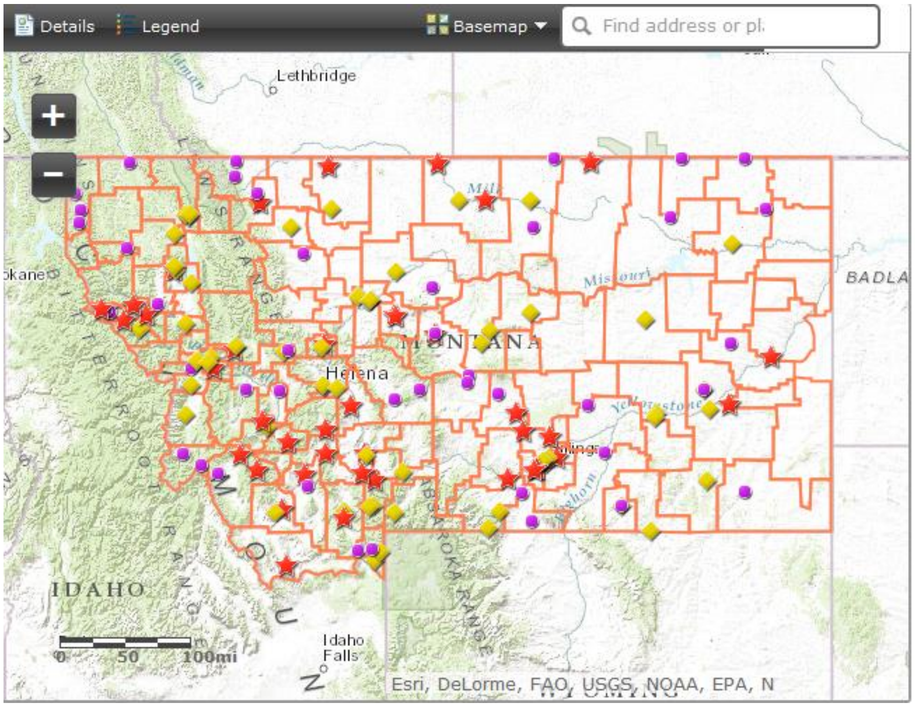

FIGURE 12 State wide distribution of ATR/WIM sites (red stars represent WIM sites, yellow diamonds represent ATR sites, and purple circles represent proposed ATR/WIM sites.)

Traffic Count Database System

MDT has been investigating the use of the Traffic Count Database System (TCDS), a subscription based software and database service offered by Midwestern Software Solutions (MS2, Ann Arbor, MI). TCDS is currently used by over 140 state DOTs, metropolitan planning organizations, counties and municipalities (MS2 2013). TCDS performs various traffic data tasks from automatic quality control to data visualization. Having been designed to accept inputs from a wide range of traffic counting devices, TCDS allows for the consolidation of data into one central database. To visualize data, TCDS can output a variety of reports and maps. Figure 13 shows the web-based interface that allows for the use of TCDS to access and visualize data from any location with internet access.

MDT has been using TCDS on an experimental basis as a way to allow for timely internal access to traffic data (TCDS is not made available to the public). Presently, the data available through TCDS is raw, unprocessed, and has no quality control checks. Additionally, TCDS is not used for design purposes or as an “official” traffic count for any location. The main users of TCDS are the Motor Carrier Service (MCS) and Montana Highway Patrol (MHP). The data are used by MCS and MHP to a) monitor trends in vehicle operations at various locations, b) study the effectiveness of enforcement activities, and c) schedule staff resources.

TCDS produces a variety of reports from daily volume to individual vehicle records. A large selection of report types are also made available. Currently, TCDS has data from permanent ATR/WIM sites with no short-term sites included in the data.

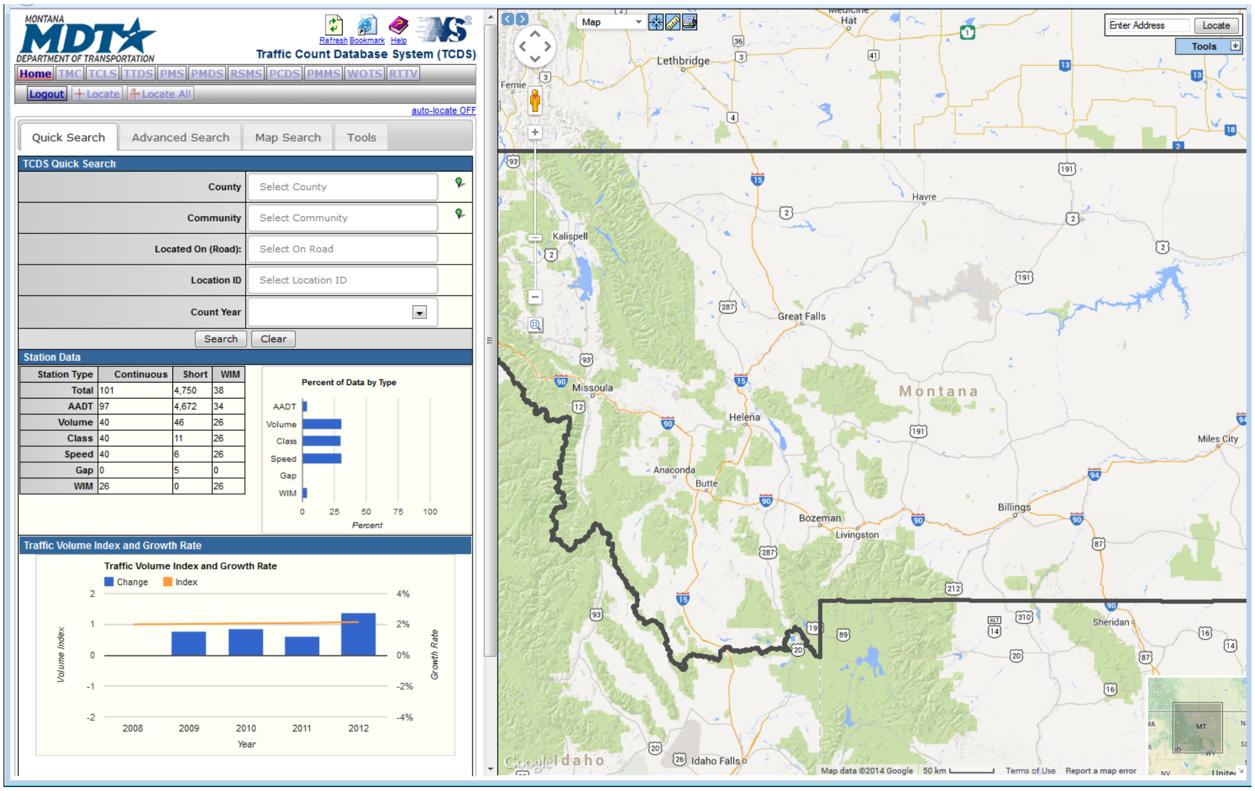

FIGURE 13 TCDS Dashboard

After selecting a location, and dependent on the type of site, AADT, volume, speed, classification, or weight information is made available. Within each of these categories data are made available in a variety of formats including exportable tables and graphs. Figure 14 presents an illustration of the volume count data that are available. At the bottom of Figure 14 are the available ways for viewing the data. The "View Calendar" option allows for the user to select a given date for the selected site. The "View in Excel" option exports an Excel Spreadsheet of the selected data. The "Bar Graph" and "Line Graph" options display the data in the respective format. The "Weekly Report" displays a weekly report as shown in Figure 15. The "Monthly Report" option exports an Excel Spreadsheet with the selected month's data.

The "Weekly Report" shown in Figure 15 presents the data in both a visual and numerical way. The data are grouped by time-of-day and day-of-week. A histogram of the time-of-day occurrence allows users to quickly identify trends. Also available are a variety of descriptive statistics including peak hour time, volume, and percentage. As with much of the information available through TCDS, an option to export the information to an Excel Spreadsheet is available.

Figure 16 presents an example of the format that the bar graphs are presented, in this case speed data. As can be seen in Figure 16, the data are grouped by speed range, in this case five mile per hour groups. Many of the data available through TCDS can be visualized in this manner.

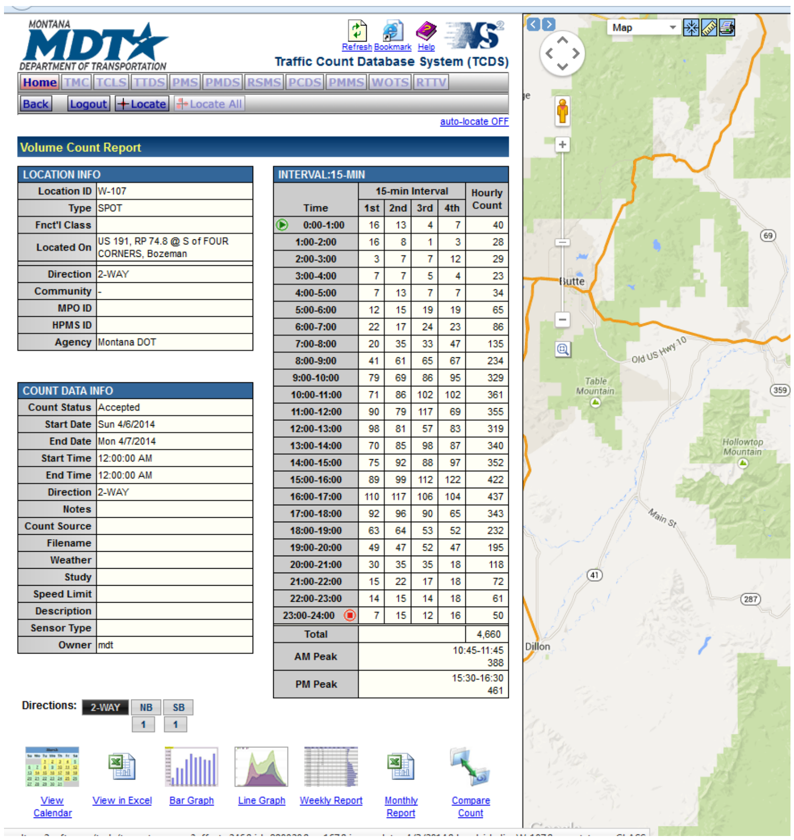

FIGURE 14 Volume Count Report for a selected site

Excel Version

Weekly Volume Report

Location ID:	W-107	Type:	SPOT
Located On:	US 191, RP 74.8 @ S of FOUR CORNERS, Bozeman	:	
Direction:	2-WAY		
Community:	-	Period:	Mon 4/7/2014 - Sun 4/13/2014
AADT:			

Start Time	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Avg	Graph
12:00 AM	39	27	35					34	
1:00 AM	11	16	15					14	
2:00 AM	13	11	15					13	
3:00 AM	16	15	16					16	
4:00 AM	31	32	38					34	
5:00 AM	120	126	126					124	
6:00 AM	230	211	221					221	
7:00 AM	358	374	399					377	
8:00 AM	297	361	337					332	
9:00 AM	313	303	331					316	
10:00 AM	276	301	275					284	
11:00 AM	302	338	65					235	
12:00 PM	258	271	0					176	
1:00 PM	298	277	0					192	
2:00 PM	297	344	0					214	
3:00 PM	351	361	0					237	
4:00 PM	368	434	0					267	
5:00 PM	477	493	0					323	
6:00 PM	350	394	0					248	
7:00 PM	171	208	0					126	
8:00 PM	123	157	0					93	
9:00 PM	88	108	0					65	
10:00 PM	73	70	0					48	
11:00 PM	49	56	0					35	
Total	4,909	5,288	1,873	0	0	0	0		
24hr Total	4909	5288	1873					4,023	
AM Pk Hr	7:00	7:00	7:00						
AM Peak	358	374	399					377	
PM Pk Hr	5:00	5:00							
PM Peak	477	493						485	
% Pk Hr	9.72%	9.32%	21.30%					13.33%	
% Pk Hr	9.72%	9.32%	21.30%					13.45%	

FIGURE 15 Weekly Volume report

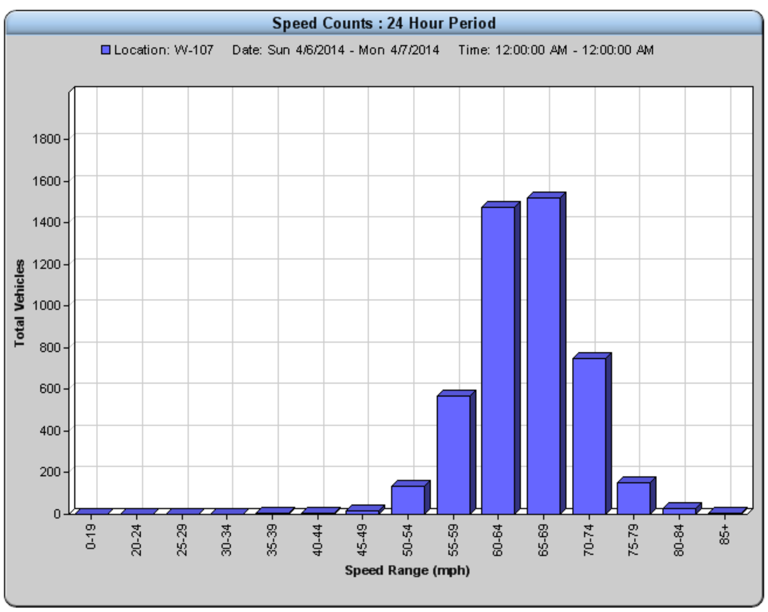

FIGURE 16 Speed Counts Graph

As mentioned in the Data Analysis section of this report, weight data from TCDS are used to help monitor and plan weight enforcement activities. For each WIM site, a variety of tabular and graphical reports are available. Figure 17 presents an interactive graph giving the daily average GVW for a given site. The graph can show data for a specific user-selected class during a given time span. Plots such as this can be used to visually identify recurring trends in vehicle operations. Figure 18 illustrates one of the tabular formats in which the data can be presented. This table gives the number and percentage of overweight vehicles by class for a selected time period.

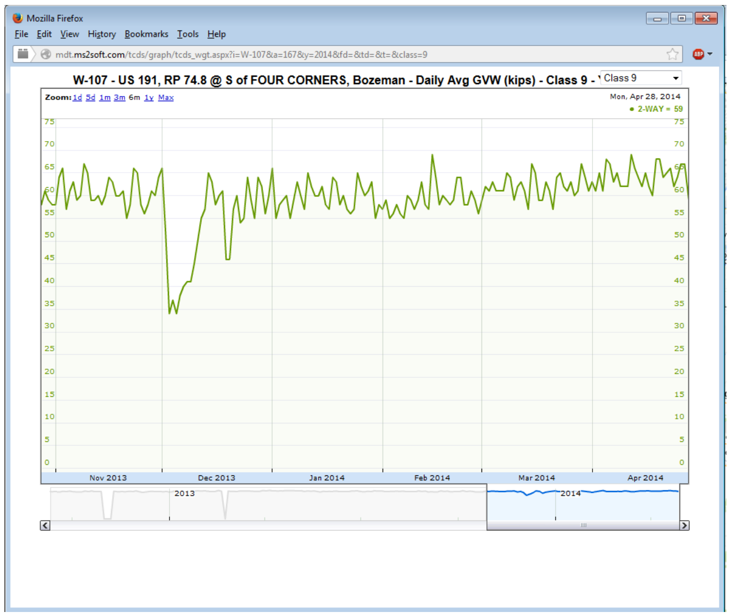

FIGURE 17 Interactive Daily Average GVW Plot

Gross Vehicle Weight by Class - 2014					
Distribution of Overweight Vehicles					
Class		Limit (kips)	Total	# Overweight	% Overweight
01	Motor cycle		4	0	0%
02	Car		310539	0	0%
03	Pick up		240868	0	0%
04	Bus	32	5953	2468	41%
05	2A SU	32	15760	356	2%
06	3A SU	46	2627	453	17%
07	>3A SU	54	560	377	67%
08	<5A 2U	66	1262	3	0%
09	5A 2U	80	19810	3258	16%
10	>5A 2U	88	2535	1173	46%
11	<6A >2U		31	0	0%
12	6A >2U		165	0	0%
13	>6A >2U	120	7529	33	0%
14	Other		664	0	0%

FIGURE 18 Gross Vehicle Weight by Class

TEMPORAL AND AREAL TRAFFIC FLOWS

While the cause and occurrence of spatial/temporal traffic flow fluctuations in Montana can be complex, some of these flows are readily recognized and can be characterized in varying degrees of detail. These various traffic flows are largely the result of the nature of economic activity in Montana, which is focused on agriculture, resource extraction (generally minerals/ore, forest products, and petroleum), and tourism. The following sections present a brief overview of some of the traffic flows associated with these activities. These traffic flows apparently have not previously been comprehensively and formally documented relative to their potential impact on traffic data collection activities and their potential use in planning such activities. Table 10 summarizes some of these traffic flows, as researched thus far in this study. Table 10 and the information it contains is offered as a possible starting point/framework to more thoroughly document such traffic flows for the TDCA Section as further information on the timing, location and extent of any such flows becomes known, notably through both a) formal studies (i.e., as may be done for other purposes but with pertinent information on traffic related to commodity flow) and b) expert assessment by experienced MDT personnel.

Referring to Table 10, for each commodity considered, the timing, general location and extent of the associated transportation activity are reported. As may be obvious, only commodities that move over the highway system are being considered. The extent of these flows is characterized in terms of the quantity of the commodity to be moved annually on Montana's roadways, and the equivalent number of trips involved per year, generally calculated using a standard payload of 25 tons per trip (approximately the payload of a common five axle tractor, semi-trailer, independent of the actual vehicle configuration employed). While very simplistic in nature, this analysis generally reveals the relative contribution to traffic on the state's highways associated with various commodity flows. Of the commodities considered in Table 10, the predominant generator of intrastate commercial truck trips is agriculture - specifically, wheat and barley shipment from field to storage/transloading facility at 274,000 trips annually - with substantially fewer trips (i.e., 50,000 or fewer trips annually) generated by the other commodities considered. No claim is made, however, that all industries are fully represented in Table 10; rather, information is presented on selected major commodities and movements that can be found in various public databases. As this work moves forward, it is anticipated that information will be discovered on other commodity flows on the state's highways as well as more refined information on the movements already identified in Table 10. Any such information will be added to the Table as it becomes available.

The information presently provided in Table 10 is at the network level, i.e., estimates are provided for total annual trips by commodity as generated in relatively broad geographic areas, rather than trips on specific routes and further, specific segments of those routes. Ideally, the rightmost columns of Table 10 will be populated with this information. In these regards, an innovative approach was explored to using Geographic Information System (GIS) databases and

TABLE 10 Identified Traffic Flows – Network Level (see Appendix B for source of values)

Nature of Activity	Brief Description	Temporal and/or Areal	Time of yr	Location	Degree of Activity	Trips per yr	Routes Impacted[b]	Vehicles per route per yr[b]
Agriculture – Crops					**tons/yr**	**25 tons/truck**		
Wheat	field to elevator (then majority out-of-state by rail	Temporal and Areal	late July through mid-September	primarily north central, central and northeastern	5,843,000	234,000	nk	nk
Alfalfa and Hay	destination less well defined	Temporal	mid June through mid-September	eastern two thirds	4,120,000	165,000[a]	nk	nk
Sugar Beets	field to collection point, to processing plant	Temporal and Areal	mid-September to mid-November	east central and northeast	1,292,000	52,000	nk	nk
Barley	field to elevator (then majority out-of-state by rail)	Temporal and Areal	August through mid-September	primarily north central, central and northeastern	1,005,000	40,000	nk	nk
Agriculture – Livestock					**tons/yr**	**25 tons/truck**		
Cattle (beef)	field to feedlot (typically out of state)	Areal	all year	Statewide	552,000	22,080	nk	nk
Resource extraction					**tons/yr**	**25 tons/truck**		
Talc – Yellow-Stone Mine	mine to processing facility	Areal	all year	Southwest	300,000	12,000	nk	nk
Timber	forest to mill	Temporal and Areal	late June through March	West	670,000	27,000	nk	nk
Tourism					**tourists per year**	**3 people/veh**		
Glacier National Pk	traffic due to tourism	Temporal and Areal	May through November	Northwest	2,162,000	721,000	nk	nk

[a]not all of commodity leaves point of origin

[b]nk – not known

analysis techniques to bring together disparate data sets to predict temporal and spatial traffic flows around the state by specific route and commodity. Selected preliminary results from this analysis are presented later in this section, specifically for wheat and barley. Expert opinion may also be useful in attempting to determine detailed commodity flows and will be further explored as this project moves forward.

Note that in general, relative to traffic data collection and analysis, information on areal and spatially specific traffic flows should be useful in a) determining times to conduct short term counts on specific routes to ensure significant but intermittent traffic flows are adequately captured and b) developing traffic group factors to be applied to specific routes known to carry certain types of traffic associated with particular economic activities.

Temporal Traffic Flows

Viewing VMT in Montana as a function of time-of-year (shown in Figure 19) immediately reveals the degree of temporal variation in traffic flow on the state's highways. Referring to Figure 19, highway use almost doubles in the summer months of July and August, compared to the winter months of December and January. This pattern in highway use is due in part to seasonal activities associated with agriculture, timber production and tourism, as further presented below.

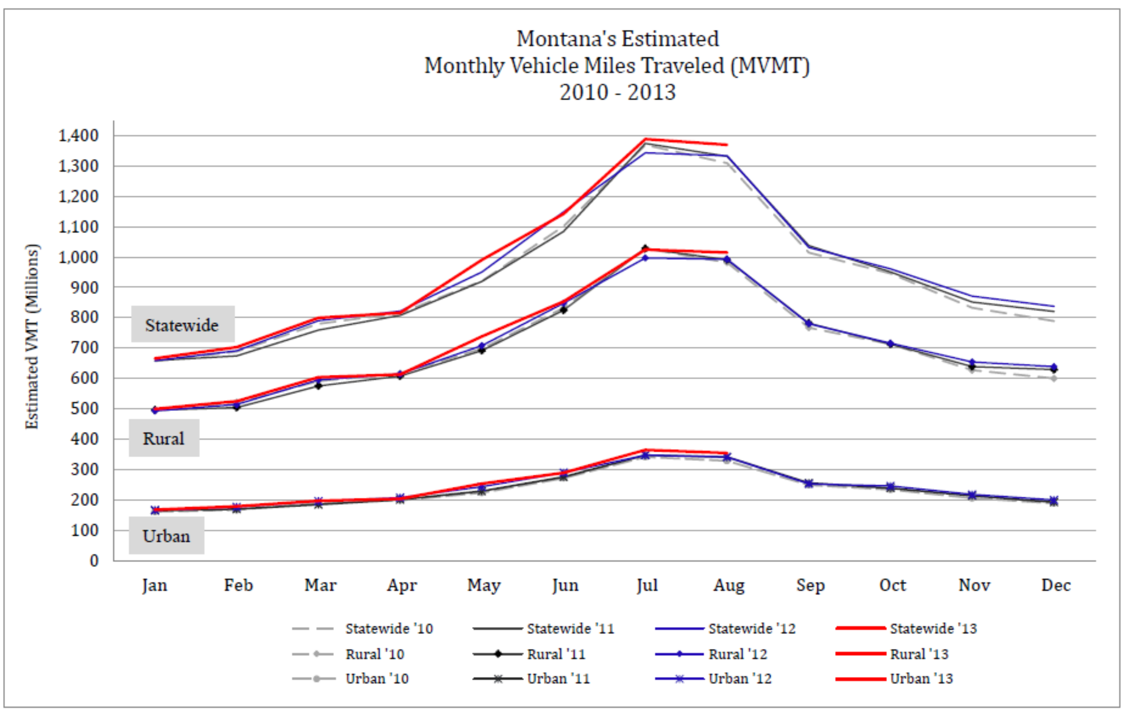

FIGURE 19 Montana's Estimated Monthly Vehicle Miles Traveled (MDT 2013)

Agricultural activities have a very clear time dependence based on when crops are being planted and harvested, and when livestock is being moved. The times at which large volumes of agricultural products move on the roadways varies significantly based on the commodities and regions involved (further detailed in the following section), but general trends in these activities do exist. Table 11 presents normal crop planting and harvesting times (as well as measures of volume produced) for the major crops raised in Montana. Referring to Table 11, the most significant agricultural crops by weight are hay/alfalfa, wheat, sugar beets, and barley. When these crops are harvested, they must be moved to collection/storage locations, processing facilities, and/or transloading facilities, all of which require over-the-road transportation. While

TABLE 11 Crop planting and harvesting

Crop	Usual Planting Date			Usual Harvesting Date			2012 Production	Weight of Total Harvest (tons)
	Begin	Most Active	End	Begin	Most Active	End		
Hay, Alfalfa	--	--	--	Jun 18	--	Sep 23	3,000,000 Ton	3,000,000
Wheat, Spring	Apr 6	Apr 14 – May 12	May 18	Jul 30	Aug 7 – Sep 6	Sep 13	95,700,000 Bu	2,871,000
Wheat, Winter	Sep 6	Sep 12 – Oct 7	Oct 16	Jul 22	Jul 26 – Aug 12	Aug 17	84,630,000 Bu	2,538,900
Sugar Beets	Apr 14	Apr 20 – May 12	May 18	Sep 28	Oct 9 – Oct 27	Nov 4	1,292,000 Ton	1,292,000
Hay, Other	--	--	--	Jun 20	--	Oct 7	1,120,000 Ton	1,120,000
Barley, Spring	Apr 3	Apr 13 – May 11	May 20	Jul 27	Aug 3 – Sep 2	Sep 10	41,870,000 Bu	1,004,880
Corn for Silage	Apr 26	May 4 – May 28	Jun 4	Aug 26	Sep 6 – Oct 1	Oct 10	840,000 Ton	840,000
Wheat, Durum	Apr 25	May 1 – Jun 1	Jun 15	Aug 11	Aug 19 – Sep 22	Oct 4	14,420,000 Bu	432,600
Corn for Grain	Apr 26	May 4 – May 28	Jun 4	Oct 4	Oct 25 – Dec 3	Dec 8	6,600,000 Bu	231,000
Potatoes, Fall	May 7	May 17 – Jun 7	Jun 13	Sep 19	Sep 22 – Oct 23	Oct 31	3,744,000 CwT	187,200
Beans, Dry	May 5	May 10 – Jun 3	Jun 9	Aug 27	Sep 3 – Oct 2	Oct 11	466,000 CwT	23,300
Oats, Spring	Apr 18	Apr 26 – May 28	Jun 5	Aug 8	Aug 15 – Sep 9	Sep 22	810,000 Bu	12,960

Source: USDA 2013

over-the-road transportation demands may be greatest during the harvest times presented in Table 11 (generally, some subset of the period June through November), it is important to note that movement of these commodities is not limited to just these harvest periods. Wheat, for example, may be stored on or near its point of origin at harvest time, to be moved to a transloading facility when space at the facility becomes available and/or a more attractive sales price will be realized. Similarly, sugar beets may be collected at regional receiving stations at harvest time, and trucked to a central processing facility over the next several months.

The movement of livestock, while dependent upon the season, is far less regular than that of crop products. Often the movement of livestock is at the discretion of the rancher and is highly variable based on market trends. This leads to complications with determining if livestock movement has a large impact on seasonal traffic volumes in Montana.

Resource extraction, while generally a year-round activity, does have some temporal dependence. The timber industry is a good example; the times and locations in which logging occurs are greatly dependent upon political pressures, permitting regulations, ecosystem considerations and road conditions (i.e., seasonal load restrictions). Generally, there is a pause in logging operations during the wet spring months, although adverse climatic conditions any time during the year can curtail harvest operations.

Tourism in Montana is a year-round phenomenon with summer recreation including fishing, backpacking, and sightseeing along with winter recreation including skiing and snowmobiling. Out-of-state tourist activity is greatest from July through September – accounting almost 50 percent of all visits, followed by the period April through June – accounting for approximately 25 percent of all visits (Nickerson 2013). While tourism results in increased traffic volumes, the associated vehicles tend to be in Classes 1 through 4, which as lighter configurations have only moderate impact on pavement design considerations.

Areal Traffic Flows

Similar to the temporal variations in traffic operations across the state, a large number of areal specific traffic flows exist due to Montana's extensive and varied nature. Crop production is spatially well documented at a relatively fine scale. Presented in Appendix C are maps summarizing the areal extent of each major crop grown in Montana based on data available from the USDA. Wheat, the largest crop in the state, is grown in almost every county, although approximately 45 percent of the state's wheat is produced in the seven counties comprising the "Golden Triangle" defined by Great Falls, Havre and Shelby (Montana Wheat and Barley Committe 2014). The location of typical wheat producing acreage is shown in Figure 20 (in this case, specifically for spring wheat). The majority of the wheat grown in Montana is shipped out-of-state by rail (approximately 80 to 90 percent of the wheat produced) primarily to the west coast (USDA 2013). Barley is produced generally in the same regions of the state as is wheat, and again, most of this commodity is shipped out-of-state by rail. Thus, the primary roadway movement associated with wheat and barley is from field to rail elevator (sometimes, with intermediate on farm storage between field and elevator). Annual production of these crops, combined, is 6,848,000 tons, corresponding to 274,000 equivalent 25 ton truck trips (Table 10).

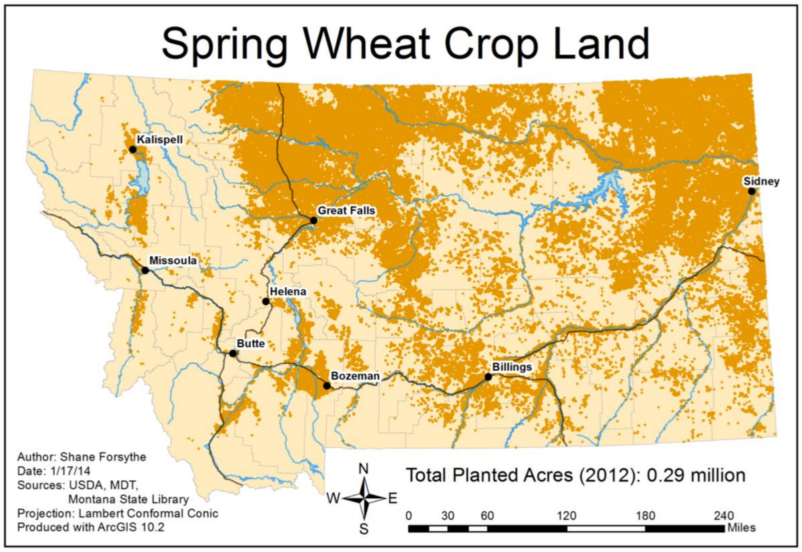

FIGURE 20 Spring Wheat Crop Land

The flow of other major crops grown in Montana - besides wheat and barley - as they move from field to market can be more difficult to predict. Notably, hay and alfalfa, grown primarily in the eastern two-thirds of the state, is second to wheat in tons produced (4,120,000 tons annually – Table 10), but transportation of hay and alfalfa is more complicated than is the case for wheat and barley, as these commodities are not directly transferred from a field to a centralized storage/transloading facility. Instead, hay and alfalfa can be stockpiled in a variety of locations and/or transported out-of-state by truck.

The next largest crop raised in Montana based on weight is sugar beets (1,292,000 tons annually, corresponding to 52,000 ~25 ton truck trips – Table 10). Sugar beets are somewhat more similar to wheat and barley again, in that sugar beet production is relatively well defined in geographic extent, with the sugar beets being moved from their point of harvest to reasonably well defined destinations. Sugar beets are primarily grown in the eastern part of the state in a region bounded by Roosevelt and Richland counties on the northeast running to Yellowstone and Carbon Counties in the south central part of the state (USDA 2013). Sugar beets are processed at facilities located in Billings and Sidney, MT (Sugar Producer Magazine 2013). Typically the beets are trucked either to a piling station or directly to the processing plant from the field, with the sugar produced than being shipped out-of-state by rail. The Sidney processing plant, for example, has five beet receiving stations in addition to the processing site, namely, Culbertson, Savage, Pleasantview, Powder River, and Sugar Valley (Sydney Sugars n.d.). Beets delivered to the receiving stations are trucked to the processing plant over the next several months after their harvest.

Other agricultural products included in Table 11 (corns, potatoes, beans and oats), collectively comprise less than 10 percent by weight of all crops listed in the table, and were not given further consideration in this study. Beef cows are the primary livestock raised in Montana, comprising 50 percent of the state's total livestock inventory – excluding poultry (USDA 2013). The majority of beef cattle are shipped live by truck to processing facilities out-of-state (GrowMontana n.d.). These shipments comprise 552,000 tons annually, which corresponds to only 22,000 ~25 ton truck trips (Table 10).

As would be expected, traffic associated with natural resource extraction is highly dependent upon the location of the natural resources. For example, talc mined south of Ennis, MT at the Yellowstone Mine (estimated at 300,000 tons annually, corresponding to 12,000 equivalent 25 ton truck trips) is transported to processing facilities near Three Forks or Sappington, MT throughout the year (MT DEQ 2004). From these facilities, the talc is processed and further transported by truck and by rail. Another example is the Stillwater Mine Complex in south-central Montana. Mine concentrates, i.e., ore that has been processed to obtain the 2 percent of material containing platinum group metals (Stillwater Mining Company 2013), are hauled nearly 40 miles from the mine site near Nye, Montana to the smelting and refining facilities near Columbus, Montana. Columbus is situated on the rail system, as well as on the primary east-west interstate highway in the state.

Other natural resource extraction activities and the associated highway traffic they generate are more complicated to describe in a spatial sense. Over the past couple of decades the timber industry has been affected by a variety of socio-economic factors that have made predicting its operations difficult, both spatially and temporally. A large amount of traffic related to hauling logs from the forest to a sawmill might be observed for example in one region, while in a seemingly similar region across the state no activity is observed. That being said, timber is primarily harvested in the south central and western part of the state, and selected information is available on logging activity by county as well as destination of the harvested timber by facility type (McIver 2013). Overall, 670,000 tons of timber is harvested annually, which corresponds to 27,000 equivalent 25 ton truck trips (Table 10).

The rise of the oil industry notably in the region of the Bakken formation in western North Dakota and northeastern Montana has led to a rapid rise in traffic volumes, especially commercial truck volumes. These types of resource extraction are harder to characterize due to their rapidly changing nature, this is why MDT has cited them as areas of interest. In the case of traffic associated with extraction of oil from the Bakken formation in eastern Montana, MDT sponsored a study of expected highway impacts from this development that forecasts changes in traffic volumes on specific routes in a 13 county area based on various future levels of oil development (Dybing, et al. 2013).

The areal distribution of tourism can be determined more readily by looking at the locations of state and national parks along with other tourist attractions. MDT has addressed this by using a recreation traffic factor group. Primary out-of-state tourist destinations are Yellowstone and Glacier national parks, being visited by approximately 75 and 33 percent, respectively, of all out-of-state visitors (Nickerson 2010). At a minimum, several hundred thousand visitor trips can be attributed annually, for example, to Glacier National Park, alone.

Estimation of Commodity Flow by Route and Highway Segment

While identification of temporal and areal traffic flows as described by geographic region should be generally useful in planning traffic data collection efforts, it would certainly be beneficial if expected traffic operations could be more precisely estimated by specific route and highway segment. Considerable data is becoming increasingly available at finer and finer levels of detail in various GIS datasets. Notably, several factors embodied in these datasets reflect the temporal and geographic nature of commodity production and processing needs, which can in turn be analyzed in the context of the available highway network to estimate associated traffic flows by commodity, route and time-of-year. Requirements for such an analysis consist of detailed information on commodity origination, amount produced, and its destination.

To demonstrate the potential to estimate commodity flow by route and highway segment by spatial analysis, movement of wheat and barley from field to grain elevator was modeled. An overview of this analysis is presented below, with a more detailed description of the model and results being available in (Forsythe 2014). Information is available in agricultural databases on specific acreage across the state planted in these crops (e.g., see Figure 20), the amount harvested annually, and the general start time and duration of the harvest season (see Table 10 and 11). This information was analyzed in the context of the location of grain elevators within the state and the layout of the highway network connecting field and elevator. Relative to other commodities, the most detailed origin and destination information required to complete such an analysis appears to be available for wheat and barley (which incidentally, are major commodity movements by highway identified in Table 11). That being said, several assumptions still had to be made in completing this analysis as described below, which impacts the accuracy of the results. The results from such an analysis could well be sufficiently accurate to be very useful in optimizing traffic data collection efforts and in general planning activities.

Relating wheat and barley production and elevator locations to determine associated traffic demand during the harvest season by route was done spatially using a four step traffic demand model. For this work, it was assumed that harvest season traffic occurred over 52 days from July 22 through September 13, with the results simply presented as average trips per day of the harvest season. Spatially, model generation was accomplished using a methodology somewhat similar to that used by Dybing, et al (2013) in a study completed for MDT on increased traffic associated with energy development in the Bakken. Dybing, et al. utilized a geographic information system (GIS) to aggregate oil production data based on the United States Geological Survey (USGS) Land Survey System. Townships were used as the traffic analysis zones (TAZs) in their model. Use of a four-step model for commodity flow was also outlined in NCHRP Report 606 (Cambridge Systematics, Inc. 2008). This model shares many similarities with a passenger trip model, but differs by using tons of commodities instead of passenger trips. The four-step model consists of:

1) Trip generation, how many trips are going to and from a given TAZ;
2) Trip Distribution, how are the trips distributed between the TAZs;
3) Mode Choice, what type of travel mode are the trips be performed with; and
4) Route Choice, what routes are being used for the trips.

The township grid for the state of Montana was selected for the TAZs in this study. Crop location data are made available through the USDA as a 30 meter grid cell raster. The ground cover attribute for each grid cell was remotely sensed and varied from urban land use to specific crop types. From this point, it was possible to determine the acres of a given land use by converting the number of grid cells per township to acres. After calculating the amount of each ground cover type in each TAZ, the data was further refined and condensed by removing the cover types that were not of interest. Wheat and barley were selected and analyzed concurrently due to their relatively known destination when leaving the field - grain elevators. The simplifying assumptions were made that all wheat and barley moved directly to elevators from the field, and that this movement occurred during harvest time. These assumptions can be refined as necessary in future analyses based on additional information on the nature of wheat and grain movements as identified in other studies (e.g., Tolliver 2006, Cambridge Systematics 2010). Location and capacity data for grain elevators were obtained from the Montana Wheat and Barley Committee. This data set included the point location, silo capacity, and rail capacity for each grain elevator in Montana.

For trip distribution, the TAZs were connected to the state highway network. Elevator and route selection was simply based on shortest travel time from field to elevator, where travel time was calculated as travel distance divided by estimated speed limit for the type of route being used. The model estimated commodity flow in tons, which was then converted to trips assuming 25 tons per trip by truck (say a 5 axle tractor, semitrailer).

The results of this analysis in terms of daily truck trips by route over the harvest season are presented in Figure 22. Qualitatively, it can be seen in Figure 22 that much of the predicted seasonal heavy truck traffic is located in areas with high agricultural production and densely located grain elevators. This is an expected result of the four-step model that was used. It also appears that the segments with high heavy truck volumes follow the major corridors through Montana. This is an expected result in light of the synergistic relationship between transportation needs and the associated evolution of the transportation network often resulting in major roadways providing shortest paths between locations of codependent economic activity. Over the past several years, large grain elevators that can service 110 car shuttle trains are increasingly being used in moving grain out-of-state as a result of the rail related transportation efficiencies they offer. The locations of these shuttle loading facilities are also shown in Figure 22. Generally heavy truck traffic is predicted in the vicinity of these facilities, although possible non-travel time related inducements to grain growers to use these shuttle loading facilities have not been considered in the analysis. It may be possible to introduce the influence of such factors in future analyses.

Among other things, the results of this analysis can possibly be used to identify routes on which seasonal grain movements are a significant contribution to the total traffic reported annually, and therefore routes on which this seasonal event should be considered in planning traffic data collection efforts and in determining appropriate traffic group factors to be used in expanding short term counts. Similar analyses may also be conducted on other commodity flows with temporal and/or seasonal features for which origin and destination is reasonably known, say, for example, sugar beets and timber.

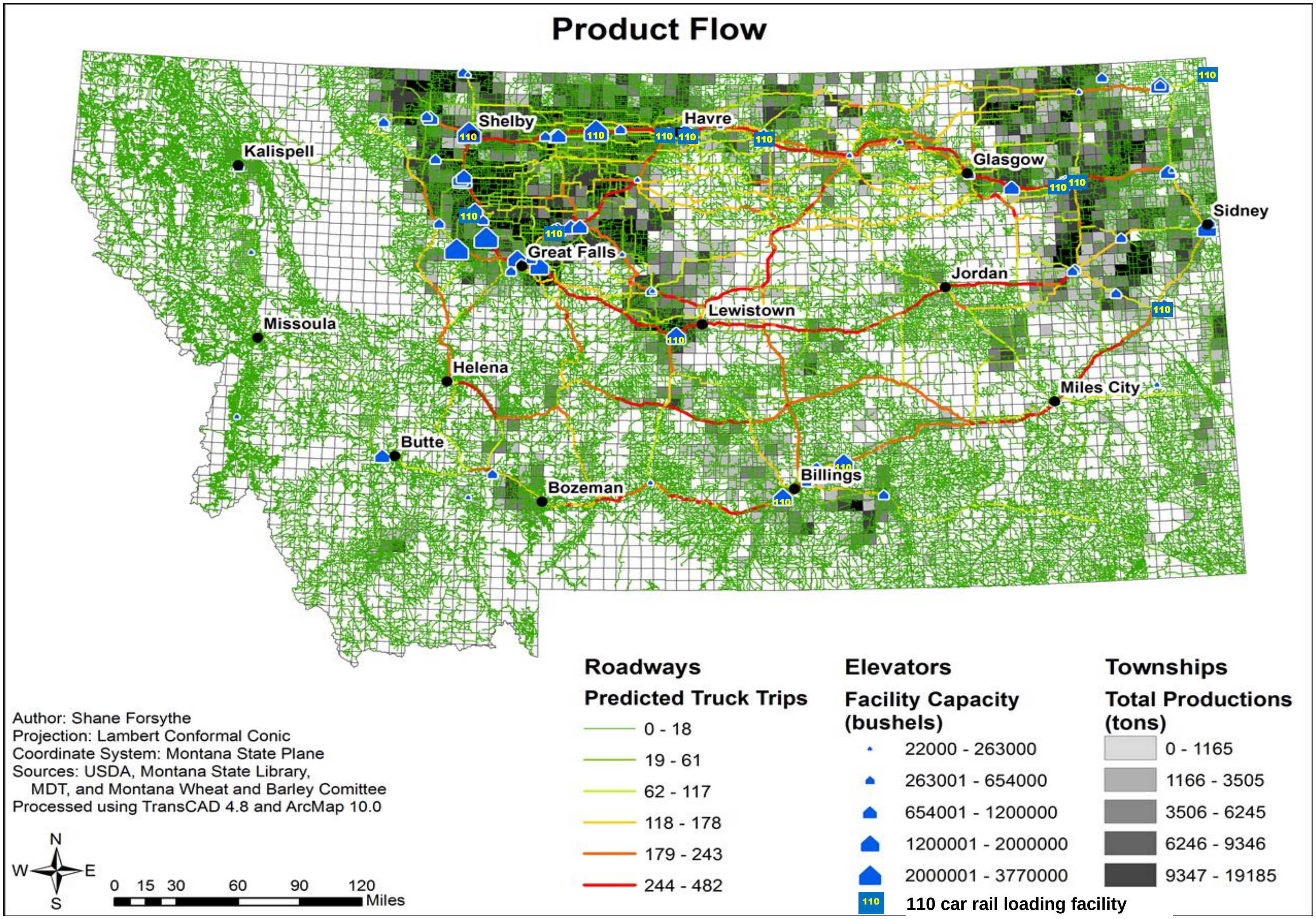

FIGURE 21. Estimated Daily Truck Trips, Harvest Season, Wheat and Barley (Forsythe 2014)

SUMMARY

Capturing and detailing the nature of traffic throughout a state can be a difficult task, particularly when the state is as large and diverse as Montana. To address these issues, MDT has deployed a traffic monitoring program that consists of permanent ATR/WIM installations and short-term counts. These three counting methods are used synergistically to generate a clear view of the traffic in Montana with respect to volume, classification and weight of the vehicles using the state highway system.

The foundation of MDT's traffic data collection program are the permanent ATR/WIM sites which continuously monitor traffic operations on the state's highways. These 99 installations (62 ATR and 37 WIM sites, respectively) directly collect data on approximately 10 percent of the VMT on the state highway system, and the data they collect is critical to expanding short term traffic counts conducted at approximately 5,000 short monitoring sites around the state to provide an estimate of annual traffic flow. The ATR systems collect volume, or volume and speed data (from which vehicle classification can be determined), while the WIM systems additionally collect data on axle/gross vehicle weight. The first step in processing this data is to perform extensive quality control checks of "reasonableness" relative to a) physical limits on the phenomena being measured/calculated and b) historical values determined for the same parameter. These checks are done both automatically, and through data review by experienced TDCA personnel.

The screened data are then used to determine various characteristics of the traffic operating on the state's highways, such as AADT, VMT, ESALs, etc. These traffic characteristics are determined for various aggregations of vehicle configurations (e.g., for each of the FHWA Scheme F classifications, for all commercial vehicles, for small and large trucks) over various time intervals (e.g., daily, weekly, monthly, annually). These data are used to determine traffic factors that are used to expand the results of short term traffic counts conducted for just a few days to AADT. Currently these traffic factors are generated for each functional class of highway (eight classes), by day-of-week (four groupings) and month of year (12 months).

Traffic data dissemination is realized through a variety of publications, interactive maps and software applications, all available on the internet. The most encompassing traditional report is the "Traffic By Sections" publication. "Traffic By Sections" presents the AADT for each roadway segment that is monitored by MDT's approximately 5,000 count sites. Other reports present various traffic attributes and provide some insight on the underlying data processing/analysis methods used by MDT. The "Yearly ATR/WIM Report" presents the data collected by the permanent sites though out Montana. The "Traffic Factor Tables" give the traffic factors that are applied to short-term counts.

In addition to printed media, two online interactive maps using GIS are available to the public. The first of these maps allows users to select a segment of roadway and review data including AADT, type of count, etc. Another feature of this map is the visualization of the roadways using line weight and color to depict the range of traffic volumes in an area. The second map that is made available presents the location of all of the permanent ATR/WIM sites. This map presents much of the same information that the previous map does, with the addition to a link to the "Yearly ATR/WIM Report" tables that correspond to the selected ATR/WIM site.

MDT has been experimenting with another online system for internal, timely data sharing – TCDS, a commercial software package developed by MS2 for processing and presenting traffic data. TCDS allows those within MDT (notably including MCS enforcement) and MHP to view timely speed, volume and weight data. TCDS has the capability to perform many of the tasks that are done in the traffic monitoring program but MDT currently does not utilize these features, instead only raw data is presented.

Whether the data that are being collected capture all of the important traffic flows on the state's highways can only be fully determined if the existence of these flows (and if appropriate, their causative factors) is known. Notably, large local/regional fluctuations in traffic volumes and in the composition of the traffic stream are encountered on many of Montana's highways both temporally and spatially, as the state's economy is agriculture, natural resource extraction and tourism intensive. Efforts were made to begin documenting various temporal and areal traffic flows related to agriculture, natural resource extraction and tourism. Specifically, seasonal/regional commodity flows for wheat, barley, sugar beets, beef cattle, talc, and timber were characterized at the network level in terms of annual trips generated assuming a 25 ton payload per truck trip. Of these commodities, wheat generated significantly more trips than other commodities considered (234,000 trips assuming 25 tons of wheat per trip), although the list of commodities considered was not exhaustive. An innovative technique to further estimate traffic impacts of such commodity flows at the route level using GIS databases and analysis methodologies was investigated, with a trial application to wheat and barley movements. This analysis methodology appears promising, and it will continue to be modified/refined in the future.

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Qi, Yan, Shane Forsythe, Jerry Stephens, and David Veneziano. *Montana Weigh-in-Motion (WIM) and Automatic Traffic Recorder (ATR) Strategy - Review of the State-of-Practice.* Helena: Montana Department of Transportation, 2013.

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APPENDIX A – WEB ADRESSES FOR REPORTS

Report	**Web Address**
Traffic By Sections	http://mdt.mt.gov/other/traffcount/external/TRAFFIC_REPORTS/TBS-ON-SYSTEM_FINAL_6-12-13.PDF
Vehicle Miles Traveled	http://mdt.mt.gov/publications/datastats/traffic_vmt.shtml
Annual ATR/WIM Report	http://mdt.mt.gov/publications/datastats/traffic_atr.shtml
Monthly ATR/WIM Report	http://mdt.mt.gov/publications/datastats/traffic_atr.shtml
Traffic Factor Tables	http://mdt.mt.gov/publications/datastats/traffic_factors.shtml
Traffic Maps (GIS)	http://mdt.mt.gov/publications/datastats/traffic_maps.shtml
Traffic Flow Map	http://mdt.mt.gov/other/traffcount/external/TRAFFIC_MAPS/2011_FLOW_MAP.PDF

APPENDIX B – CALCULATION OF COMMODITY FLOWS – TABLE 11

Wheat - Data Source – Annual Production in Bushels: (USDA 2013)

Spring Wheat	95,700,000 Bu	60 lbs/Bu	2,871,000 t		
Winter Wheat	84,630,000 Bu	60 lbs/Bu	2,538,900 t		
Durum Wheat	14,420,000 Bu	60 lbs/Bu	432,600 t		
Total			5,834,000 t	25 t/trip	234,000 trips

Alfalfa/Hay – Data Source – Annual Production in tons: (USDA 2013)

Alfalfa	3,000,000 t		
Hay	1,120,000 t		
Total	4,120,000 t	25t/trip	165,000 trips

Sugar Beets – Data Source – Annual Production in tons: (USDA 2013)

Sugar Beets	1,292,000 t	25t/trip	52,000 trips

Barley – Data Source – Annual Production in bushels: (USDA 2013)

Barley	41,870,000 Bu	48 lbs/Bu	1,005,000 t	25t/trip	40,000 trips

Cattle (beef) – Data Source – Annual Production in lbs: (USDA 2013)

Cattle (beef)	552,000 t	25t/trip	22,000 trips

Talc (Yellowstone Mine) – Data Source – Production in tons: (MT DEQ 2004)

Talc	300,000 t	25t/trip	12,000 trips

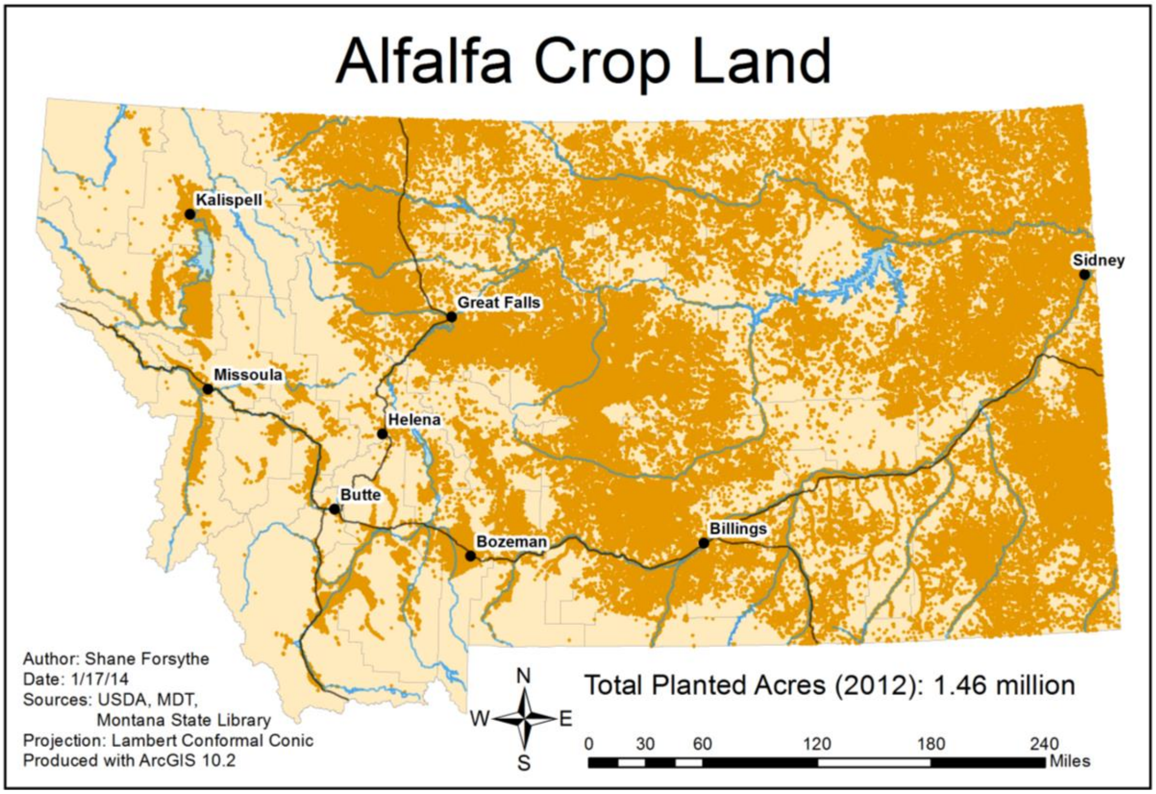
Timber – Data Source – Annual Production in board feet: (Morgan 2012)

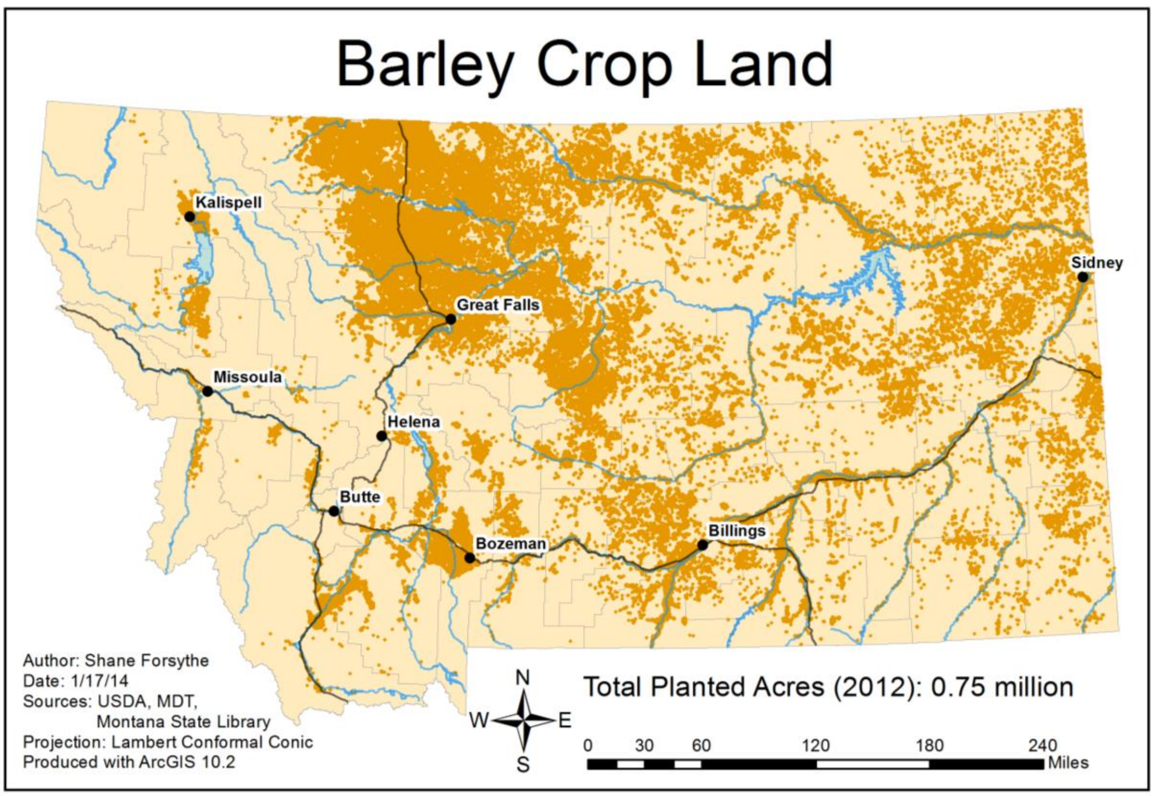
Timber	134,000,000 bd ft	5 t/ 1000 bd ft	670,000 t	25t/trip	27,000 trips

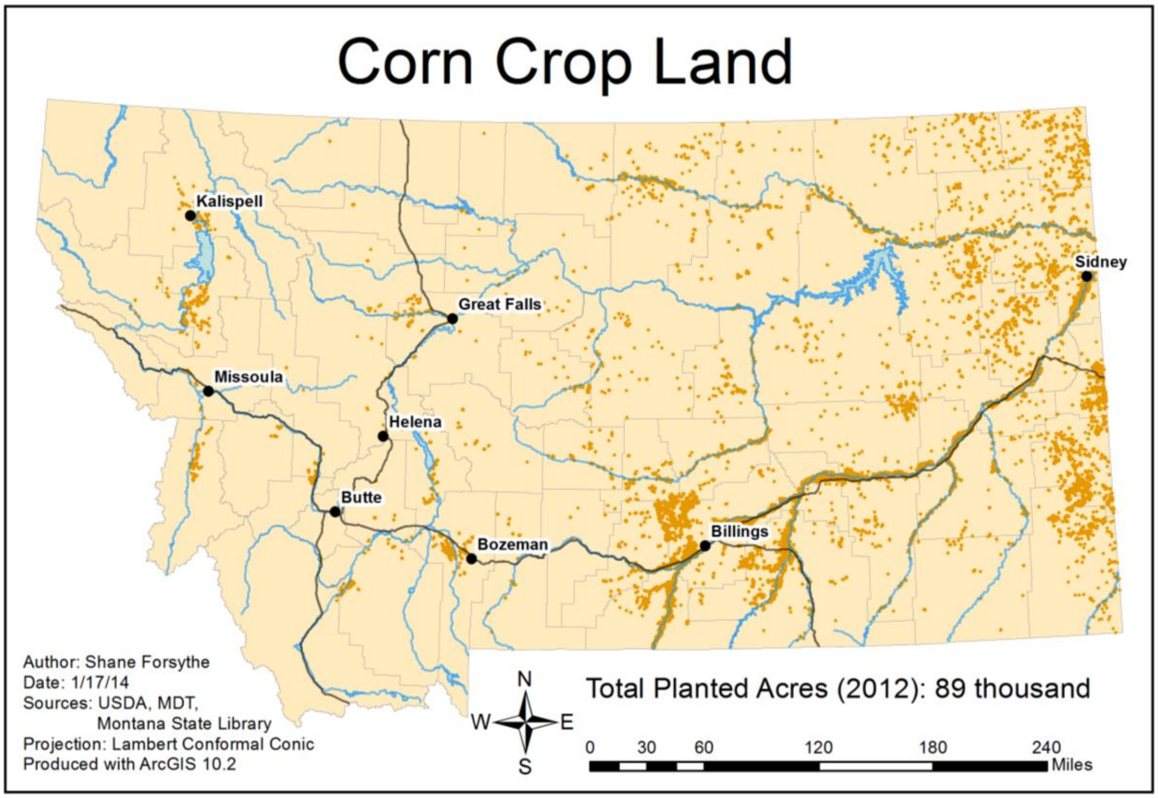
Tourism (Glacier National Park) – Data Source – Annual Visitors: (Nickerson 2010)

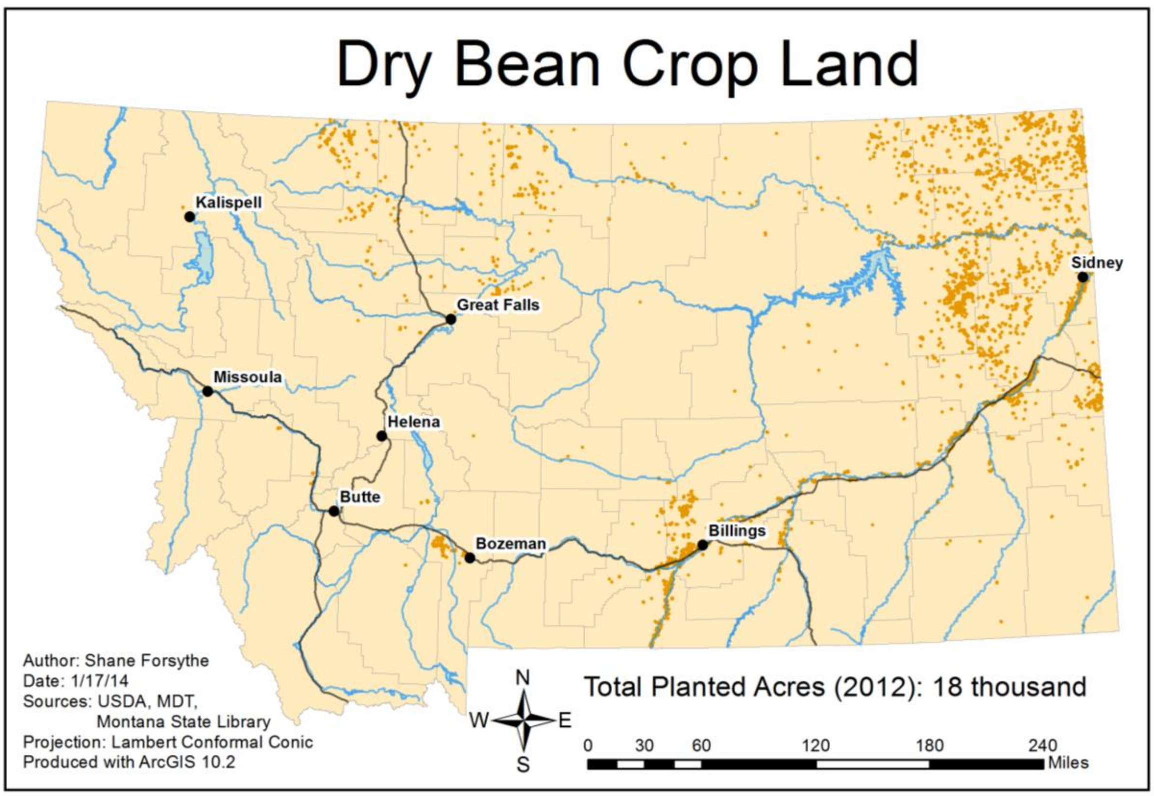
Visits	2,160,000 visitors	3 visitors/veh	721,000 trips

APPENDIX C – AREAL EXTENT OF MAJOR CROPS






Corn Crop Land
Kalispell
Great Falls
Sidney
Missoula
Helena
Butte
Bozeman
Billings
Author: Shane Forsythe
Date: 1/17/14
Sources: USDA, MDT,
Montana State Library
Projection: Lambert Conformal Conic
Produced with ArcGIS 10.2
N
W
E
S
Total Planted Acres (2012): 89 thousand
0 30 60 120 180 240
Miles


Dry Bean Crop Land
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Butte
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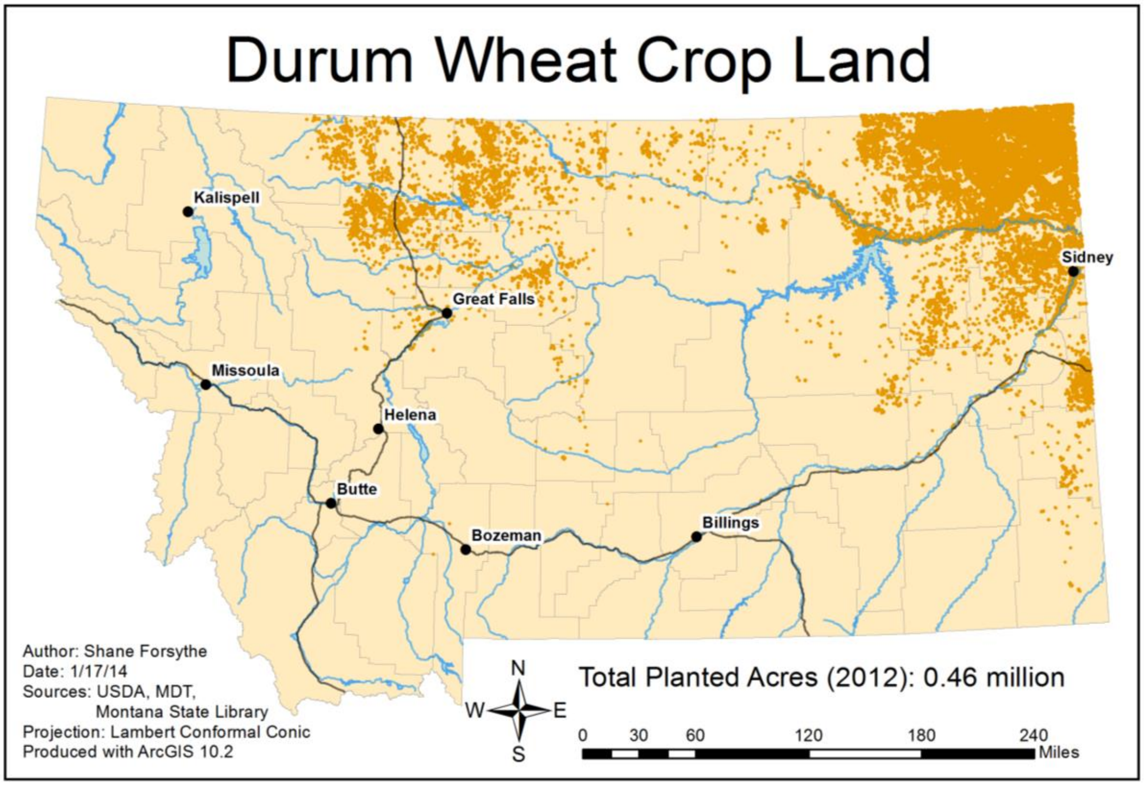
Billings
Author: Shane Forsythe
Date: 1/17/14
Sources: USDA, MDT,
Montana State Library
Projection: Lambert Conformal Conic
Produced with ArcGIS 10.2
N
W
E
S
Total Planted Acres (2012): 18 thousand
0 30 60 120 180 240
Miles


Durum Wheat Crop Land
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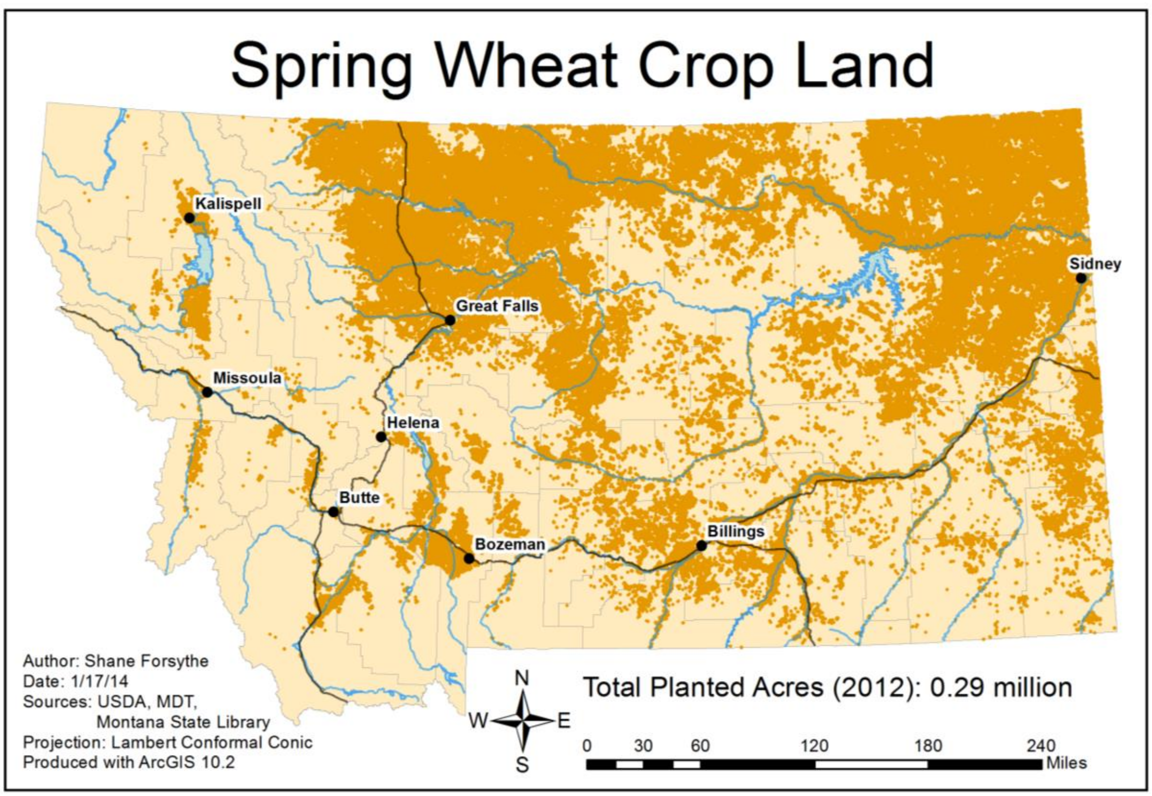
Great Falls
Missoula
Helena
Butte
Bozeman
Billings
Sidney
Author: Shane Forsythe
Date: 1/17/14
Sources: USDA, MDT,
Montana State Library
Projection: Lambert Conformal Conic
Produced with ArcGIS 10.2
N
W
E
S
Total Planted Acres (2012): 0.46 million
0 30 60 120 180 240
Miles


Spring Wheat Crop Land
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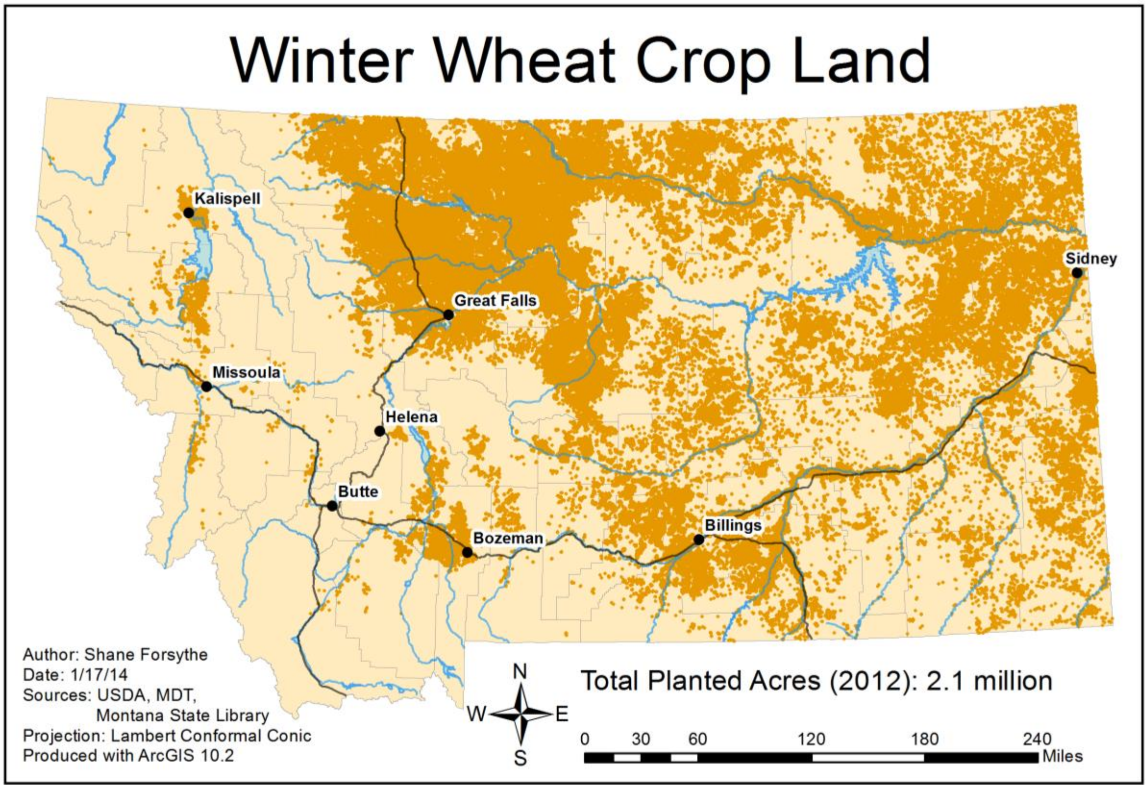
Missoula
Helena
Butte
Bozeman
Billings
Sidney
Author: Shane Forsythe
Date: 1/17/14
Sources: USDA, MDT,
Montana State Library
Projection: Lambert Conformal Conic
Produced with ArcGIS 10.2
N
W
E
S
Total Planted Acres (2012): 0.29 million
0 30 60 120 180 240
Miles


Winter Wheat Crop Land
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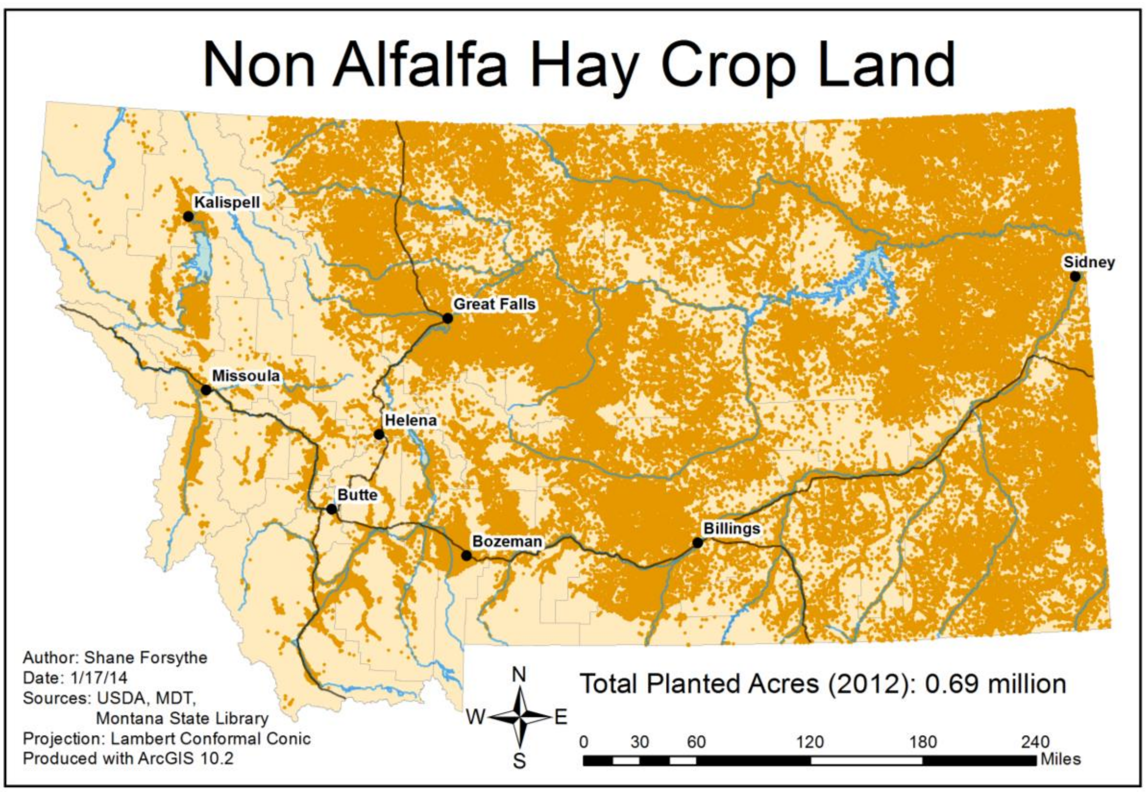
Sidney
Missoula
Helena
Butte
Bozeman
Billings
Author: Shane Forsythe
Date: 1/17/14
Sources: USDA, MDT,
Montana State Library
Projection: Lambert Conformal Conic
Produced with ArcGIS 10.2
N
W
E
S
Total Planted Acres (2012): 2.1 million
0 30 60 120 180 240
Miles


Non Alfalfa Hay Crop Land
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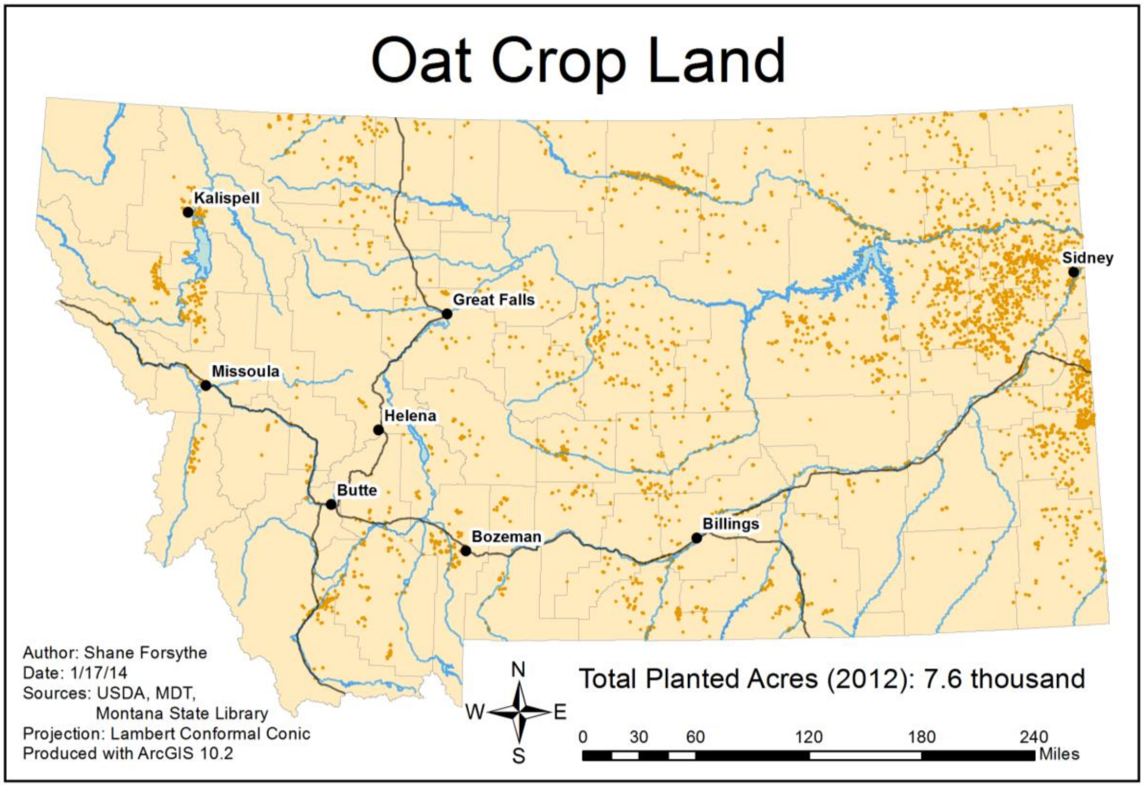
Great Falls
Missoula
Helena
Butte
Bozeman
Billings
Author: Shane Forsythe
Date: 1/17/14
Sources: USDA, MDT,
Montana State Library
Projection: Lambert Conformal Conic
Produced with ArcGIS 10.2
N
W
E
S
Total Planted Acres (2012): 0.69 million
0 30 60 120 180 240
Miles


Oat Crop Land
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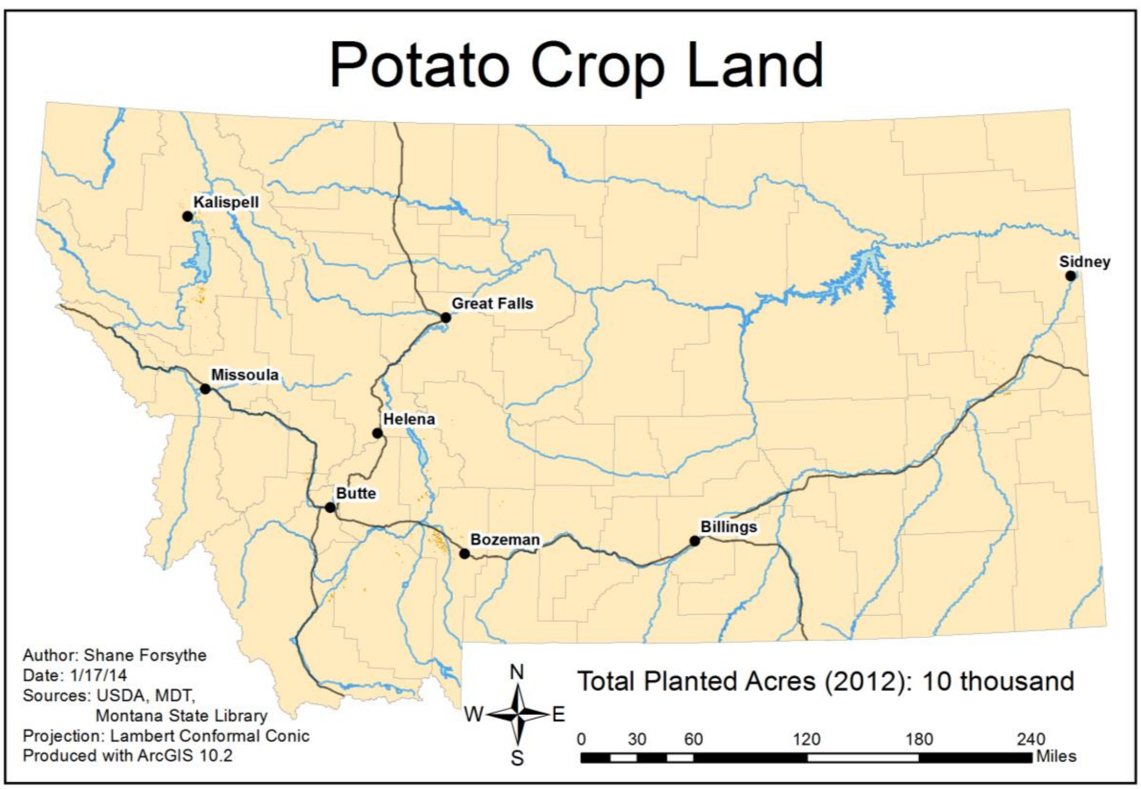
Great Falls
Missoula
Helena
Butte
Bozeman
Billings
Author: Shane Forsythe
Date: 1/17/14
Sources: USDA, MDT,
Montana State Library
Projection: Lambert Conformal Conic
Produced with ArcGIS 10.2
N
W
E
S
Total Planted Acres (2012): 7.6 thousand
0 30 60 120 180 240
Miles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Sidney
Great Falls
Missoula
Helena
Butte
Bozeman
Billings
Author: Shane Forsythe
Date: 1/17/14
Sources: USDA, MDT,
Montana State Library
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Produced with ArcGIS 10.2
N
W
E
S
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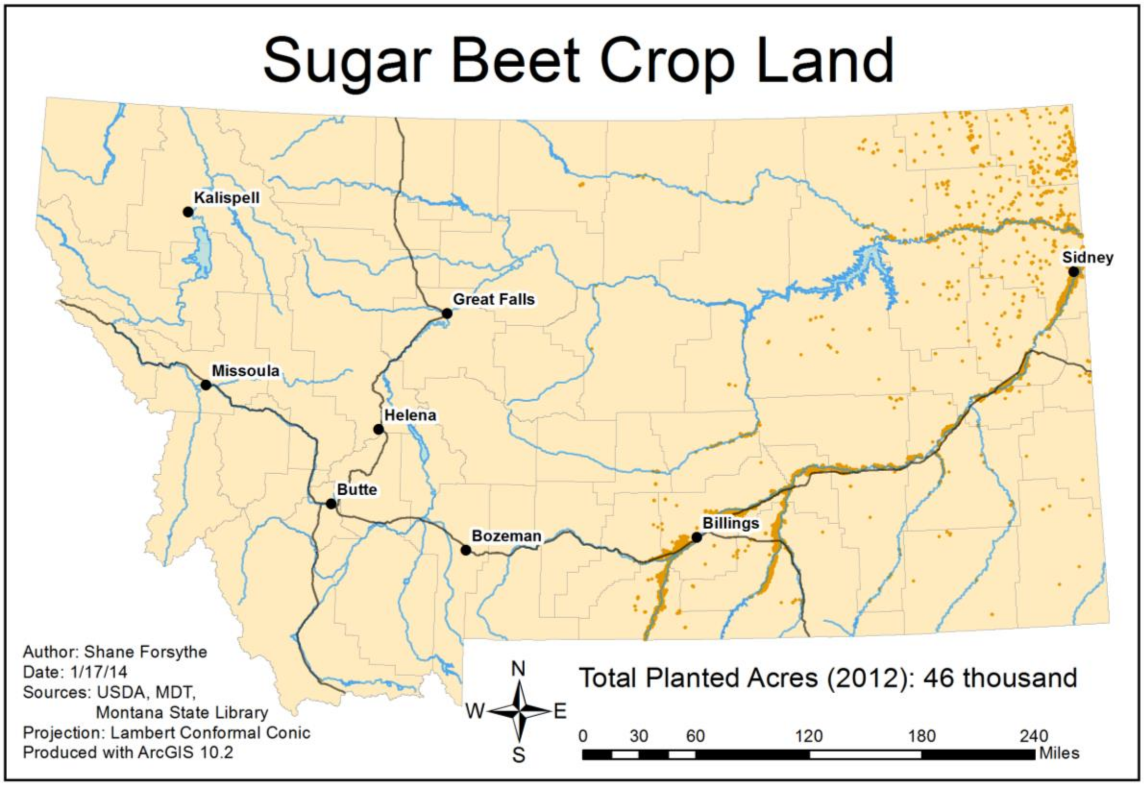
Miles



Sugar Beet Crop Land
Kalispell
Great Falls
Missoula
Helena
Butte
Bozeman
Billings
Sidney
Author: Shane Forsythe
Date: 1/17/14
Sources: USDA, MDT,
Montana State Library
Projection: Lambert Conformal Conic
Produced with ArcGIS 10.2
N
W
E
S
Total Planted Acres (2012): 46 thousand
0
30
60
120
180
240
Miles