

Impacts of Bakken Region Oil Development on Montana's Transportation and Economy

MONTANA DEPARTMENT OF TRANSPORTATION

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Acronyms

- AADT** – Annual Average Daily Traffic
- BBL** – Barrel of Oil
- DVMT** – Daily Vehicle Miles Traveled
- EIA** – Energy Information Administration
- MBOG** – Montana Board of Oil and Gas
- MDT** – Montana Department of Transportation
- NAICS** - North American Industry Classification System
- NDIC** – North Dakota Industrial Commission
- REMI** – Regional Economic Modeling, Inc.
- UGPTI** - Upper Great Plains Transportation Institute

Definitions

Montana Bakken - portion of the Bakken shale formation in Montana

North Dakota Bakken - portion of the Bakken shale formation in North Dakota

Glendive District/District 4 – (Figure 1) Administrative district of MDT encompassing the eastern sixteen counties of; Phillips, Valley, Daniels, Sheridan, Roosevelt, Richland, McCone, Garfield, Prairie, Dawson, Wibaux, Rosebud, Custer, Fallon, Carter, and Powder River.

Bakken - The whole Bakken area (Figure 2).

Shock – The impact from increased activity

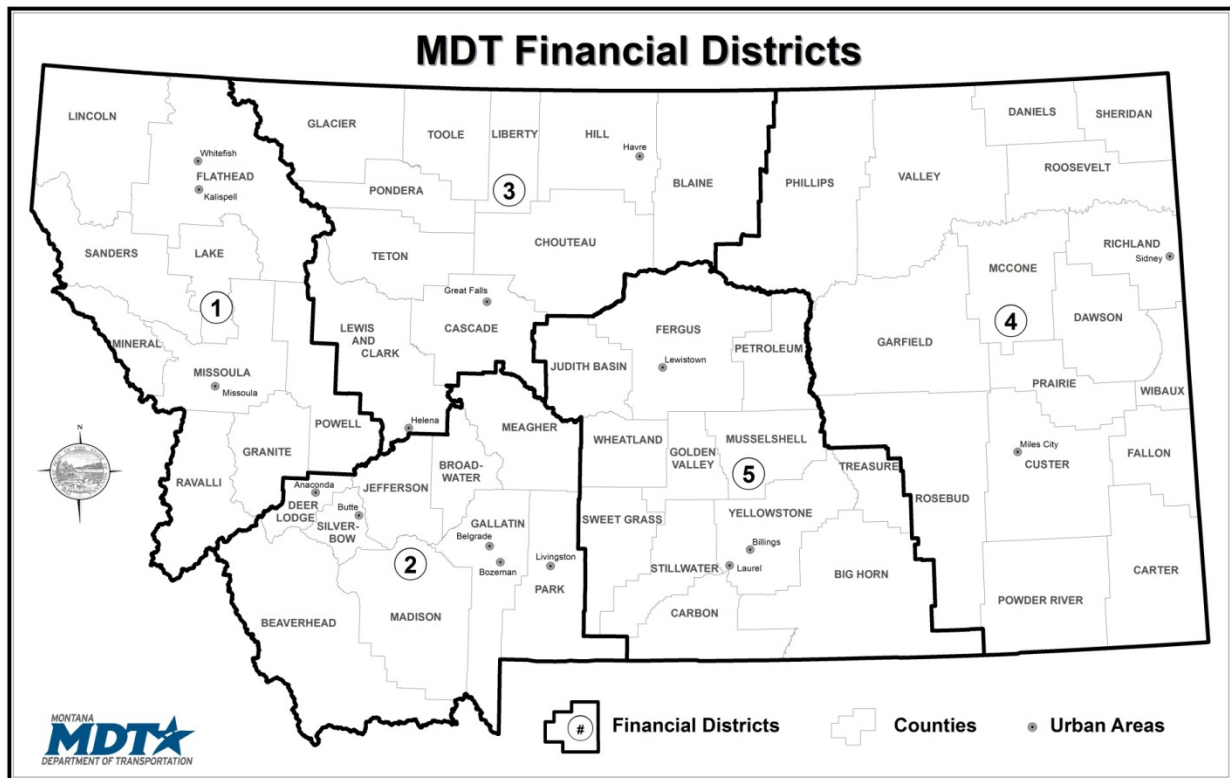


Figure 1: MDT Districts

Executive Summary

The Bakken is an oil field encompassing Montana, North Dakota, and Canada which has recently become economically viable due to advances in horizontal drilling practices. Eastern Montana has subsequently been experiencing an increase in traffic from rapid growth in oil production in the area. It is in the interest of the Montana Department of Transportation (MDT) to assess potential impacts to the road network from this. Research by the Upper Great Plains Transportation Institute (UGPTI) for MDT forecasted truck traffic increases by route to examine road wear issues. The purpose of this study is to determine if there are road capacity issues, based on forecasted population growth due to increasing economic activity in the area.

Four oil production scenarios were run, the results of which converge around two levels of population growth. A population increase of roughly 10,000 in Eastern Montana is the result if oil production does not follow a similar growth rate as North Dakota, alternatively a population increase of roughly 30,000 is projected if oil production follows a similar growth pattern to the North Dakota boom. Total traffic is highly correlated to population over time, such that these two outcomes produce significantly different levels of projected traffic.

This analysis focuses primarily on the higher population scenario, in which the Sidney to Fairview corridor is expected to have the largest increase in traffic, growing from around 4000 Average Annual Daily Traffic (AADT) in 2007 to 16,000 AADT by 2030. With this type of increase, capacity issues are not currently expected, however MDT will continue to monitor this situation for other needed improvements.

Purpose

The purpose of this analysis is to increase the Montana Department of Transportation's knowledge as to potential impacts on transportation infrastructure in Eastern Montana. This study serves as a companion study to a body of work already done by MDT including corridor studies, cost studies, and an Upper Great Plains Transportation Institute (UGPTI) research study. The UGPTI study was designed to determine the impacts of trucks on MT highways in order to design those roads to withstand the increase in truck traffic and associated weight. This study examines the impacts of total traffic due to population increases from increased economic activity to determine if there are capacity needs on state highways in the oil impacted region.

This paper is organized to briefly introduce the topic and the Bakken area, provide an overview of the methodology, and discuss oil production, population, and traffic impact results in that order. A detailed methodology is provided in Appendix A, and references are located at the end of the document.

Introduction

Between 2004 and 2011 oil production activity in North Dakota increased from half a million barrels to 126 million barrels per year, (NDIC Oil & Gas Division, n.d.) stemming from the increased use of horizontal drilling to access reserves that were previously uneconomical to recover. While the rest of the nation has been gripped by recession North Dakota has both, been seeing increasing oil tax revenues and record low unemployment, as well as experiencing growing pains and pressures of increased demand on local resources and unmet infrastructure needs. The recent boom of oil exploration in western North Dakota, as well as significant growth in oil permitting and development in eastern Montana of late has led to the expectation of significant upcoming growth in oil drilling activity and production in Montana. While growth is anticipated, the extent and level of oil production growth in Montana's future is uncertain, prompting the need for this and other MDT studies to examine potential transportation infrastructure impacts.

This analysis estimates economic impacts and their corresponding transportation impacts in Montana as a result of current and anticipated oil-related development in the Bakken shale play and compares 4 possible growth scenarios in order to address uncertainty. The results of this report will contribute to MDT's effort in forecasting traffic and infrastructure needs, specifically relating to roadway capacity issues. Oil production levels are used as a model input to estimate potential effects such as population growth, employment levels and increases in tax revenue.

In combination with other research done at the Montana Department of Transportation (MDT) and the Upper Great Plains Transportation Institute (UGPTI) for the MDT, this report informs estimates of transportation capacity impacts. The aim of these studies is to improve the ability of MDT to plan for transportation infrastructure needs in light of expected industry, workforce, and population growth in this rapidly changing area.

Four scenarios have been run in this analysis, which represent three levels of oil production growth as well as one of oil production decline in eastern Montana. We find that the four scenarios converge on

two possible population levels, growth of approximately 10,000 residents (2028) if oil production does not follow a similar growth pattern to North Dakota, and population growth of approximately 30,000 residents (2028), if drilling activity occurs proportionally to that experienced in North Dakota. Information contained within this report focuses primarily on a projection that produces a population increase of 30,000, not because it is our view that this is the most likely scenario, but because from a road impact viewpoint it is worth examining a high scenario to be able to prepare for largest potential impacts.

The Bakken

The Bakken (Figure 2) is a vast shale oil formation that crosses parts of North Dakota, Montana, and Saskatchewan. As advances in horizontal drilling technology have made recovery of oil from shale economically viable the industry attention has turned to this region. In recent years, the section of the Bakken within North Dakota has seen large growth in oil output: from a half-million barrels in 2004 to 126 million barrels in 2011 (NDIC Oil & Gas Division, 2012).

The effects of Bakken oil development have not been limited to North Dakota. Rapid development in the region has created a variety of public infrastructure needs in Montana. As of this analysis, oil-related employment and

industrial activity in Montana are rising sharply, population is growing, and number of drilling permits issued is increasing. As oil development and production activity continue, the pressure on transportation infrastructure in Montana is expected to increase due to industrial, workforce, and population growth.



Figure 2: Map of Bakken

Methodology

The methodology for this analysis involved five basic steps, pictured (Figure 3):

1. **Assess** current available data such as the number wells being drilled historically in Montana.
2. **Customize** oil industry spending data to better represent how the industry is spending in Montana.
3. **Forecast**, with the information from steps 1 and 2, major impacts from the Bakken activity in areas such as the value of royalties that could be expected.
4. **Run** the forecasted numbers as inputs in the REMI model, which produces a great deal of data on economics and demographics, an example of which is expected population growth in the area due to the increased employment opportunities associated with the Bakken development.
5. **Analyze** the data out of REMI to create projections on transportation impacts.

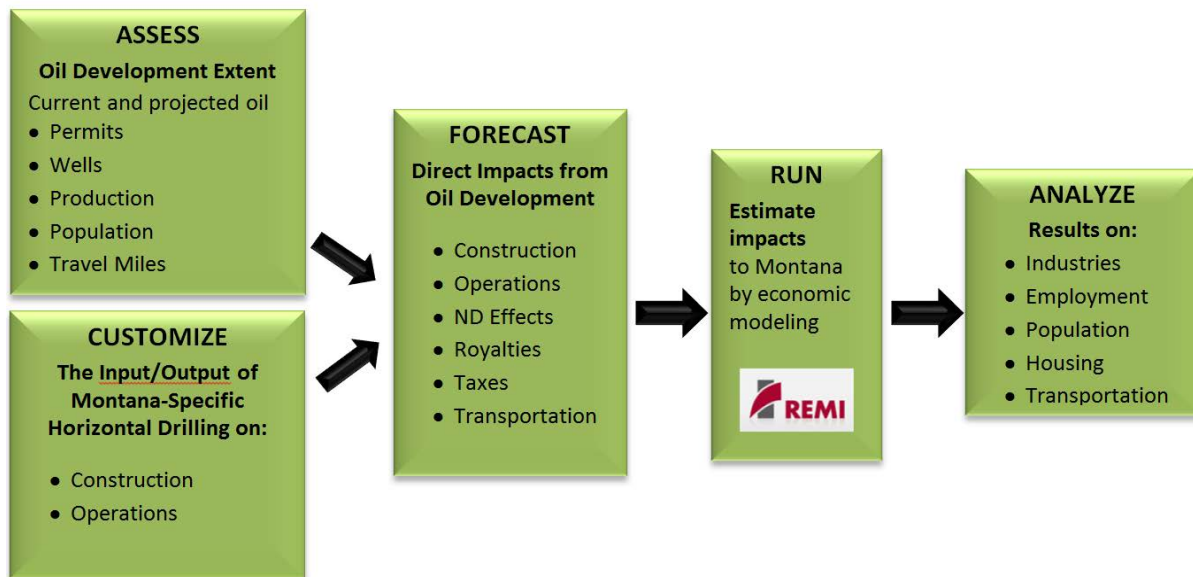


Figure 3: Methodology Flow

Assumptions

A number of assumptions were made that influence the analysis. Primary assumptions regarded the extent of the oil production in the Montana Bakken along with assumptions regarding elements listed in the **ASSESS** box (Figure 3). The assumptions that were made are:

1. Oil production in Montana would either continue its decline as it has since 2007, or increase proportionally with the permitting increases that have been seen in the last four years.
2. If the oil production did follow new permitting, and increase, a plateau and eventual decline would occur.

These assumptions are the basis of the four oil production scenarios that were examined.

Inputs

Model inputs, listed below, are the major direct impacts from oil production in Montana, and were calculated and put into the REMI model in order to estimate population effects. Inputs correspond to **FORECAST** (Figure 3) and were calculated for each of the four oil production scenarios that were examined. The Model inputs which were calculated are:

1. Construction of new oil wells in Montana.
2. Operation of oil wells in Montana.
3. North Dakota effects felt from production currently and expected in North Dakota.
4. Royalties from Montana oil production (both private and public).
5. Taxes from Montana oil production (allocated at a local and state level).
6. Truck transportation that would be associated with the construction and operation of oil wells in Montana (and/or from oil support activities for North Dakota oil production).

The effects felt from North Dakota include both the effects of workers in Montana as well as construction in Montana associated with increased economic activity in North Dakota.

(A detailed methodology with references is located in Appendix A.)

Results

Oil Production

Historic (Figure 4, in blue) and projected oil production levels in Eastern Montana from 1990 to 2035 are shown. A period of high production peaking in 2006 is primarily attributable to oil development in the Elm Coulee part of the Bakken. Activity shifted from the Elm Coulee region to the North Dakota Bakken after the 2006 peak, but oil output is widely believed to begin rising in Montana again as the Bakken begins growing into Montana. In this analysis, three of four projections for Montana were made to coincide with North Dakota's forecasts, first assuming that the number of permits issued continues to increase as they have, 2009-2012, and second, assuming new wells begin to follow the historic 1990-2012 permit to drilling ratios. While the fourth assumed a decline in oil production similar to what has been occurring since the Elm Coulee peak of 2006. These four scenarios produce the oil production possibility curves (Figure 4).

The four scenarios that were run (in basic terms):

1. **High** – Coincides with North Dakota's "Possible" scenario for oil production
2. **Medium High** - Coincides with North Dakota's "Probable" scenario for oil production
3. **Medium Low** - Coincides with North Dakota's "Proven" scenario for oil production
4. **Declining** – Continues recent decline in oil production back to historic levels

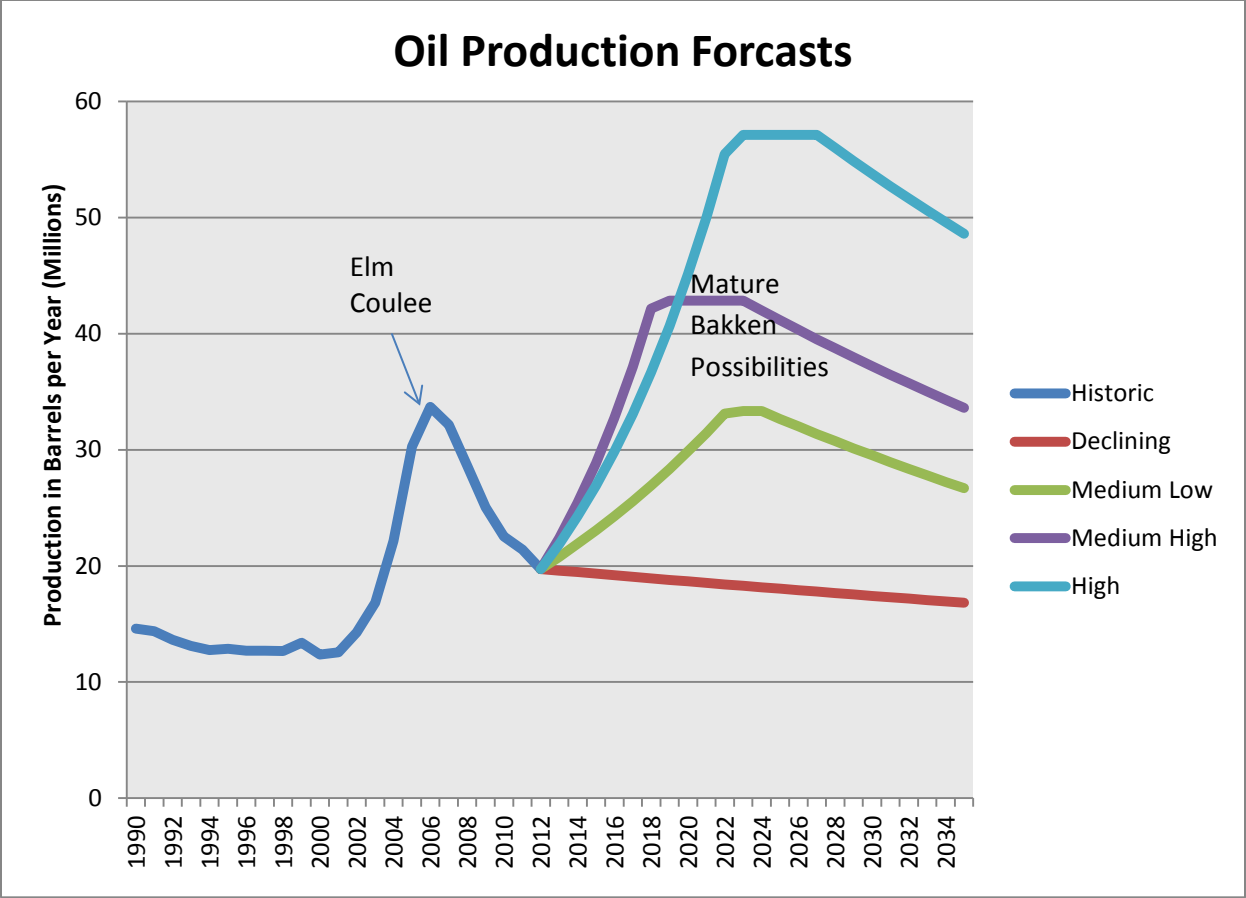


Figure 4: Production Forecasts

Total oil production in this region depends on the constant development of new wells. Unlike water wells, which aim for constant volume over a long term, oil wells have a distinct lifecycle with the majority of their output in the first 2 years (MTBOG, 2013). In general, annual growth in the oil output of a region indicates that more wells per year are being added and a decline in output means that fewer wells per year are being added. This means that production is largely a factor of the number of new wells: maintaining oil output of X barrels per year requires a constant addition of Y new wells. This is exemplified in the fact that

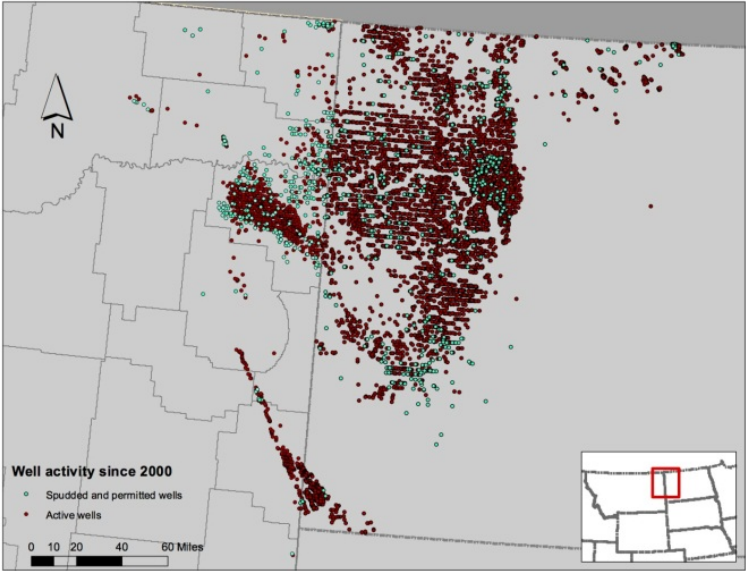


Figure 5: Oil Wells since 2001 (MTBOG, NDIC)

the Montana Bakken region has needed around 50 new wells per year to produce the historic baseline, 1990-2001, production of around forty-thousand BBLs per day.

Montana’s wells produce roughly half the barrels of oil as North Dakota’s wells, coupled with the size of the oil field in Montana, about 20% compared to ND (NDIC Oil & Gas Division, 2012)(MTBOG, 2013) (Figure 5), it is not surprising that North Dakota has greater oil output than Montana. The Energy Information Administration (EIA) data shows that Montana has roughly 21% of the total Bakken(U.S. Department of Energy, 2013); based on our calculations, this 21% of the Bakken will produce 11.7% of the output at the peak of total Bakken production under the medium high production scenario (Figure 4).

Total expected oil output (Figure 6) incorporates historic values for Montana and North Dakota as well as the probable case from the North Dakota Oil and Gas Division(Ritter, 2012) with our expected projection added. The combined output is very close to industry estimates for the Bakken(Hargreaves, 2011). According to North Dakota’s projections, they will plateau in production in 2013. Our medium high estimate has Montana production leveling off two years later and leaving the plateau stage before North Dakota, causing a five year period of peak output in the Montana Bakken.

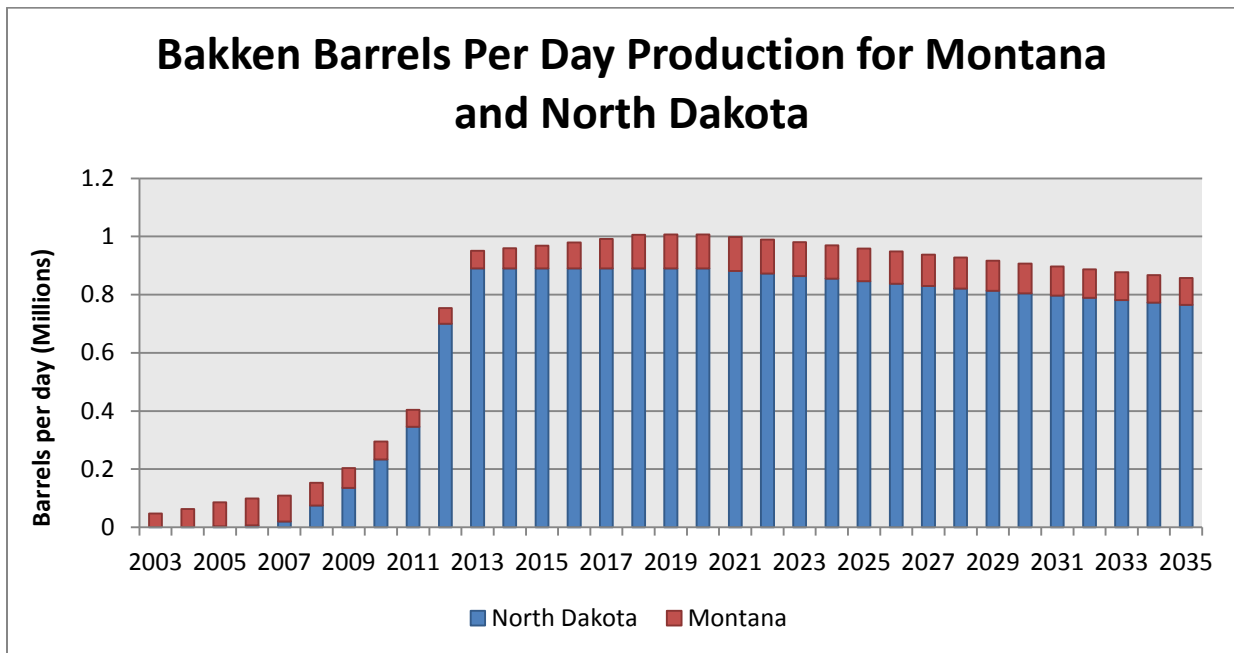


Figure 6: North Dakota and Montana

Population Growth

Expected population effect from the oil shock on the Glendive district is shown (Figure 7). Both the medium high and high scenarios produce a population increase of around 30,000 in the District by the late 2020’s, while the low oil growth estimate produces much more modest growth in the 10,000 range. Once oil production levels off and infrastructure construction catches up with demand, population is expected to fall slightly. The additional population mark slightly above 30,000 in the high estimate is

important as our current data does not indicate population in the district will expand much beyond this, providing a high end figure for analysis of infrastructure needs.

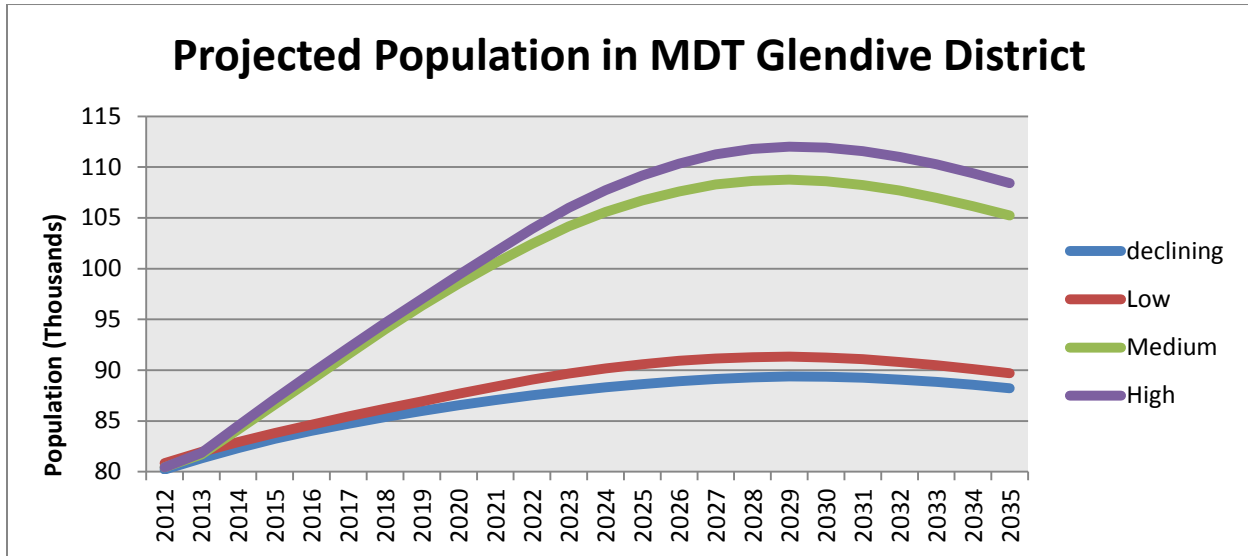


Figure 7: Population Estimates

While this is a district-wide level population growth estimate, much of this growth is expected in the Bakken area counties, such as Sheridan, Roosevelt, Richland, and Dawson. The expected growth in the Glendive District is significant, but it is helpful to compare this to the other districts of the state, using the medium high case for oil production. We expect the Missoula District to continue to be the population growth leader to 2035 (Figure 8). The Glendive district will likely keep pace in population growth with the Butte, Great Falls, and Billings Districts through the mid 2020's, When the population starts to slightly decrease.

While the population growth in absolute terms in the Glendive District are expected to be close to other areas of the state, this growth will likely be felt much more acutely, as the percentage change in the Glendive District is pointedly different than all other districts in Montana (Figure 9). This will most likely continue to produce pressure on infrastructure in the District, and particularly for MDT purposes, pressure on transportation infrastructure in the Bakken area of the District with increased traffic and road wear from heavy truck load volumes.

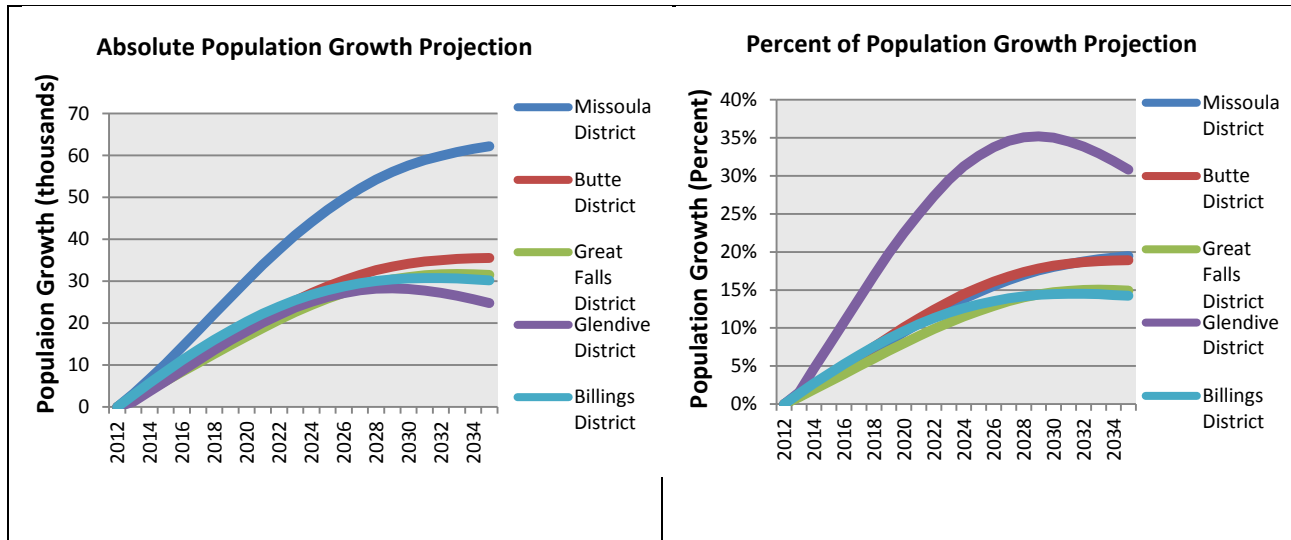


Figure 8: Absolute Growth

Figure 9: Percentage Growth

Traffic Growth

Traffic growth is particularly high in the Montana Bakken region of northeast Montana where there is oil activity. Traffic increases are also seen to the southeast through Treasure County and Yellowstone County (Billings), which is suggestive, of oil-related traffic generation in the corridor between the communities of Sidney, Glendive, Miles City, and the larger hub of Billings (Figure 10).

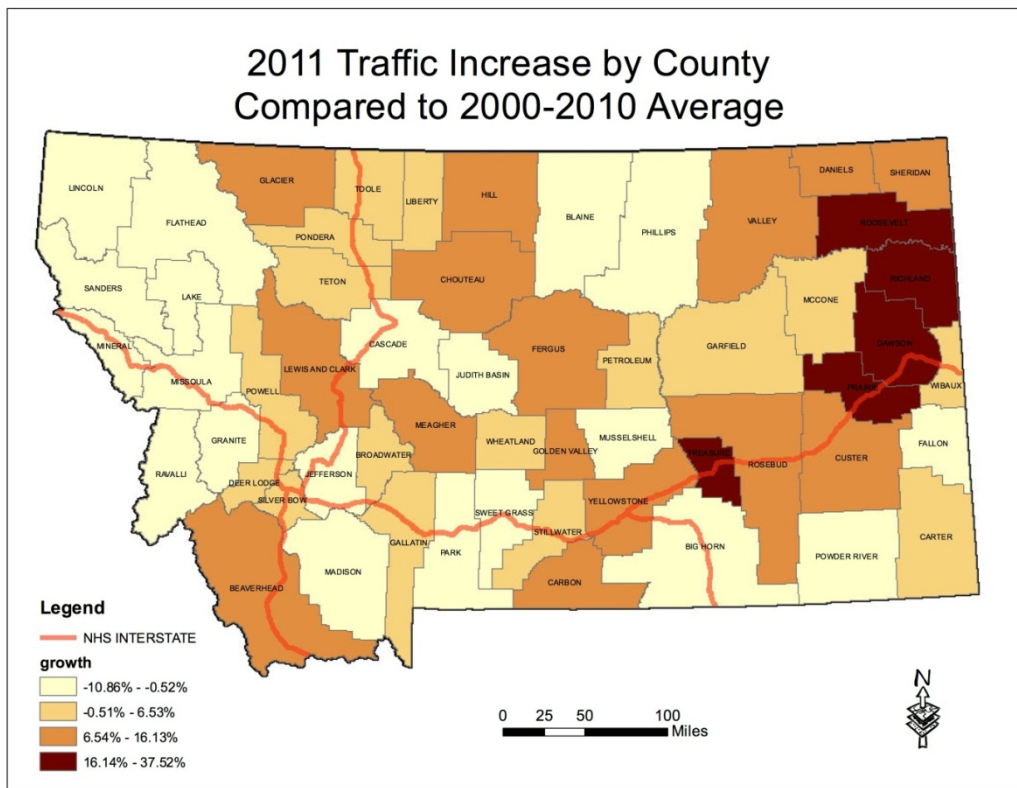


Figure 10: Historical Traffic Growth (Percentage)

By extrapolating historic traffic growth trends and applying these to the projected population growth, Daily Vehicle Miles Traveled (DVMT) can be allocated by county. Displayed (Figure 11) shows that the Bakken Counties, particularly Richland and Roosevelt, along with counties along major corridors coming out of the oil region, will see increased traffic growth. This growth is expected to peak in the mid 2020's, which is consistent with estimates for peak traffic in the North Dakota Bakken. (Tolliver, 2012) Counties outside of the Bakken affected area are likely to see minimal increases of DVMTs and have been averaged (Figure 11).

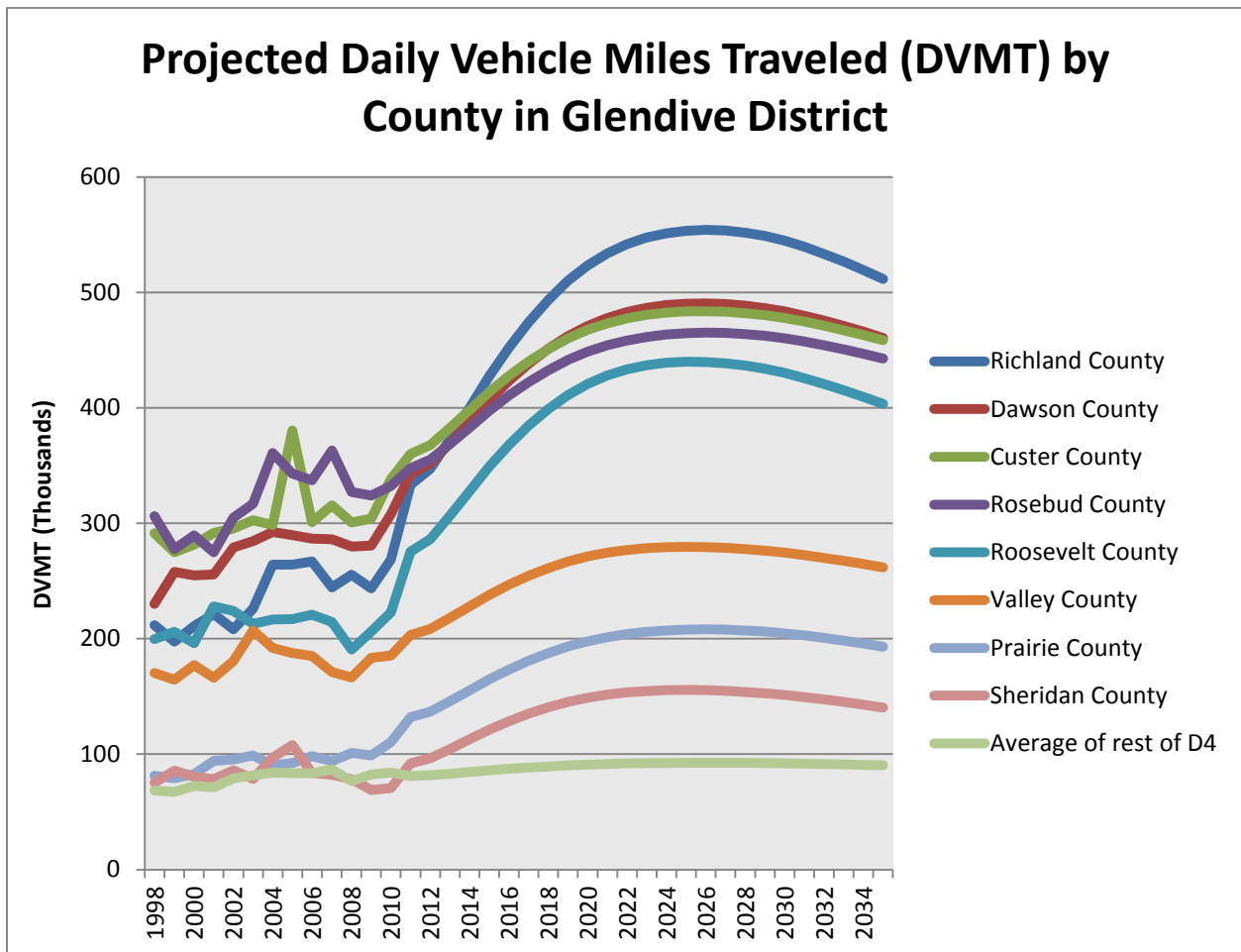


Figure 11: Traffic Growth in Medium High Scenario

MDT traffic data shows that there are several corridors of concern around the Montana Bakken area. These corridors and their AADT between 2001 and 2012 (2012 is currently a preliminary number which is subject to change) are displayed (Figure 12). The corridor with the most rapid growth and highest AADT is Sidney to Fairview on Highway 200. This 11.8 mile strip of roadway accounts for a large part of the increase in DVMT in Richland County during this period, primarily due to the last three years of increases.

Average Annual Daily Traffic (AADT) by road segment in Glendive District (Historic and Projected)

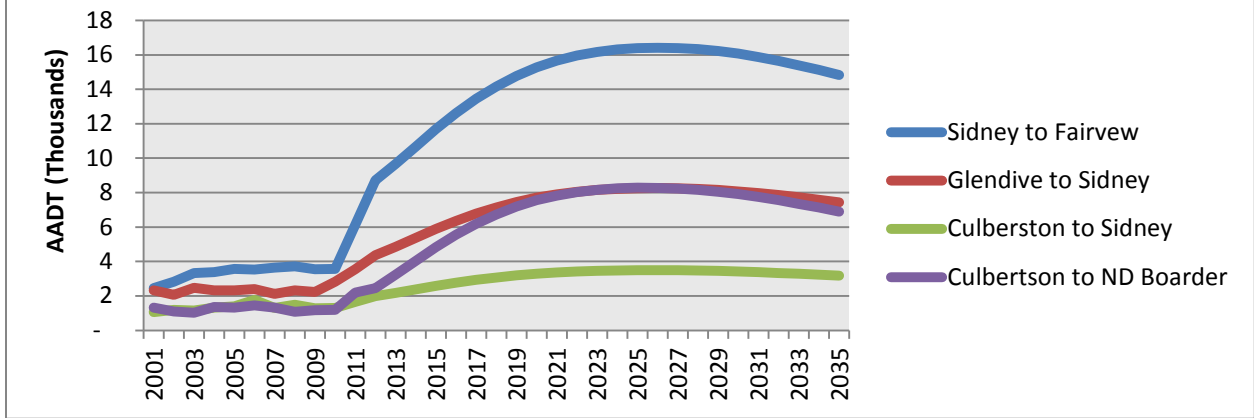


Figure 12: AADT Growth

Sidney to Fairview in particular is likely to continue to see increases in traffic. However, even if the corridor continues to take large amounts of the County’s traffic, based on the ratio of current AADT to average peak volume and the expected growth in traffic and population, volume should not exceed capacity of this corridor based on a 1500 vehicle per hour per lane capacity (Figure 13).

Projected Peak Average AADT by road segment in District 4 (one lane and per hour)

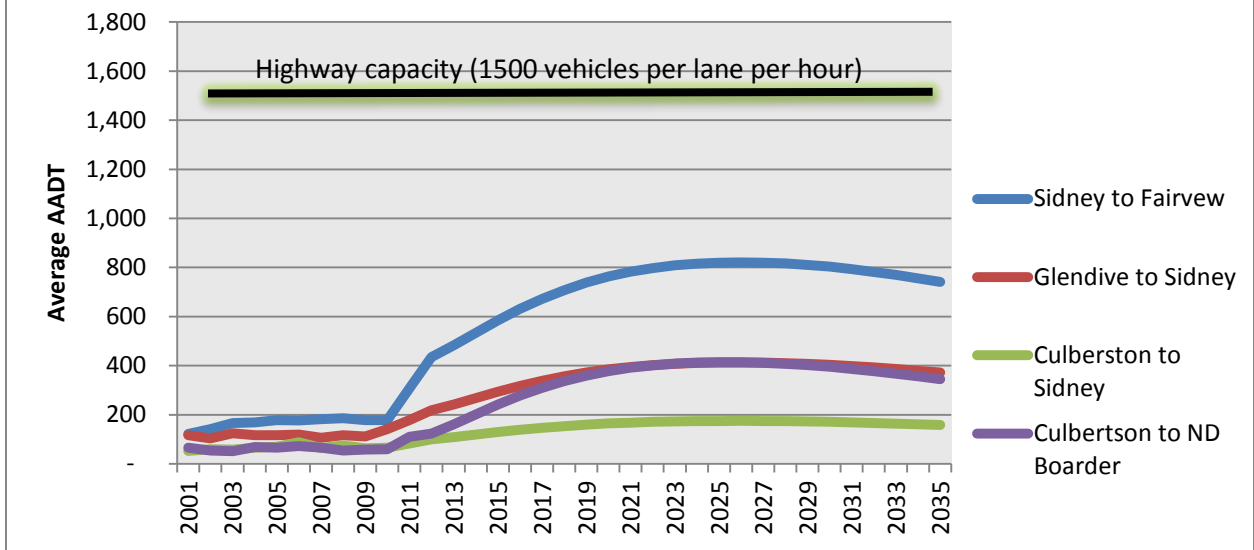


Figure 13: Projected Peak Average AADT

Peak average AADT by road segment of concern is listed in Table 1. The Peak AADT represents what is expected in the year of highest traffic (2026) in the medium high scenario for one lane in one hour.

Corridor	Sidney to Fairview	Glendive to Sidney	Culbertson to Sidney	Culbertson to North Dakota Boarder
Peak Average AADT in 2026	820.75	413.20	174.95	413.73

Table 1: Peak AADT in Medium High Scenario

Conclusion

Eastern Montana will for now and the near future continue to experience the effects of the oil boom from the Bakken. While the majority of drilling activity is located in North Dakota, an increase in drilling (commensurate with the increasing permits) is very possible in Montana as activity moves from the center to the periphery of the Bakken. There is however the possibility that the increasing permits will turn out to be primarily speculative and there will instead be a decline in drilling and production in Montana.

If drilling does follow permitting, as it has done historically, the findings here are current best estimates of the impacts that could occur, causing population increases in the region of around 30,000 people and a corresponding traffic impact from both population and industry, particularly on major corridors such as Sidney to Fairview. The alternative is a less significant increase in oil production resulting in a population gain in the 10,000 range, with a corresponding traffic increase.

MDT will continue to monitor the transportation growth in Eastern Montana, conducting annual updates to this analysis. This will be done to keep current with emerging trends and subsequent infrastructure needs in order to continue serving the public by providing a transportation system and services that emphasize quality, safety, cost effectiveness, economic vitality and sensitivity to the environment.

Appendix A: Extended Methodology

Analytical Approach

The analysis was done in a five stage process (Figure 14). First, primary data were gathered. Main elements of this included: (a) oil drilling permits, in addition to wells in-development and in production from the Montana Board of Oil and Gas; (b) socioeconomic information, including population and industry trends; and (c) data on truck and overall vehicle miles travelled.

The economic modeling system was customized to account for the industrial technology involved in the hydraulic fracturing (i.e., “fracking”) process. New industry input and output parameters were estimated based on expert input and on studies of similar processes (Hefley et al., 2011). The industry-specific model addresses labor, transportation, and input demands related to this drilling technique.

Forecasts were then prepared to reflect key growth factors. The expected oil development activity was estimated from a combination of sources, elaborated on in the *extent* section. This informs estimates of activities relating to land leasing through permitting and construction. Similar techniques were used to estimate continuing impacts related to the operation of active oil wells.

The majority of the Bakken is outside Montana (U.S. Department of Energy, 2013). Oil development from North Dakota has had, and will continue to have, spillover effects in this state. (We refer to this as “the ND Effect,” in reference to primary construction and operations activity in North Dakota that is driving growth in Montana.) Impacts on Montana from oil activity outside the state were estimated with reference to data on population, housing, industrial output, and transportation demand.

Royalties were estimated based on published reports for both private and publicly-owned tracts. Tax revenues estimated from state Board of Oil and Gas data, enabling a per-well average tax impact. Future transportation effects were based on traffic data from MDT’s Data and Statistics Bureau.

With these projections and estimates, direct economic impacts were estimated and put into the REMI economic model to yield total economic effect estimates (a combination of direct, indirect and induced activity). Direct, indirect, and induced effects are used here as economic terms. Direct economic activity refers to spending by the industry itself on labor, goods, and services (e.g., the development and operation of oil wells). Indirect activity refers to spending by industries hired. Induced impacts refer to the changes in household income and spending due to the ongoing circulation of money due to direct and indirect spending within a region. One objective of economic impact analysis is to estimate the total of these. The ratio of the total (direct, indirect, and induced) spending to direct spending is commonly referred to as a “multiplier effect.” Economic impact estimates are specific to the event, time, and region: in this case, Bakken oil development in Montana’s transportation districts. Such multipliers are not emphasized in this report. Rather, the analysis focuses on specific impacts in terms of transportation demand, population, revenue, etc. The output for Montana can be shown for each of the

state's five transportation districts, or for the state as a whole.

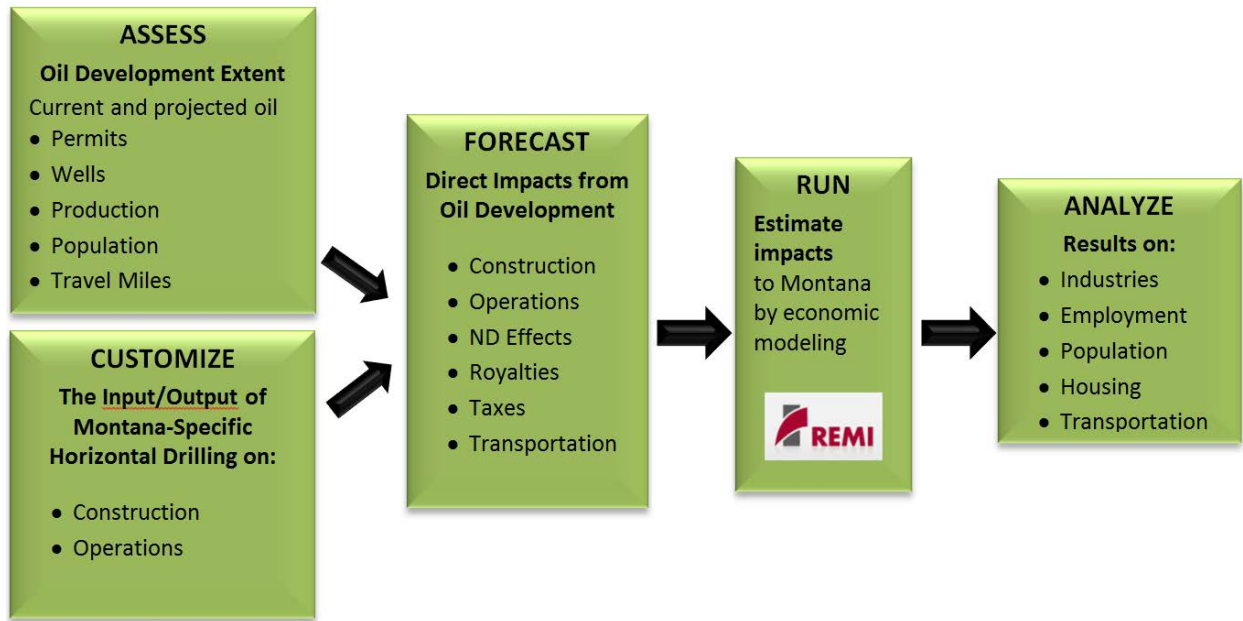


Figure 14: Methodology Flow (2)

REMI

For this analysis, MDT used economic modeling software by Regional Economic Models, Inc. The PI+ (i.e., Policy Insight Plus) model incorporates Input-Output, General Equilibrium, and Economic

Geography as major modeling approaches (REMI, 2012). The model is generally accepted in its use of publically available data and economic modeling techniques. Sources and methods in REMI are separately available from that provider and not detailed here. The model allows users to input specific changes to an industry and region. It yields year-by-year forecast outputs for a range of economic and demographic

characteristics. (For more information on the REMI PI+ model visit www.remi.com)

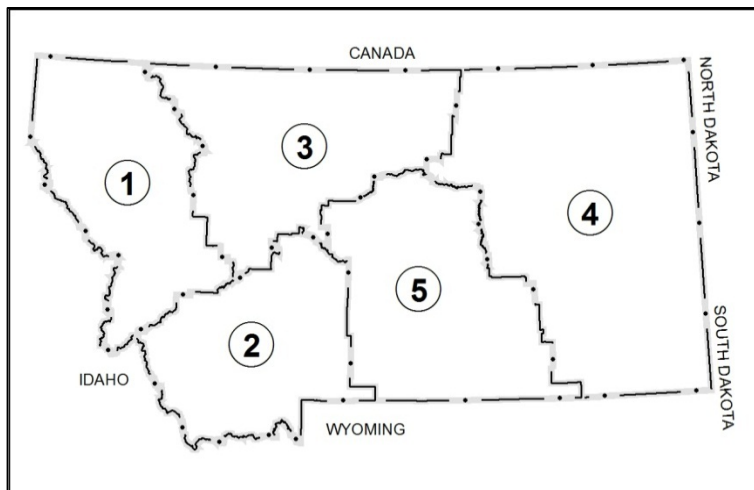


Figure 15: MDT Districts

MDT Districts

The REMI model allows changes and effects to be seen on a regional scale in Montana. The state is divided into five regions which correspond to the five MDT districts, often referred to by the location of their headquarters: District 1- Missoula; District 2 – Butte; District 3 – Great Falls; District 4 – Glendive;

and District 5 – Billings. District 4, the Glendive District, is the eastern district where the Bakken is located. Due to the regional nature of the model, all the output analysis from REMI will be for the entirety of District 4, a sixteen county region including counties; Phillips, Valley, Daniels, Sheridan, Roosevelt, Richland, McCone, Garfield, Prairie, Dawson, Wibaux, Rosebud, Custer, Fallon, Carter, and Powder River. However, the growth pressure of the region is in very large part due to the oil production growth of the Bakken and is thus can be assumed to be concentrated most heavily in the northeastern counties of District 4.

Custom Industries

The REMI model is in large part based on input-output tables. This quantifies the interdependencies of industries on each other, recognizing that, excluding final demand, purchases from one industry are the sales of another (Leontief, 1986). For example, for each dollar the construction industry spends a certain portion of that dollar goes to the transportation industry, the electrical equipment manufacturing industry, and a number of other industries. The interconnectedness of all industries in an economy is modeled with this type of input-output model such that a change in activity can be seen moving through the whole economy.

The model can show the Montana economy with 70 sectors, or industries, of detail. Included in the 70 sectors are 1. *Oil and Gas Extraction* and 2. *Construction*, which could be used for the production and construction phases of oil drilling respectively. However, construction and operation of horizontal drilling has a somewhat different set of industry inputs and outputs as compared to the conventional oil and gas extraction or construction industries. Therefore custom industry lines were created for both the construction and operations of the horizontal wells tailored specifically to Montana horizontal wells.

The two custom industries started with the base construction and oil and gas extraction industries contained within the REMI model and adjusted with Montana specific based input. The adjustment was based on Marcellus shale well value chain study out of the University of Pittsburgh (Hefley et al., 2011). This adjustment, done by economists at REMI, moved the standard construction and oil and gas extraction industry lines to a horizontal well specific industry lines by converting direct investments in the study to The North American Industry Classification System (NAICS) codes. "... (NAICS) is the standard used by Federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy." (Special Projects Staff, n.d.) This line was then further refined to reflect Montana shale wells, accounting for issues such as fewer inputs to industries dealing with vegetation clearing, a less significant issue in eastern Montana than the eastern US forests where the Pittsburgh study was based.

These two custom industry lines were put into the REMI model so that activity in construction of wells and oil production could more accurately be reflected in the model outputs. All other impacts were able to use standard input-output lines in the model.

Extent

The basis of much of the analysis, such as construction and operation expenditures, is based on the extent scenarios of oil production that is expected in the Montana Bakken. These production scenarios

were constructed from a variety of both public data and industry estimates in order to have a number of converging pieces of information.

First, new oil wells as well as oil permits were obtained from the Montana Board of Oil and Gas (MBOG) between the years of 1990 and 2012(MTBOG, 2013). Several trends in the data were identified such as the ratio of total barrels of oil to new wells and the ratio of permits to new well completion. It was also noted that new wells produce the big differences in the final output because the first year of a well is the most productive and a steep decline in production is seen in subsequent years(NDIC Oil & Gas Division, n.d.). Based on these ratio's an equation relating production to the number of new wells drilled and the total number of wells producing was created using a least squares relationship of new wells to barrel production and average relationship of new wells to cumulative producing wells for northeast Montana from 1990-2011.

Production Equation

$$P_f = 41.656(W_{nf}^2 + W_{nf}W_{p(y-1)}) + 5815.8W_{nf} + 7898.6 W_{p(y-1)} - 394,930$$

- P_f = Production of Barrels (Forecasted)
- W_{nf} = New Wells (Forecasted)
- $W_{p(y-1)}$ = Number of Producing Wells in Year Y-1

The production formula performs well through the expansion of the Elm Coulee (Figure 16). There is a divergence around 2010 that is likely due to the movement to North Dakota and the exploratory permitting in Montana. It is expected that if and as production commences in Montana, the equation will be good for forecasting production given an expected number of new wells.

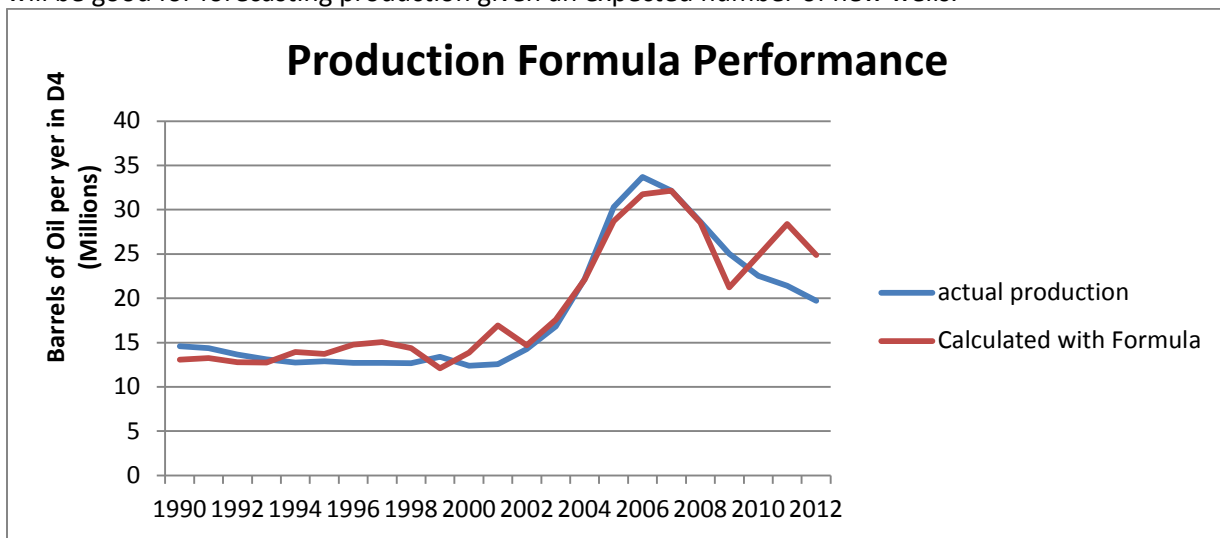


Figure 16: Equation Performance

As the actual production has a smoother curve than the calculated curve, the prediction curve was smoothed between the known 2012 value and the top end value, explained below, with Microsoft Excel's fill function, using a growth trend.

This calculation is based on the assumption that permits are a leading indicator of future new oil wells. This has been the case at an average 54% conversion ratio since 1990 (Figure 17). Permits were taken to 2035 using a simple linear growth trend with Excel, at which point the 54% conversion ratio is applied to calculate new wells. The only exception to this is for 2013. There has been a large amount of speculation with permits, driving the permit to conversion ratio closer to 34% since drilling moved primarily to North Dakota (2009-2012). This 34% conversion ratio is continued in 2013 under this forecast.

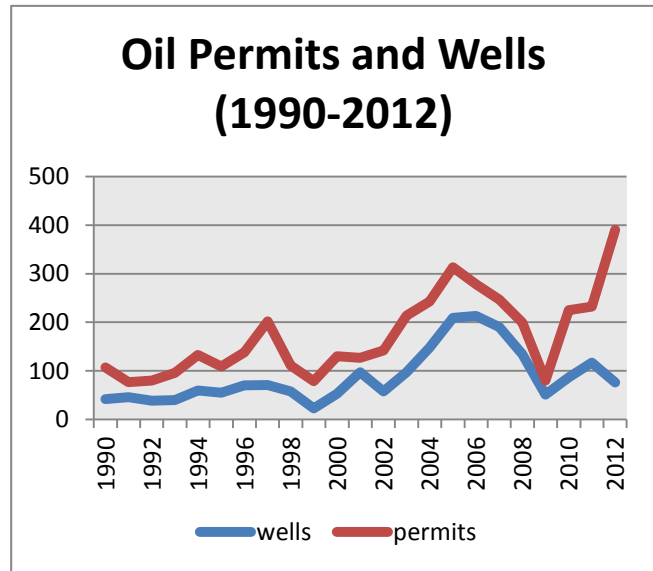


Figure 17: Well/Permit Correlation

To calculate a top end for oil production in

Montana, estimates from the North Dakota Oil and Gas Division were used. These estimates show a proven, probable, and possible value for the amount of oil coming out of North Dakota (Figure 18) (Ritter, 2012).

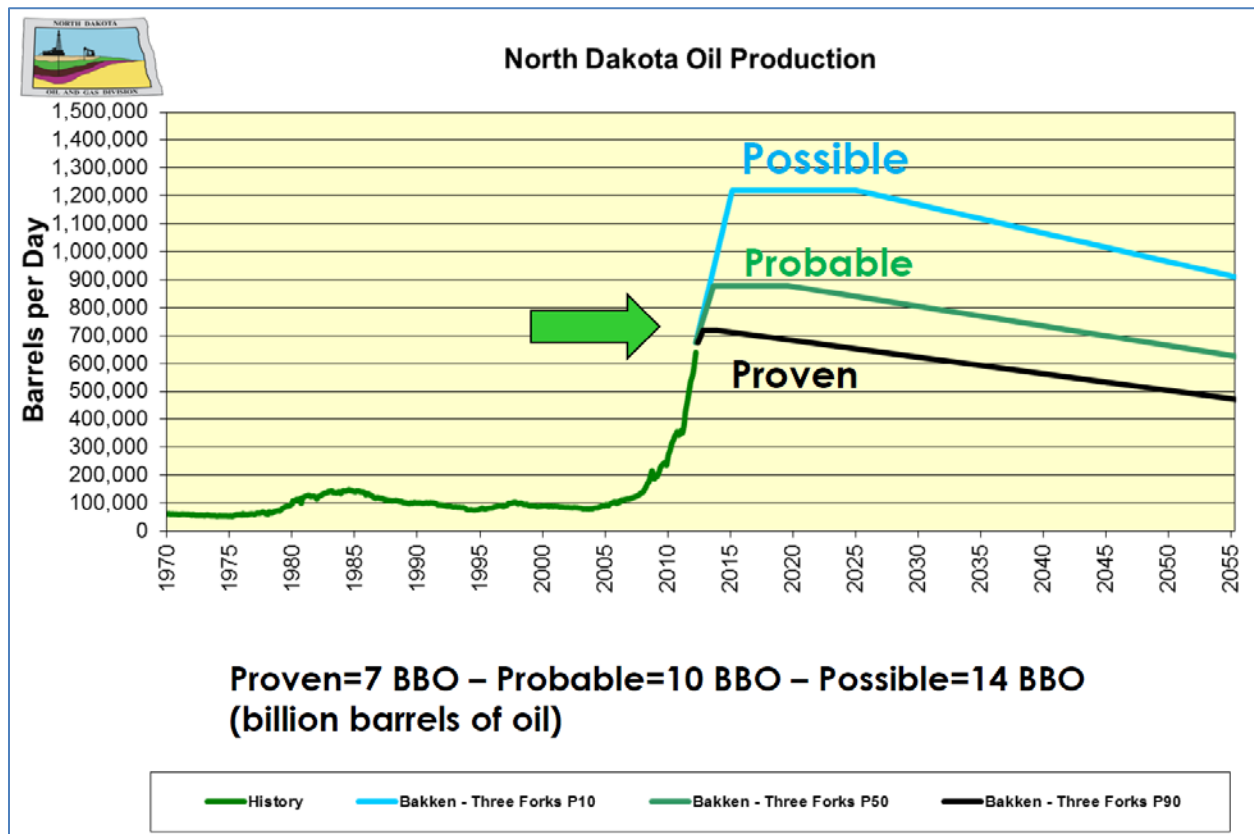


Figure 18: North Dakota Estimates

A high medium high and medium low projection for a plateau of oil production for Montana was calculated based on the three North Dakota estimates, with the medium high projection corresponding to North Dakota's Probable scenario. This was done by taking both the ratio of Bakken located in Montana as opposed to North Dakota at 21.1%,(U.S. Department of Energy, 2013) as well as the ratio of productivity for an average North Dakota(Ritter, 2012) and Montana well(MTBOG, 2013). This put Montana at producing 11.7% of Bakken oil at peak. A plateau of several years short and a subsequent decline of twice that of North Dakota's is used to create the remainder of the curve.

A fourth projection was done without reliance on increasing permits or any of North Dakota's data. This projection is a simple growth line projection on oil production utilizing 2001-2012 data(MTBOG, 2013). Oil continues its gradual decline seen in the last several years in this forecast.

The number of barrels is then multiplied by the average 2012 price per barrel (Rose Rock Midstream Crude, n.d.)(held at that inflation-adjustable price) to calculate a forecasted value of the oil coming out of District 4 in Montana. Once that number was available, new well construction, total number of wells, and total number of barrels were the values that were primarily used for many of the other model input variables such as construction, operation, and transportation.

Direct Impacts

Six major impacts were calculated to be added to the model. Each of these represents a major direct impact of the oil industry expansion in Montana or North Dakota. In Each case the additional shock of the oil industry was input into the model, the methodology for each is discussed below.

1. Construction

Construction in this case represents the construction of new wells, as other infrastructure will be included in the model through the custom industry line. This makes for a relatively simple calculation. The number of new wells comes out of the extent section and this is then multiplied by the cost of constructing a horizontal well in Montana. This cost used is the low end of the North Dakota cost estimate.(NDIC Oil & Gas Division, n.d.) The low end was used as wells in Montana tend to be shallower and fracked less than North Dakota wells(MTBOG, 2013)(NDIC Oil & Gas Division, n.d.), both of which lead to a decreased cost.

2. Operation

Operation of wells for the shock includes the cumulative wells operating in the area minus the baseline of wells that was being added prior to the oil shock. There is not a straight additive property of new wells to the cumulative number of wells operating in the region however. The reason for this is that there are constantly a number of wells being taken out of production. The recent ratio, 2007-2011, of this is approximately 38%. This means that for every 100 new wells, the cumulative number of wells in operation for the year is an additional 38. This number of cumulative wells is multiplied by the cost of operating a horizontal well in the rocky mountain west.("Oil and Gas Lease Equipment and Operating Costs 1994 Through 2009," n.d.)

3. Housing Investment

Building permit numbers from The U.S. Department of Housing and Urban Development (U.S. Department of Housing and Urban Development, n.d.) for counties Sheridan, Richland and Roosevelt, bordering the prime development area of North Dakota, as defined by the Minneapolis Fed (Federal Reserve Bank of MPLS, n.d.) were gathered. While it is known that not all areas of Montana require building permits, it is assumed that building permits remain an indicator for home construction, and was used for analysis due to time limitations. Richland County accounted for 84% of all building permits within these three counties in 2011. Farther from this active area, counties often had zero permits in 2011, so they did not appear to be affected, at least in large part considering the lack of certain permitting in some areas, by the ND effect in terms of housing investment up to 2011.

Building permits for counties in the North Dakota Bakken, using the same Federal Reserve report to define which counties to examine (Federal Reserve Bank of MPLS, n.d.), were also gathered. A trend line based on 2009, 2010, and 2011 permit data for both Montana and North Dakota was created using Microsoft Excel's linear growth trend line function. Total permits, from both states, had a limit of between 35,000 and 40,000 set for the area. This range corresponds to the number of permanent jobs that the North Dakota Oil Commission projects as permanent full time jobs (NDIC Oil & Gas Division, n.d.). While there are temporary housing needs for the transient workforce, an effect discussed later, permanent housing needs for the North Dakota impact were set at a one to one ratio with permanent job projections. A decline in permits was added to the housing needs model at the same rate as the historical increase in permits; this produces a sigmoidal curve of housing permit activity. This decline rate, accounts for the housing industry catching up with demand and gradually slowing new home construction. Thus, the trend line in total permits, and the assumed housing, for both ND and MT produces a sigmoidal curve, with the peak rate of building occurring in 2015.

The added value to the economy of housing in the area is calculated by using an average price of all houses in the Williston ND area minus the average price of all building lots in the same area, with prices from Realtor.com. ("Homes for Sale, Real Estate & Property Listings - REALTOR.com®," 2012) The Williston area was used as it is the representative center of the Bakken and towns on the Montana side had too few homes and lots for sale to produce a good average. When put in the REMI model, aggregate house value is added to the year after the permits are issued, to account for the lag in permit issue and the value of the housing added to the economy.

4. Transient workforce

The transient workforce section of the analysis takes into account the impact of the workforce that is coming into the area but retaining residency and spending time outside of the area. This is one of the more difficult aspects of the analysis to quantify as there is no good metric to measure the number and time spent in the area of this workforce. "City officials can't track the actual number of people moving into town. Many stay in campers, RVs and motel rooms, providing city officials few solid numbers." (Krotzer, 2012) What we do know however is that "Covenant Consulting Group in Bismarck, ND, reported that three different independent sources estimated man-camp numbers at approximately 24,000 beds on the North Dakota side of the Williston Basin region" (Montana All Threat Intelligence Center & North Dakota State and Local Intelligence Center, 2012) While this provides the basis number

used in the analysis, even this from the law enforcement center in the area recognizes the difficulty of obtaining a good number here. *“The fusion centers lack a clear understanding of the total number of personnel and demographic composition of Montana’s man camps.”* (Montana All Threat Intelligence Center & North Dakota State and Local Intelligence Center, 2012)

Due to this lack of good info on the number of transient workers a number was calculated using the starting point of 24,000 man-camp bed on the ND side of the Bakken. Because of the inherently mobile nature of transient workers, a straight ratio of Bakken area was not used, but was averaged with another measure of housing, the ratio of building permits. This gave us a 12.04% ratio of beds on the MT side when compared to ND to be applied to the 24,000 man-camp bed ND number. As this only applies to man-camp beds, it was simply doubled to account for transient workers living in RV’s as RV living is also impacting the area.

This number of transient workers stays constant in the model through 2013, as this is where North Dakota shows the production of oil in their Bakken plateauing. (Ritter, 2012) Post 2013, a large amount of transient workers are expected to remain, but that number declines in proportion to the increases in the number of permanent residents. The decline of the transient workforce was then calculated at half the rate of the increase in housing, a calculated assumption that reduces the transient workforce but does not eliminate it. The number of transient workers decreases slowly with this model, and levels out around 2019-2020.

Values of \$700 a month for an RV hookup spot, and \$900 a month for a room were used to calculate housing impacts for the transient workforce. These values are based on Craigslist (“Craigslist,” 2012) advertisements, using the low values found for the area as the assumption that good deals are generally taken off of Craigslist fairly rapidly. The separate values were multiplied by the two groups. Additionally, \$46 a day for meals and other expenses was input for all transient workers; this is based on the United States General Services Administration’s per diem costs for Montana. (U.S. General Services Administration, n.d.) This value was chosen as it is a publically available figure on spending.

5. Royalties

As of August 2012, the majority of oil wells in Eastern Montana were located on private land at 90.36%, while state government land had 5.78%, and local and tribal government had 2.52%. (MTBOG, 2013) (Montana State Library, 2012) There are a small number of oil wells also located on federal government land, but it assumed that the vast majority of that revenue will leave the state and is thus not included in the model. Using the simplified percentages of output to revenue at 14.51% for government royalties and 15.73% for private royalties, based on Department of Revenue numbers since 2007 (Department of Revenue, 2012), royalty values were forecasted. These impacts were then input into the model in government and private royalties respectively.

6. Taxes

Oil taxes are a complicated issue that, for shorter forecasts than this analysis, is examined in great detail by the Department of Revenue. (Montana Department of Revenue, 2013) The complication is in large part due to the state severance tax holiday in the first 18 months of production. (MCA, 2011a) Because

of these complications a simplified ratio of production to oil revenue(Department of Revenue, 2012) was used to calculate future taxes based on estimated oil production.

This category represents increased government spending due to taxes from, primarily, exported output. With the tax holiday in consideration, the average tax rate on oil in the Bakken counties has been 9.36% between 2007 and 2011(Department of Revenue, 2012). Total tax is calculated by applying this tax rate to future predictions of output. This is added to royalties, from the previous section, to get total government income, which is included as government spending in the model as this money will be spent at the local and state level. Both royalties and tax rates are split for the model 47.17% local, 52.83% to the state.(MCA, 2011b) The state taxes are split each forecasted year in the model based on that year's regional population percentage of Montana.

Traffic Calculations

The ultimate purpose of this analysis for MDT was to obtain traffic projections for the Bakken region of Montana. To do this traffic had to be separated into a finer level of detail than a regional model. It is recognized that the economic model is a regional level model, and while it is anticipated that the Bakken area of the Glendive District will see a large portion of the projected growth, every increasingly specific level of detail that is calculated is estimation on a projection. The confidence in the given values therefore is diminished and should be recognized as so.

Keeping this in mind, traffic was separated to a county level by a formula developed to use the REMI population output as the level of growth, and the shifting DVMT trends(MDT Data and Statistics Bureau, 2012) in District 4 counties as the metric to separate this growth. As can be seen in the historical DVMT by county in the Glendive District chart, there are significant changes in the level of DVMT in some, but not all, counties starting around 2009, and especially between 2010 and 2011. This uptick is certainly the increased traffic associated with the Bakken oil boom and is thus reflect as a higher weighing for separation in the traffic distribution equation.

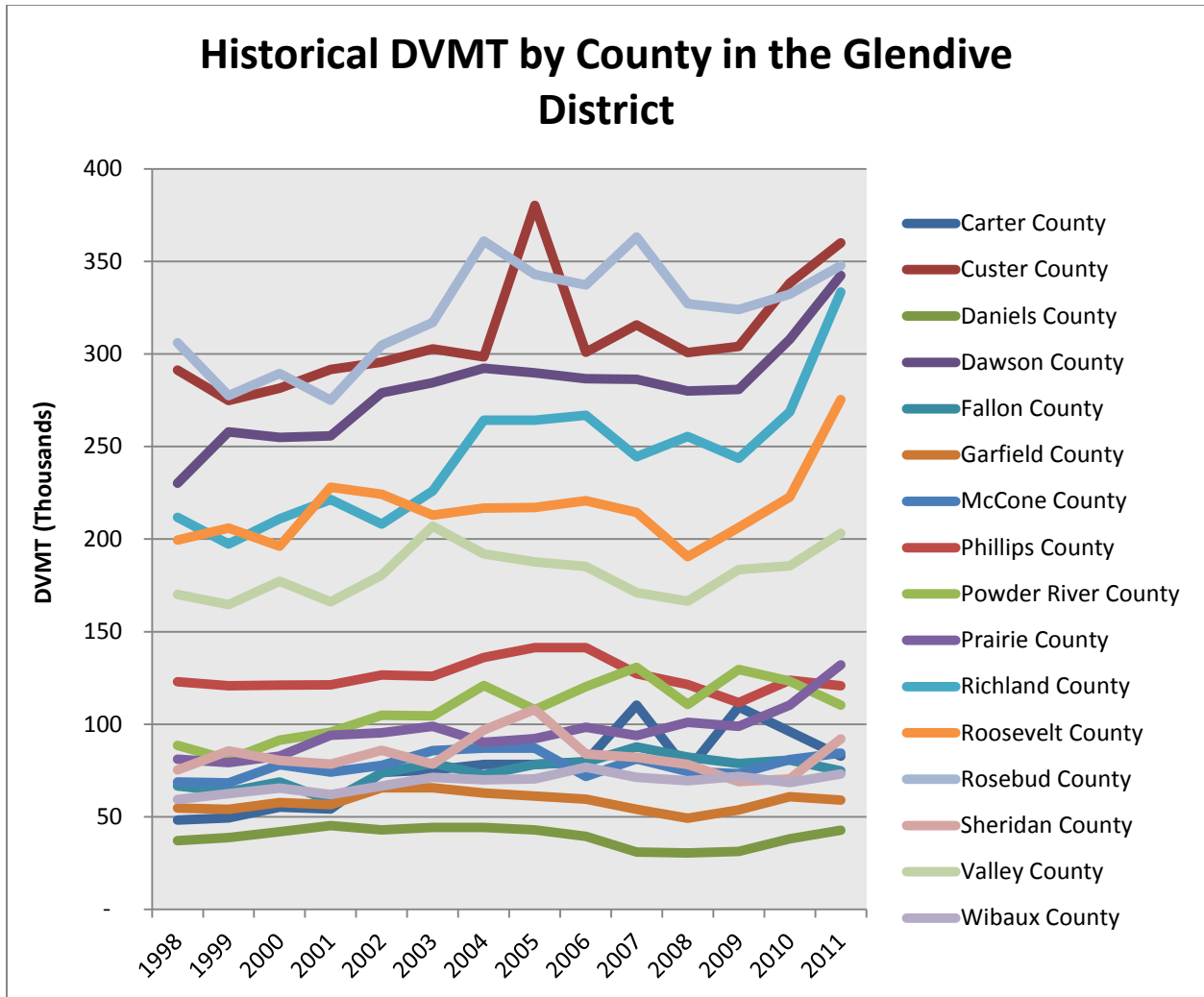


Figure 19: Historical DVMT (District 4)

Traffic Distribution Equation

$$FDVMT_{cy} = DVMT_{2011c} + \left(\frac{1}{2} \frac{DVMT_{2011c} - DVMT_{2010c}}{DVMT_{2011r} - DVMT_{2010r}} + \frac{1}{2} \left(\frac{T_{cy}}{T_{ry}} \right) \right) * (Pop_{ryf} * DVMT_{pc-avg} - DVMT_{2011r})$$

FDVMT_c = Forecasted DVMT in county C in year Y

DVMT_{2011c} = DVMT in year 2011 in county C

DVMT_{2010c} = DVMT in year 2010 in county C

DVMT_{2011r} = DVMT in year 2011 in MDT region 4

DVMT_{2010r} = DVMT in year 2010 in MDT region 4

DVMT_{pc-avg} = Per Capita DVMT in MDT region 4

T_{cy} = The value in year Y in county C from a least squares calculation of county C DVMT years 2000-2010

T_{ry} = Σ of T_{cy} for year Y of all counties in MDT region 4

Pop_{ryf} = Forecasted population in MDT region 4

Due to the additive ability of DVMT, it is the most useful metric of available MDT data. This metric was also chosen because although, there can be a low correlation between DVMT and regional population year by year, there is a strong correlations between DVMT and population over longer periods of time. This allows the population output of REMI to be used as a growth rate for DVMT when combined with the 2001-2011 per-capita DVMT.

It is worth noting that in counties outside the immediate oil area, which are having large increases in traffic, there is a high correlation between the number of major roadways, specifically interstate mileage, and the expected growth of traffic (Figure 20). This correlation in the growth is of course based on the historical DVMT figures. While expected the counties on the interstate coming out of the Bakken area in the Glendive District have an especially high correlation of DVMT changes to Interstate miles, as seen below. This correlation would likely be even greater if not for the effect of Miles City traffic on Custer County.

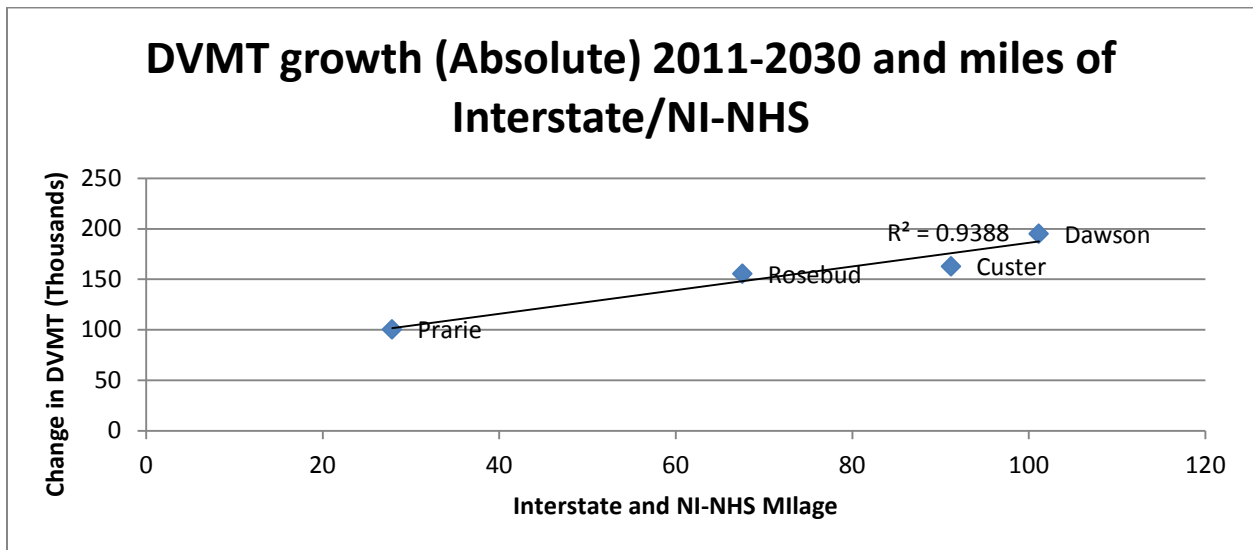


Figure 20: DVMT and Interstate Mileage Correlation

Annual Average Daily Traffic (AADT) was extrapolated from the DVMT by county estimations using the standard AADT to DVMT equation. At this extrapolated level the confidence in the numbers is quite reasonably stretched, as such, only high end estimations were done in order to see which areas should be focused on, and if possible capacity issues may be arising.

AADT Equation(Vandervalk-Ostrander, 2009)

$$DVMT = \sum AADT * L$$

DVMT = Daily Vehicle Miles Traveled

AADT = Average Annual Daily Traffic

L = Road Segment Length

AADT is a rate at a traffic count site, so an average rate from the multiple traffic count sites along the routes of interest were used for AADT as well as peak hour AADT. The peak hour AADT was used for calculations as this is the area of concern for capacity issues. These calculations were done for the four corridors of concern, Glendive to Sidney, Sidney to Fairview, Culbertson to Sidney, and Culbertson to the North Dakota boarder.

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[crime/article_e6bb2760-4a2b-11e1-9f91-0019bb2963f4.html](http://missoulian.com/news/state-and-regional/population-influx-in-northeastern-montana-near-oil-fields-ups-crime/article_e6bb2760-4a2b-11e1-9f91-0019bb2963f4.html)

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