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Comparing Crash Trends and Severity in the Northern Rocky Mountain Region

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Abstract: Safety Management Systems are federally mandated in an effort to encourage states to develop strategic programs in order to mitigate severe crashes. In 2006, the Wyoming Department of Transportation (WYDOT) published the Wyoming Strategic Highway Safety Plan (SHSP). The plan outlines goals for the state and transportation areas of strategic emphasis. While the SHSP has proven successful in lowering crash rates, Wyoming is constantly plagued by one of the highest fatal crash rates in the region. In the northern Rocky Mountain region, North Dakota historically boasts the lowest fatal crash rates, while Colorado has the highest. Other states in the region are Wyoming, Montana, Utah, South Dakota, and Idaho. In an effort towards continued safety improvement, WYDOT is investigating whether there is a link between certain factors in North Dakota and the low number of fatal crashes experienced there. The basis of this research centers on evaluating key differences between North Dakota and Wyoming to determine if there are policies, practices, and or physical differences that keep North Dakota's fatal crash rate lower. This research investigates patrol enforcement differences, traffic safety laws, crash records, mileage records, vehicle records, and economic factors as possible sources of crash rate differences. When some critical factors were identified, Logistic Regression Modeling was applied to two Wyoming interstates to identify safety concerns for implementation within Wyoming's transportation SHSP. It was found that on Interstates 80 and 25 in Wyoming, sobriety, motorcycle usage, and speed were some of the largest factors in increasing the probability of a critical crash. From comparing crash trends between the two states, it was found that interstates are an area where fatal crashes happen more often in Wyoming. Wyoming also has more fatal crashes on weekends and in the summer months than North Dakota. It was found that both states are behind in the adoption of nationally recommended laws and that Wyoming enforcement needs more resources to effectively patrol and maintain safety on highways such as interstate 80. Finally, it was determined that in those counties where mining and construction industries have high levels of employment, crashes were more frequent and care should be taken to educate those communities on the benefits of safe driving.

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Approximate Conversions from SI Units

Symbol	When You Know	Multiply By	To Find	Symbol
Length				
mm	millimeters	0.039	Inches	in
m	meters	3.28	Feet	ft
m	meters	1.09	Yards	yd
km	kilometers	0.621	Miles	mi
Area				
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	Acres	ac
km^2	square kilometers	0.386	square miles	mi^2
Volume				
ml	milliliters	0.034	fluid ounces	fl oz
l	liters	0.264	Gallons	gal
m^3	cubic meters	35.71	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
Mass				
g	grams	0.035	Ounces	oz
kg	kilograms	2.202	Pounds	lb
Mg	megagrams	1.103	short tons (2000 lbs)	T
Temperature (exact)				
°C	Centigrade temperature	1.8 C + 32	Fahrenheit Temperature	°F
Illumination				
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
Force and Pressure or Stress				
N	newtons	0.225	Poundforce	lbf
kPa	kilopascals	0.145	pound-force per square inch	psi

Approximate Conversions to SI Units

Symbol	When You Know	Multiply By	To Find	Symbol
Length				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
Area				
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
Volume				
fl oz	fluid ounces	29.57	milliliters	ml
gal	gallons	3.785	liters	l
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
Mass				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lbs)	0.907	megagrams	Mg
Temperature (exact)				
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celsius temperature	°C
Illumination				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
Force and Pressure or Stress				
lbf	pound-force	4.45	newtons	N
psi	pound-force per square inch	6.89	kilopascals	kPa

Comparing Crash Trends and Severity in the Northern Rocky Mountain Region

Abstract

Safety Management Systems are federally mandated in an effort to encourage states to develop strategic programs in order to mitigate severe crashes. In 2006, the Wyoming Department of Transportation (WYDOT) published the Wyoming Strategic Highway Safety Plan (SHSP). The plan outlines goals for the state and transportation areas of strategic emphasis. While the SHSP has proven successful in lowering crash rates, Wyoming is constantly plagued by one of the highest fatal crash rates in the region. In the northern Rocky Mountain region, North Dakota historically boasts the lowest fatal crash rates, while Colorado has the highest. Other states in the region are Wyoming, Montana, Utah, South Dakota, and Idaho. In an effort towards continued safety improvement, WYDOT is investigating whether there is a link between certain factors in North Dakota and the low number of fatal crashes experienced there. The basis of this research centers on evaluating key differences between North Dakota and Wyoming to determine if there are policies, practices, and or physical differences that keep North Dakota's fatal crash rate lower. This research investigates patrol enforcement differences, traffic safety laws, crash records, mileage records, vehicle records, and economic factors as possible sources of crash rate differences. When some critical factors were identified, Logistic Regression Modeling was applied to two Wyoming interstates to identify safety concerns for implementation within Wyoming's transportation SHSP. It was found that on Interstates 80 and 25 in Wyoming, sobriety, motorcycle usage, and speed were some of the largest factors in increasing the probability of a critical crash. From comparing crash trends between the two states, it was found that interstates are an area where fatal crashes happen more often in Wyoming. Wyoming also has more fatal crashes on weekends and in the summer months than North Dakota. It was found that both states are behind in the adoption of nationally recommended laws and that Wyoming enforcement needs more resources to effectively patrol and maintain safety on highways such as interstate 80. Finally, it was determined that in those counties where mining and construction industries have high levels of employment, crashes were more frequent and care should be taken to educate those communities on the benefits of safe driving.

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CHAPTER 1 INTRODUCTION

1.1 Background

The National Highway Traffic Safety Administration (NHTSA) Region 8 consists of North Dakota, South Dakota, Wyoming, Colorado, Nevada, and Utah. Of those states, North Dakota has had a significantly lower fatality rate in recent years. Fatality rates are a measure of safety used to compare the number of fatalities in a certain area to other areas, normalizing those numbers by million vehicle miles traveled. In recent years, Wyoming has had an average fatality rate of 1.9 fatalities per 100 million vehicle miles traveled. On the other, hand North Dakota has had a fatality rate of 1.4 over the same time period.

Highway safety has been an ongoing societal goal in recent times due to the high social and economic costs of crashes and the tolls they impose on the transportation system. Because the fatal crash rates in Wyoming are significantly higher than North Dakota, it was postulated that an objective and comparative study of various factors affecting crashes in both states might lead to the discovery of potential actions that could help lower the fatality rate in Wyoming.

1.2 Problem Statement

One of the FHWA's missions is to reduce highway fatalities by making roads safer through a data driven, systematic approach and addressing all four "Es" of safety: Engineering, Education, Enforcement, and Emergency medical services. Recent improvements in safety databases in the Rocky Mountain region have made crash data more accessible for research studies. Wyoming and North Dakota are located geographically in the same region and they have relatively similar populations. However, a quick investigation of the crash numbers and severity in both states shows that North Dakota has significantly lower crash severities. After this study was initiated, more crash information has become available. This information revealed figures very different from the trends for fatal crashes in 2009. North Dakota began experiencing more fatalities than Wyoming and an equal number of fatal crashes for the first time since reliable records are available. Many reasons were speculated for this sharp change in trends, but the most relevant and believable explanation was the increased drilling activity in North Dakota that began in 2008 in the Bakken formation. Figure 1-1 shows the fatalities in both North Dakota and Wyoming from 1992 to 2009. The idea that this change in crash trends could be due to increased drilling activities led to the notion that economic conditions could have real effects on crash rates. This is explored in Chapter 6 of this study.

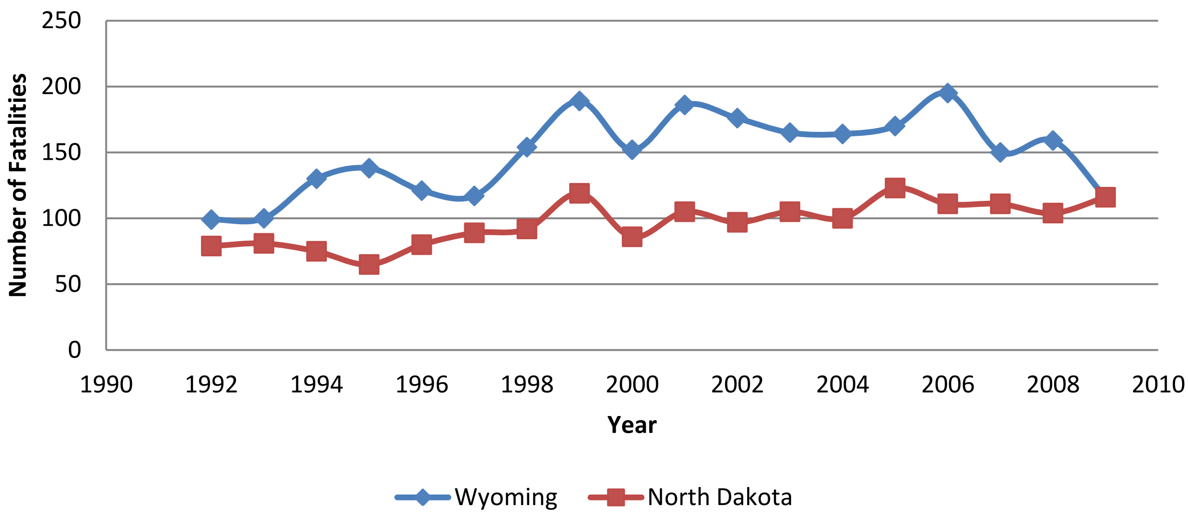

Figure 1-1 Wyoming and North Dakota Fatalities

The original objective of this study was to identify potential reasons for higher fatality rates in Wyoming and to develop recommendations to mitigate those fatal crashes. With the increase in fatal crashes that was discovered in North Dakota and speculation that economic factors could play a role, additional research was initiated to understand if a link existed. A closer look at fatality rates in the two states, normalized per 100 million vehicle miles of travel (MVMT), shows even more of a disparity in the trend. In 2009, Wyoming experienced 1.43 fatalities per 100 MVMT while North Dakota had 1.76 fatalities per 100 MVMT, up 28% from 2008. Figure 1-2 illustrates those trends compared to the national trend for 1998 through 2009.

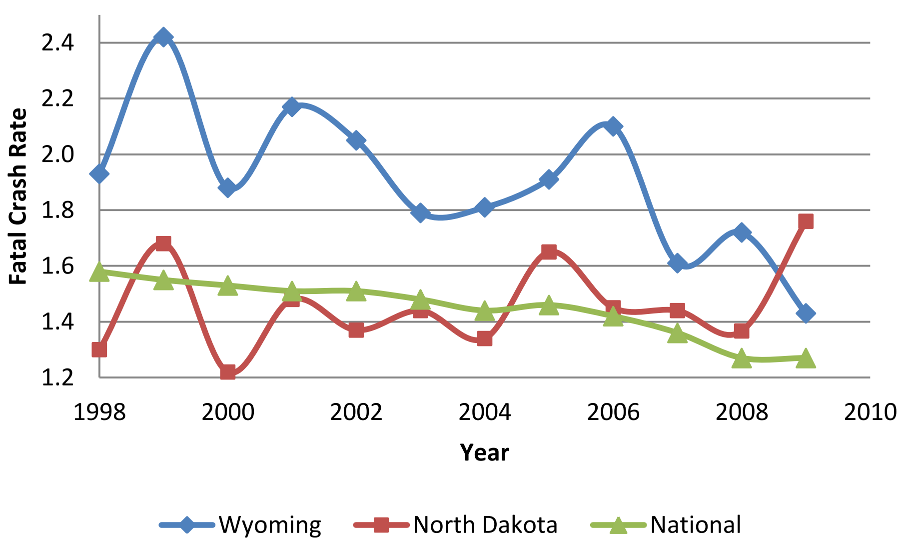

Figure 1-2 Fatality Rate per 100 Million Motor Vehicle Miles Traveled (MVMT)

The national fatal crash rates have been decreasing in recent years while the Wyoming crash rates have been decreasing at an even faster rate. The injury rates in both states have been decreasing as well, aside from some short term increases. Wyoming had higher injury rates than North Dakota for 10 years until 2009 when the two rates cross for the first time. It is most important to recognize in this information that for both injury and fatal crash rates, Wyoming leads. Figure 1-3 shows the injury crash trends from 1998-2009.

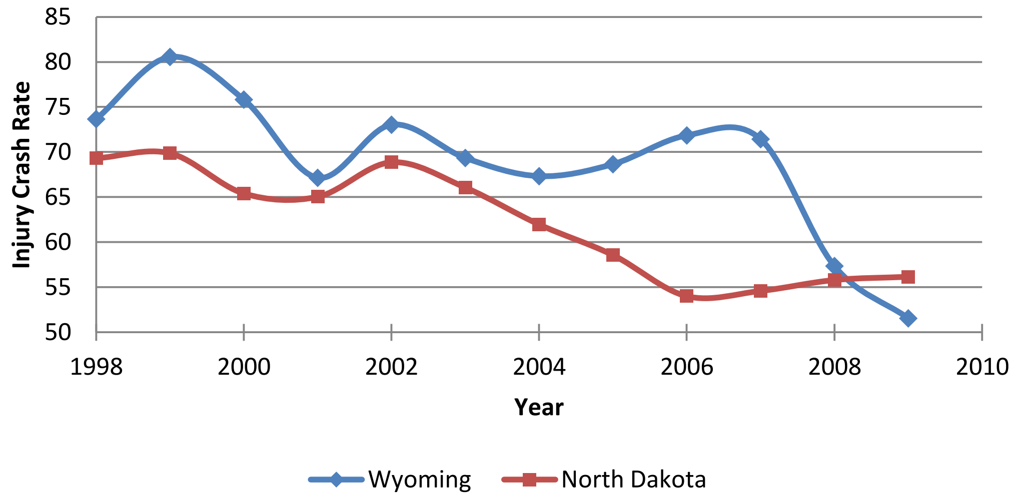

Figure 1-3 Injury Rate per 100 MVMT

When considering that Wyoming has more trips with a higher amount of VMT, it would make sense that there would be more crashes. However, North Dakota has more total crashes than Wyoming, most coming from the Property Damage Only (PDO) severity. Figure 1-4 shows the PDO crash rate in North Dakota and Wyoming. It is evident that North Dakota has more property damage crashes, suggesting that North Dakota has more crashes but they are lower in severity. Figure 1-5 shows the overall total crash rates for both of the states. This graph reiterates the idea that North Dakota has more crashes than Wyoming but the severity is much less. It is this difference in crash severity that prompted this research.

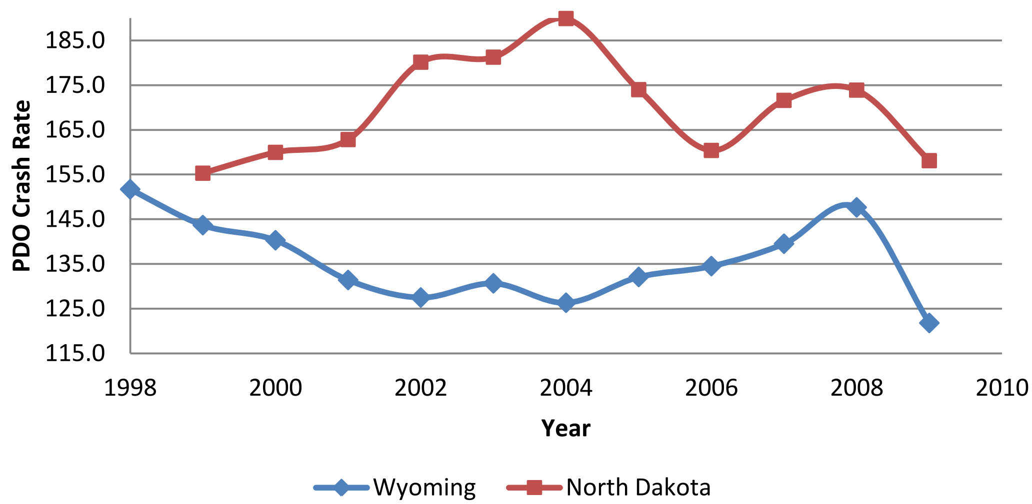

Figure 1-4 PDO Crash Rate per 100 MVMT

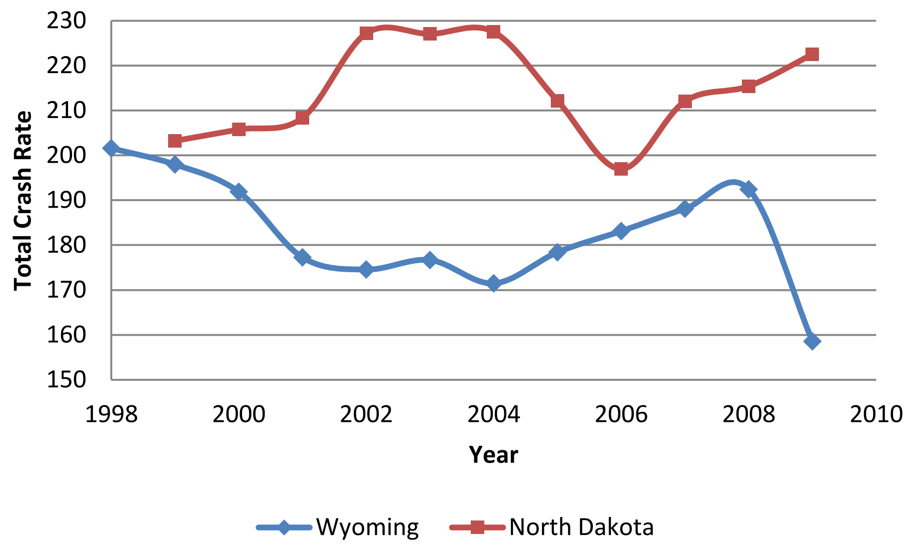

Figure 1-5 Total Crash Rate per 100 MVMT

One area this report explores is different economic factors as contributors to higher crash rates in the two states. Wyoming and North Dakota have different prominent industries and rate very differently in the nation in terms of gross domestic product (GDP) per capita, and employment. The industry breakdown of the two states economies is not similar and the amount of industry per capita is significantly less in North Dakota.

It was also speculated that enforcement could have an effect on the number crashes and Wyoming officials were interested to learn if there were different enforcement practices between the two states that may contribute to the deficits in the fatal crash rates. An investigation into differences in state enforcement practices as well as traffic safety laws and education programs will be included in this report.

1.3 Research Objectives

The main objective of this research is to identify the differences in crash numbers and severity between Wyoming and North Dakota. Potential causes of any differences will be identified in order to provide decision makers with information on the causes of crashes to improve the safety performance of roadways in both states.

The following tasks will ensure the objectives are fulfilled:

- Evaluate crash data from both states to determine differences in crashes between North Dakota and Wyoming.
- Examine the differences between Wyoming and North Dakota crash trends and compare them to traffic law enforcement practices in those states.
- Determine if highway patrol efforts in one state are more effective at mitigating crashes.
- Evaluate the traffic safety laws in North Dakota and Wyoming to determine any critical differences.

- Compare crash trends to economic factors in North Dakota and Wyoming to determine if certain areas of employment can have an impact on crash rates.
- Apply statistical modeling techniques to Wyoming interstates to evaluate the effect that certain identified factors can have on crash severity.

1.4 Report Organization

There are seven chapters in this report. The Literature Review (Chapter 2) contains a description of the background research on law enforcement comparisons, economic crash effects, crash rates, regional research, and logistic modeling. Chapter 3 details the data collection and methods used to attain all of the Highway Patrol, economic, employment, raw crash data, and aggregated crash data. Chapter 4 outlines all of the general information related to the two states: miles of highway, vehicle miles traveled (VMT), and crash statistics as well as modeling techniques used in this report. The differences in safety laws and highway patrol practices are shown in Chapter 5. Economic and employment related evaluations are discussed in Chapter 6. Chapter 7 summarizes all of the findings of the research and a list of recommendations for future implementation.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

This chapter summarizes current methodologies and practices for comparison of crash statistics in different areas. The chapter begins with a discussion of safety research and projects that have been conducted in North Dakota and Wyoming. Secondly, it also contains an exploration of state crash comparisons and methods of normalization. The third section of this chapter includes a discussion of crash regression modeling and methods and practices associated with logistic regression of crash severity. The fourth section explores the uses of enforcement, practices used to evaluate enforcement efforts, and their effect in decreasing crashes. Lastly, this chapter contains a section summarizing the limited research pertaining to the evaluation of economic and employment factors being used to evaluate crash trends.

2.2 Wyoming Strategic Highway Safety Plan

In September, 2006 Wyoming adopted its first Strategic Highway Safety Plan to "create a future direction for a comprehensive and coordinated approach to improving traffic safety by all safety partners in Wyoming." The measure of success of the new safety plan is to be a reduction in fatal and serious injury crashes in Wyoming. It identifies combined and coordinated efforts by all parties as the avenue to success in its primary goal. The Safety Management Systems (SMS) Committee was identified as the steward of the plan which establishes six steps to be carried out in two phases. The first phase consists of three steps that are to be performed by the SMS Committee and focus on identification of area of direction and communication of that direction to safety partners throughout the state. The 4^{th} through 6^{th} steps include developing strategies, action plans, and the implementation of those actions plans (Carlson et. al., 2006).

The Strategic Highway Safety Plan is a comprehensive document that identifies several specific areas of interest for improvement. The areas identified for safety improvement were sorted into three categories: safety emphasis areas, continuing safety areas, and special safety areas. Section I addresses specific areas of emphasis and importance. These areas include roadway departure crashes, safety restraints, impaired driving, and speeding. The areas identified in Section 1 represent the greatest opportunity for reduction in crashes. The plan identifies direction, strategies, recommendations, and potential partners for addressing the identified challenge (Carlson et. al., 2006).

Section II of the plan identifies areas that are already being addressed and that should still maintain emphasis in the future. Some areas included in this section are: intersection safety, bicycle/pedestrian safety, school zone safety, motorcycle safety, and the traffic record system. Section III identifies several programs that do not exist but should be initiated within the state to further accomplish the goals of the safety plan. Some new projects identified in this section are: access control, narrow medians, high risk rural roads, animal vehicle crashes, and visibility improvement. The Strategic Highway Safety Plan is currently under review and some areas have shown improvement while others will take longer to achieve improvements (Carlson et. al., 2006).

2.3 North Dakota Strategic Highway Safety Plan

North Dakota's Strategic Highway Safety Plan is a much larger document and is released on an annual basis. The performance plan outlined in the 2012 highway safety plan includes five steps: problem identification, planning, project selection, monitoring and technical assistance, and annual report. One major difference between Wyoming and North Dakota is that the highway safety plan is updated, evaluated, and released on an annual basis. The North Dakota plan identifies projects and provides annual budgets for those projects as well as an evaluation released on projects that have been completed at years' end. In the 2012 version of the plan, nine performance measures were identified.

Within those performance measures, an overall description of the task is included as well as strategies for improvement, a specific budget, and specific steps needed to complete each step of the performance measure. The performance measures identified within this report are shown in the list below (Ziegler et.al., 2011).

- Planning and administration
- Police traffic services
- Traffic records
- Occupant protection (restraint usage)
- Motorcycle safety
- Speed management
- Youth or young adult
- Community traffic safety projects
- Impaired driving prevention

The performance measures identified in the North Dakota plan are much more specific than the Wyoming plan. Each measure has a specific action plan that includes various agencies and groups around the state. The measures include a budget broken down by project within the performance measure. The total funds allocated for impaired driving prevention in North Dakota in 2012 was $3,631,973. These funds are spread out though media campaigns, overtime enforcement, video camera surveillance, alcohol testing equipment, DUI training, parents LEAD program, and server training curriculum (Ziegler et.al., 2011).

Some focus areas that are different between the two states are that Wyoming does not have a section pertaining to youth safety, or community traffic safety. The youth program includes several educational programs that help to educate young drivers on the dangers of driving and what they can do to be a safer driver. Some programs in this area include enhanced drivers education curriculum, teen media outreach, young individuals establishing logical driving decisions, and driving skills for life programs. Additional descriptions of these programs can be seen in the 2012 North Dakota highways safety plan. The community traffic safety projects included within that performance measure focus on at risk groups such as counties or tribes that may benefit from additional education (Ziegler et.al., 2011).

2.4 Safety Studies

Safety research in North Dakota and Wyoming has only become prominent within the past decade. North Dakota has been the staple of traffic safety research within the Northern Rocky Mountain region. Reports on several programs within North Dakota have been supplied by the Upper Great Plains Transportation Institute. Some of these reports include evaluation of the use of safety survey information, evaluation of the effectiveness of traffic safety corridors, rural traffic safety, and high risk rural roads. North Dakota has also published many public safety briefs on topics including alive at 25 programs, seatbelt usage, teen drivers, and texting while driving.

A report published by the traffic safety office in North Dakota in 2010 entitled “North Dakota Statewide Traffic Safety Survey” uses a mail survey which realized a 31% response rate. The survey asked questions on annual driving activity and perceptions of impaired driving, seatbelt usage, and speeding. The report explores the perceived risk of being ticketed and how often a driver may perform illegal activities. It also asked if more supervised and classroom hours should be required and the overwhelming response was positive. The main results of the study showed that young male drivers were at risk of disregarding the use of seatbelts when driving (Vachel et. al., 2010).

North Dakota has also identified rural roads as a good opportunity for crash reduction around the state. Several recent reports explore areas for crash and safety improvement on rural roads. Safety corridors and education campaigns were implemented for seatbelt usage and it was found that the steps taken in that study had little effect on seatbelt usage in that county (Huseth et. al., 2011). Another report entitled “Rural Traffic Safety in the Northern Rocky Mountain Region Revisited” sought to determine the effect of changes in safety laws since 2006 in the Rocky Mountain region. This report closely analyzes four states in the region comparing their safety plans and the effects on crashes. The report examines the Northern Rocky Mountain Region (NRMR) as a whole and compares its crashes to the national figures.

The findings of that report suggest that fatalities have decreased 6.7% since 2005 and that traffic law changes since then have not been enacted yet or are so new that any changes in safety will not have been felt at this point. It does identify some areas where Wyoming leads the NRMR in terms of safety. Wyoming is the only state in the region to have a no texting law (Huseth et. al., 2011).

Wyoming has also conducted research in the traffic safety field. The Wyoming Rural Road Safety Program has developed a method for identifying high risk rural roads and focuses on low cost, high impact improvements that make those facilities safer (Evans, 2011). There has also been research towards the use of intelligent transportation systems for safety improvement. Variable speed limits, animal detection systems, and high wind warning systems have all been investigated in Wyoming as routes to making highways safer (Ringenberg, 2010).

2.5 Crash Comparison

When performing crash comparisons between two different geographic locations, it becomes very difficult to establish a frame of reference for comparison so that numbers are congruent and represent the same conditions in each state. It was decided to compare different parts of the data provided in this report in different ways due to differences or availability of data. This report uses crash rates for both states as described in the Highway Safety Manual (HSM). In this process crash frequencies are normalized by an exposure variable, in this case million vehicle miles travelled. Different crash severities in both states were represented as a rate so that total crashes could be compared.

Crashes are random events and naturally fluctuate over time because they are random events. This suggests that short term crash frequencies are not reliable sources of comparison and that long term crash trends are hard to approximate with short term data. This means that when a short time of high crash frequency is observed, it is probable that it will be followed by a relatively low crash frequency and vice versa. This tendency is known as regression to the mean (RTM). If a site is selected for treatment based on short term crash frequencies, it is likely that this bias may be present. This RTM bias is especially crucial when evaluating the effectiveness of improvements and should be corrected for. When examining crash data it is important to remember to consider long term trends (HSM, 2010)

2.5.1 Logistic Regression Modeling

There are many forms of regression that are suitable for crash frequency. Crash severity, however, is much more difficult to model unless a different frequency model was to be developed for each severity level; fatal, incapacitating injury, non-incapacitating injury, possible injury, and property damage only. For modeling the probability of specific severity, the logistic regression model is better suited. The logistic regression model uses binary response variables to determine the probability of a certain event given a set of regression variables (Hosmer et. al. 1989).

The logistic regression model has been used to model crash severity in some instances. In a study conducted by the University of Connecticut, researchers explored the use of logistic regression to model all five different severity levels to determine the increased crash severity for seniors. The study was successful in showing that as the population ages the severity levels for senior citizens increases (Mooradin et.al, 2012). This research further shows that the use of logistic regression for severity modeling has been conducted successfully.

2.6 Enforcement and Crashes

Overall, there has been little research evaluating the effectiveness of law enforcement efforts on crash trends. Efforts have been made to evaluate certain aspects of law enforcement and its effect on traffic safety. These are usually localized kinds of efforts on specific problem sections where patrol saturations are used at intervals to determine if traffic speed patterns change depending on the amount of law enforcement present.

One such study, commissioned by the Oregon Department of Transportation, investigated whether a relationship existed between running speeds and law enforcement levels. The study instituted eight week cycles of enforcement. Two of those weeks consisted of enhanced enforcement and six weeks of normal patrols. The study found that on sections where law enforcement was present and higher than it was on a regular basis there was a decrease in speeds. This decrease was not large and the decreased speed never approached the posted speed limit (Haas et al 2003).

Another study conducted in Illinois evaluated the effects of several different speed enforcement techniques in work zones to determine the optimum use of enforcement efforts for those areas. The speed enforcement techniques studied were speed trailers, police with lights on, police without lights on, and speed photo-radar enforcement (SPE). This study determined that the SPE lowered the running speeds the most in work zones and was the most effective (Benekohal et al 2010).

The most extensive study of law enforcement effects on traffic safety was conducted by the National Highway Traffic Safety Administration and was published in 2011. The study investigates the feasibility of collecting traffic safety data from law enforcement agencies to better follow the decreases and increases in law enforcement. Those decreases or increases could then be tracked and studied to better understand the relationship between enforcement and the frequency, rate and severity of crashes. The study identified the same limitations found in this study: that there is currently no collection system or database of traffic information collected by law enforcement agencies. The study identified the information that would be included in a national database of law enforcement agency data (Wiliszowski et al 2011).

Research into the effects of DUI arrests and enforcement on the level of DUI related crashes has shown that there is little relationship between the number of DUI arrests and crash levels. That research suggests that in order to continue to decrease DUI related crashes, different techniques such as public education should be explored (Dula et al 2007). Other research suggests that sobriety checkpoints are an effective way of decreasing alcohol related crashes (Elder et al 2002).

A common theme in all research conducted on the subject is that more research by more states is needed to determine if similar results are found. Often, reports have different findings depending on the method and location. The limited amount of research on traffic enforcement and its effects on crashes, has either failed to show a relationship between enforcement and crashes or the relationship has been insignificant. Furthermore, no research has looked into the possibility of evaluating the enforcement techniques of one state with lower crash rates and comparing those practices to a state with high crash rates, in an attempt to lower crash rates in that state.

2.7 Economic Analysis

There has been little research evaluating the effect of economic activities on highway crashes. Some work has been done using spatial modeling to determine land use and its effect on roadway safety. However, the literature is somewhat silent on the subject of employment and economic factors in resource extraction related industries and its effects on regional crash rates. One report, distributed by the Upper Great Plains Transportation Institute, forecasts the road and infrastructure improvements needed in oil and gas producing counties in North Dakota over the next 20 years (Vashal et.al. 2010)

The study utilized production forecasts, trip forecasts, and traffic analysis to determine the future degradation of the road surface. It then evaluated the current condition of the roadways and forecasted what improvements will be needed to ensure that the roads will be in workable condition in the future. This research focuses on the condition of the roadway and the infrastructure improvements needed to sustain the current and growing traffic rates in the northwest part of the state. There is no mention of the safety effects associated with this increased traffic, only the increased infrastructure needs (Vashal et.al. 2010).

2.8 Chapter Summary

This chapter contained a review of literature pertaining to the highway safety plans in both states. It shows that North Dakota updates its plan every year and is slightly more specific than Wyoming's. It also discusses different methods and considerations pertaining to comparison of crashes. It follows with a discussion of logistic regression modeling and its uses for severity probability prediction.

The chapter also shows the different aspects of the effects of law enforcement on crashes. The final aspect of this chapter investigates employment in certain fields as a cause of crashes. Land use has been investigated, but not specifically mining and construction, as causes for different crash types. Additionally, some literature does exist linking oil and gas exploration to road deterioration, but not to safety.

CHAPTER 3 DATA COLLECTION

3.1 Introduction

Many different types and forms of data were collected for this study including data from four agencies within Wyoming and North Dakota. When seeking, requesting, and selecting data from two different states and so many separate agencies, it becomes very difficult to obtain the exact same information from all sources. This chapter discusses the selection and collection of data used in this study as well as some of the barriers and limitations met when trying to collect the data from two different states.

3.2 General Information

Some descriptive data that was used for this research was collected from national databases to ensure that it came in the same format for both states. Information that was not specific to an area of research, but was used in this report, was collected in this way. This information includes populations, miles of highway, MVMT, and Motor Vehicle Registrations. The Federal Highway Administration has an office dedicated to nationwide highway information called the Highway Statistics Series. This is where information such as MVMT, vehicle registrations, and roadway miles was collected. This site gives the information for each of the 50 states and some provinces. The data used in this study from this website was from 2008. Population data for this research was collected from each state's individual website where they provide this information from the census and for the years in between.

3.3 Crash Data Comparisons

The essential data for all crashes in Wyoming used in this study was exported from the Critical Analysis Recording Environment (CARE 9) database. The State of Wyoming maintains this database so that crashes can be accessed and analyzed from any authorized computer over the internet. The crash data in this database is updated quarterly from the live WYDOT crash database where crashes are originally recorded. The CARE 9 system allows the data to be sorted and filtered by any factor that is recorded at the time of the accident. This is very convenient for the researcher because data is always available at their fingertips. The CARE 9 software allows the user to extract cross-tabulated, frequency, milepost, and hotspot analyses simply by downloading the datasets updated periodically throughout the year. All analysis included in this report is from the 1999-2010 data set, uploaded in August of 2010.

North Dakota crash data was provided by the Upper Great Plains Transportation Institute (UGPTI) with primary contact being through Andrea Huseth-Zosel. Raw data was not available from North Dakota, but it was provided in the aggregated form based upon many sorting factors. This data received from North Dakota includes fatal and total crash data from 2002 through 2009 based on the following categories: gender, age group, driver blood alcohol level, driver seatbelt usage, vehicle type, day of the week, month, and functional classification. All of this data was provided in aggregated cross tabulation reports and the individual crashes were not linked. The absence of linked data for North Dakota made it impossible to perform the logistic analysis for that data.

The Wyoming crash data was then exported from CARE in the same format as the provided North Dakota data. This was beneficial because it allowed for both data sets to be summarized in exactly the same format. There was an issue with normalization of the two data sets so that both states would be compared on an equal baseline. Some techniques were explored such as normalizing by population or VMT but in both cases neither option was suitable for all eight categories. It was then decided to represent the number of crashes as a percent of the total number of crashes in that category. For instance, the percent of total interstate crashes is simply the number of interstate crashes in a state divided by the number of crashes for the time frame in that state. This data was used in the crash comparison section of Chapter 4 and shown in Appendix A.

3.3.1 Logistic Regression Modeling

The crash comparisons between the two states identified several factors within Wyoming that needed to be investigated further. Because severity was identified as a goal in this research plan, it was decided to attempt to model crash severity using regression methods. Logistic regression modeling was selected as the most logical choice for modeling crash severity because of its binary nature. The data for this portion of the analysis was gathered from the CARE 9 system using a frequency analysis that reported all crashes reported in Wyoming from January, 2000 to August, 2010. This method produces all crashes with a reported milepost in the database within the time period.

The data was then exported in a detailed report that recorded 56 fields of data for every crash. Much of the information produced in this report is duplicate or second vehicle events that were left out of this analysis due to the low frequency of second vehicle information. The data then had to be pared down because of low frequencies in some areas. The crash severity was reduced down from the standard fatal, incapacitating injury, non-incapacitating injury, possible injury, and property damage only designations to simply critical and non-critical crashes. The number of vehicles was simplified to single and multivehicle crashes. Weather was sorted into clear and adverse categories where anything reported not clear was given the adverse designation. Crash speed was sorted by crashes at speeds higher than 70 mph and crashes at speeds lower than 70 mph. Sobriety was simply represented as impaired crashes and sober crashes. Surface condition was paired down from ten categories to simply dry or adverse. Vehicle type was sorted into three categories: passenger car, truck, and motorcycle. The simplification of the predictor variables limits the modeling procedure some, but was necessary due to the rarity of some sorts of crashes. For instance, the frequency of emergency vehicle crashes is very low and would not be detected in the modeling process. This facilitated the need for the combination with other categories.

It was also important to consider that the reporting officers do not always have the same ideas of what a category is. One officer may think that a condition is snowing and the next would consider the same weather condition to be sleet or a blizzard. Slight generalities are needed to compensate for this as well as coding complications to make sure the results were as clear as possible. Traffic information was also not provided in the CARE detailed report and had to be added after extraction. Average Daily Traffic (ADT), Average Daily Truck Traffic (ADTT), Vehicle Miles Traveled (VMT), and Truck Vehicle Miles Traveled (TVMT) were added by matching the milepost of the individual crash with the traffic data given for that milepost of the interstate. Once entered, the traffic data was sorted into two groups. Those crashes that occurred in areas where the ADT was above the median ADT were sorted into a different group than those with ADTs below the median.

Null Values and unknown values were transformed to dots (.) for coding purposes and treated as missing data. This allows the statistical program to overlook that category for that crash without eliminating the crash from the data set. A sample of this data can be seen in Appendix B.

3.4 Data for Enforcement Analysis

The data used for the comparison of the enforcement efforts in both states was collected in several ways. Information pertaining to the traffic safety laws in each state was collected from the 2010 Roadmap to State Highway Safety Laws by the Advocates for Highway and Auto Safety. Bond Schedules came directly from the Highway Patrol in each state and some specific laws were researched through each state's regulatory codes pertaining to vehicle laws and punishment for the violation of those laws.

Officials in North Dakota provided the annual reports published by the North Dakota highway patrol and the information available in those reports was gleaned for comparisons. Some of this information includes the number of officers, organizational goals, budgets, crashes activity hours, contacts, violations, and motor carrier operations. Performance measures were also included as ways to determine to progress of yearly goals. This information was provided from 2000 through 2009 in the annual report from each year.

Once all of the North Dakota data was collected, the Wyoming highway patrol was contacted and was very helpful in providing data in the same format as North Dakota. The information in some cases was not available for the entire study period due to changes in the ways data is reported or that it was not reported until a certain time within the study. This section was the most difficult to ensure that the information from both states was representing the same data and not something slightly different. The data was also normalized by population but this did not change the results of study and it was decided to report numbers as the actual observed values rather than an arbitrary rate. All data collected for this portion of the research is shown in Appendix D.

3.5 Data for Economic Analysis

The data for the economic and employment portion of this study was collected primarily from five contributing parties. The first of the five involved collecting crash data from counties identified as having high and low levels of mining. This information for Wyoming was taken from the CARE 9 database just as all other crash data in this study for Wyoming was collected. It was filtered down into the month of the crash and then to the counties used in the study. The data was also further sorted by interstate facilities and non-interstate functional classifications. Following the collection of this data from the CARE 9 database, it was aggregated into quarterly crash frequencies over the 10 year period. This was done so that it would match the same time frame as the employment data, which is published every quarter.

The employment data for Wyoming was obtained from the Wyoming Quarterly Census of Employment and Wages website, which supplies employment data for all fields of employment in all counties in Wyoming since 1999. This information combined with the crash information comprised the dataset used for the employment/crash analysis portion of this study. The North Dakota employment information for the counties was provided from a similar organization as the Wyoming data. The only difference was that the data was an average of the quarterly employment presented as a yearly figure. This left less data for use in the North Dakota comparisons and, combined with low mining levels, it made differences harder to detect.

Crash data from North Dakota was again provided aggregated by the selected counties declared for use in this portion of the study. North Dakota officials gathered the data and forwarded it to Wyoming where it was used in analysis of the crashes linked to construction and mining employment in their respective counties. The fifth contributor of data used in this portion of the research was the Wyoming and North Dakota Divisions of Economic Analysis websites. This information was collected to determine the scale of mining and construction industries within the two states and measure the possible effects on crashes these conditions may have. All data, information, and statistics used in this section of the study can be found in appendix E.

3.6 Chapter Summary

This chapter sets forth the techniques used to collect the copious amounts of information needed in this study. Data was collected from two different states and four different agencies within those states. When data is being collected from so many sources, congruency is always an issue. There were some limitations experienced due to differences in record keeping techniques and changes in the manner used to record data. There were also differences in policy between the two states. North Dakota does not release raw data externally and therefore this research had to be conducted solely from aggregated data sets released from state agencies. This made it impossible to conduct the logistic regression on the North Dakota data. Despite many of the recording and policy differences, accurate, usable, and reliable information was gathered for all portions of this study and it did not hamper the quality of the research or data included.

CHAPTER 4 CRASH COMPARISONS

4.1 Introduction

In order to investigate the differences in both North Dakota and Wyoming crash numbers, several methods of comparison were used to compare all of the data that was available. This chapter provides the crash comparisons, shown aggregated as a percentage of the total, and provides an in depth statistical analysis of crash severity on Wyoming interstates in an attempt to pinpoint specific critical crash factors. A summary of information used to normalize some of the crash details is also provided in this chapter.

4.2 State Differences

It became apparent very quickly that North Dakota and Wyoming have some small differences that needed to be taken into account when doing this comparison. There are physical factors in the two states that set them apart. NHTSA classifies both states in Region 8 and they are similar geographically but there are some differences that cannot be ignored. Wyoming is more wide open, with higher elevations. The population distribution is different in Wyoming because there are not as many local roads and fewer small towns. Some of the information provided in this chapter shows differences between the two states such as population, highway miles, miles traveled, and vehicle registrations.

4.2.1 Population

Population differences between Wyoming and North Dakota are relatively small; Wyoming ranks 50th in population with North Dakota just slightly higher at 48th. North Dakota and Vermont are the only two states that are even comparable with Wyoming in terms of population. For a period, Wyoming was growing at a rate higher than North Dakota and it appeared as though the two might become even, but then in 2009 the North Dakota population began increasing at higher rates. Figure 4-1 shows the population for both Wyoming and North Dakota from 2000-2011. Wyoming and North Dakota are the only two states of similar size with populations of 150,000.

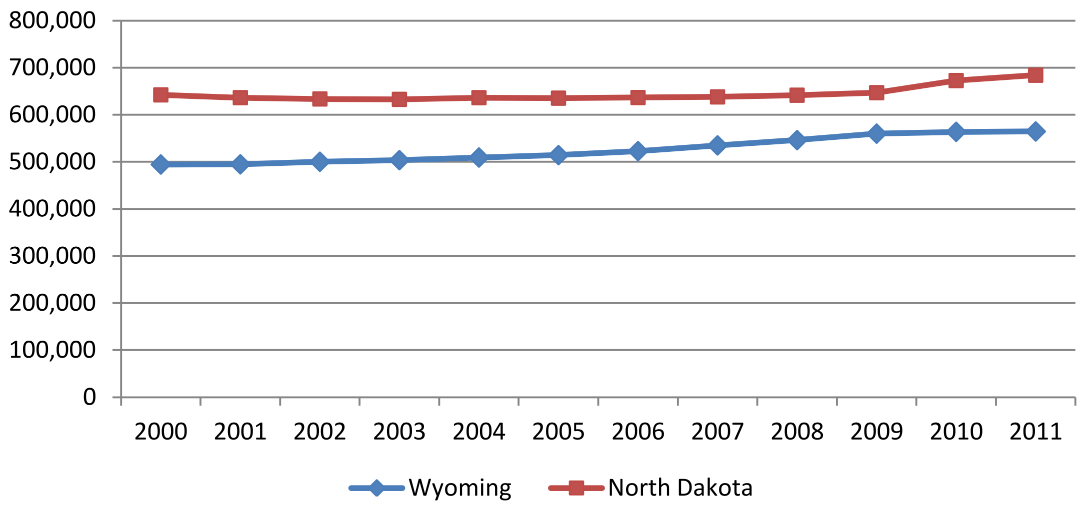

Figure 4-1 Population of Wyoming and North Dakota

4.2.2 Miles of Highway

When a comparison of this nature is initiated, it is standard to check the miles of roadway in each state as the higher number of fatalities could be attributed to the higher mileage of roads. The miles of roadway sorted by functional classification for Wyoming and North Dakota are shown in Table 4-1.

North Dakota has approximately 56,000 more miles of local roadways than Wyoming. It can also be observed that Wyoming has more miles of interstate. There are almost 60% more interstate miles in Wyoming than in North Dakota. This may be cause for concern as a large percentage of the crashes in Wyoming happen on the interstate. Wyoming's higher severity problem may be attributed to the difference in distribution of functional classification. This idea will be investigated further in this report.

Table 4-1 Miles of Highway by Functional Classification

STATE	INTERSTATE	OTHER PRINCIPLE ARTERIAL	MINOR ARTERIAL	COLLECTOR	LOCAL	**TOTAL**
North Dakota	**571**	**3101**	**2812**	**11810**	**68548**	**86842**
Wyoming	**913**	**2204**	**1389**	**11190**	**12410**	**28106**
DIFFERENCE	**-342**	897	**1423**	620	**56138**	58736

4.2.3 Vehicle Miles Traveled

The main differences in roadway miles are that Wyoming has 342 more miles of interstate and that North Dakota has approximately 56,000 more miles of local roadways. Vehicle miles traveled (VMT) is a function of ADT multiplied by the length of the section. It is a measure of exposure by vehicles to driving in a given area. The VMT has increased in North Dakota from 1999 to 2009. Wyoming's VMT has increased in the same period but most of that increase occurred prior to 2003. Wyoming has also experienced roughly 1,000 MVMT more than North Dakota during the period, 22% of those miles being from heavy trucks. Figure 4-2 graphically represents the VMT for Wyoming and North Dakota in the time period.

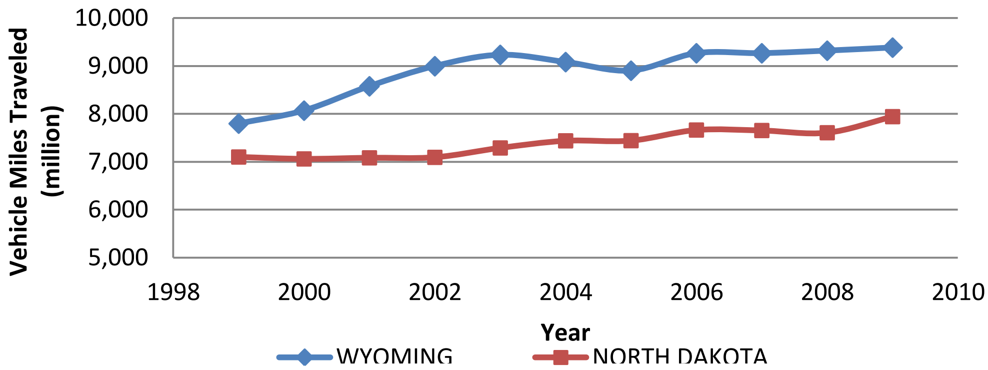

Figure 4-2 Vehicle Miles Traveled in Wyoming and North Dakota

4.2.4 Motor Vehicle Registrations

Another factor considered in the course of this research was the number of motor vehicles registered in each state. Figure 4-3 compares the number of motor vehicle registrations in Wyoming and North Dakota. North Dakota has had significantly more registrations than Wyoming. It seems logical that a state with more vehicle registrations would have more crashes. With more miles of roadway, more vehicle registrations, and a higher population it would seem as if North Dakota should have higher crash rates. This may explain why the North Dakota PDO and total crash rates are higher than Wyoming's, but it still leaves the question of higher fatal and injury crash rates unanswered.

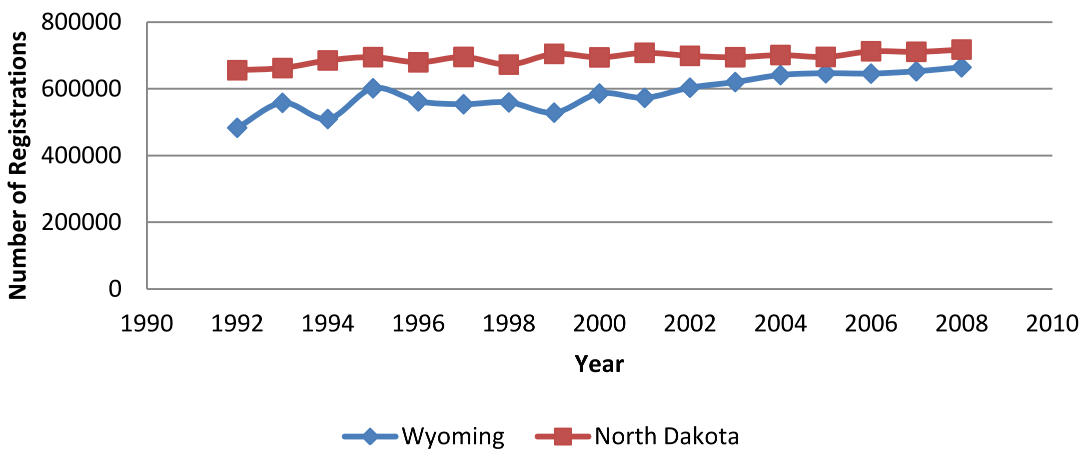

Figure 4-3 Motor Vehicle Registrations in Wyoming and North Dakota

4.3 Aggregated Crash Comparison

Crash data provided from North Dakota was aggregated into total and fatal crashes as well as many categories. It was requested that some comparative categories be provided so that crash comparisons between the two states could be conducted. Crash data was provided in two categories: fatal crashes and total crashes. The time period included in the comparisons was from 2002-2009. This does not quite match the time period for some of the other sections in the study, such as the enforcement comparisons, but it was a time period when data was most reliable and accurate. The data was aggregated in several ways for the overall crash comparisons. Some categories included: day of the week, seatbelt usage, functional classification, gender, month, age group, and impaired status.

4.3.1 Day of the Week

When looking at the total crashes in Wyoming compared to those in North Dakota based on the day of the week from 2002-2009, it becomes very apparent that both states have a similar crash distribution on each day. Figure 4-4 illustrates the number of fatal and total crashes in both Wyoming and North Dakota sorted into bins for day of the week. The crash figures here are shown as a percentage of the total number of crashes from the time period. The top chart shows the total number of crashes including fatal, injury, and PDO. The bottom chart shows the fatal crashes for comparison. It is observed that in both Wyoming and North Dakota a larger percentage of all crashes happen on a Thursday, a difference of more than 15%. For both states fewer crashes happen on Saturdays.

In terms of fatal crashes, the day by day distribution between the two states is somewhat different. Wyoming leads in fatal crashes on the weekends: Fridays, Saturdays, and Sundays. Both states have nearly the same percent of fatal crashes on Mondays and Tuesdays. North Dakota sees more fatal crashes on Wednesdays and Thursdays. Fridays and Saturdays may be ideal targets for a reduction in Wyoming fatal crashes.

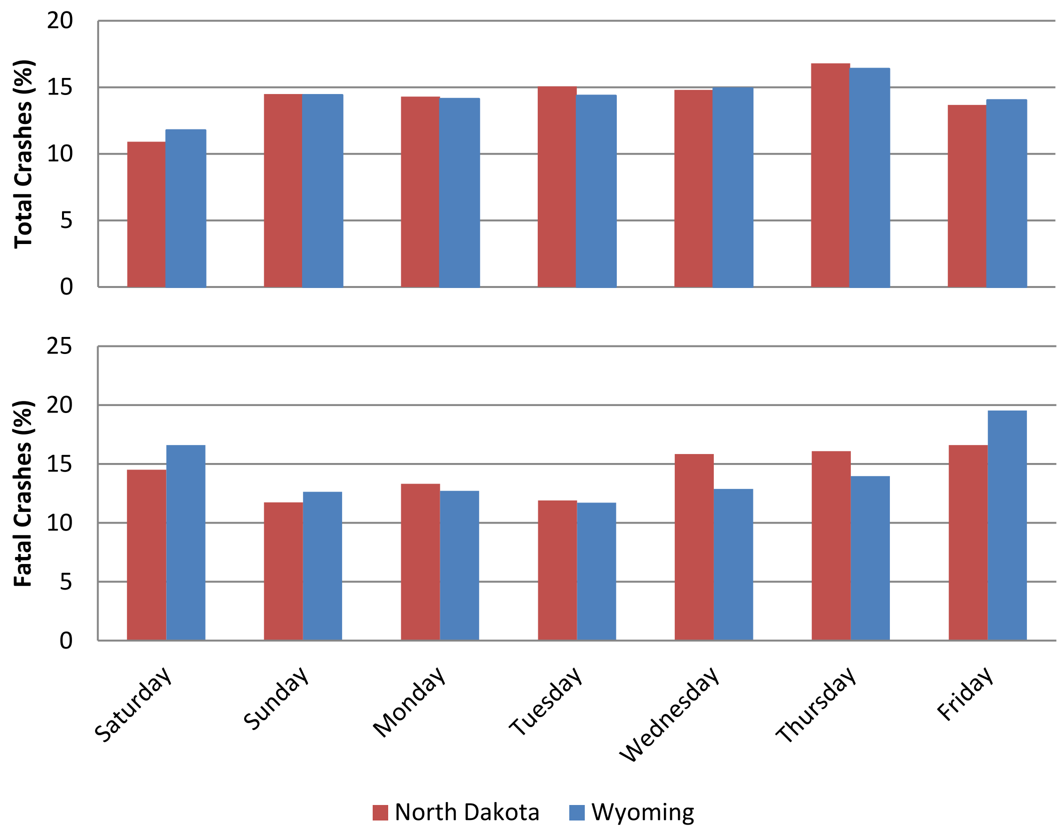

Figure 4-4 Crashes Based on Day of the Week in Wyoming and North Dakota

4.3.2 Seatbelt Usage

Seatbelt usage is an important factor to consider. In Wyoming, 89% of all crashes that occurred between 2002 and 2009 recorded seatbelt usage in the incident. This equates to 12,000 crashes in that time period where a seatbelt was not used. North Dakota shows less seatbelt usage across all crashes at 76%. Seatbelt usage in fatal crashes is much less common. In both states, a smaller percentage of people used seatbelts in fatal crashes than did those in non-fatal crashes. Wyoming shows almost double the seatbelt usage in fatal crashes. This information shows that seatbelt usage is a key factor in crash severity. Figure 4-5 shows the fatal and total crashes related to seatbelt usage.

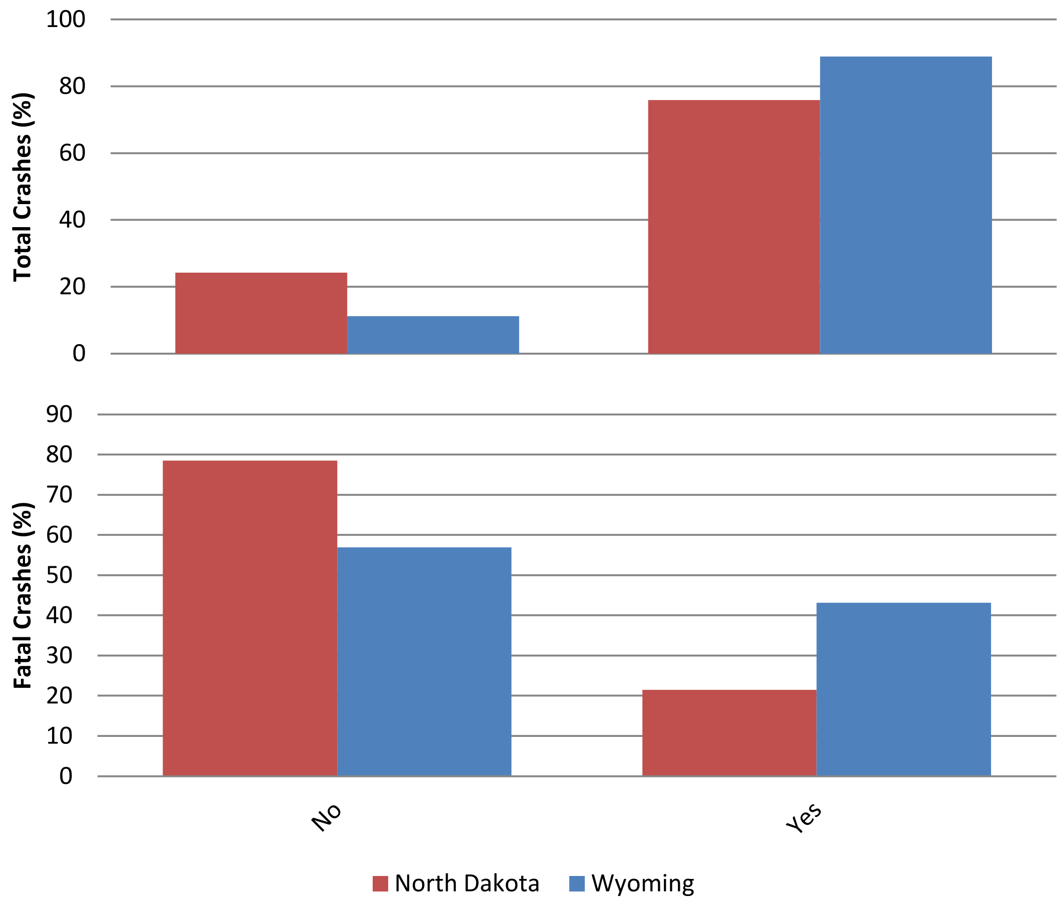

Figure 4-5 Crashes Based on Seatbelt Usage in Wyoming and North Dakota

4.3.3 Functional Classification

The differences in miles of roadway when sorted on functional classification are quite large in a few areas. Wyoming has more interstates while North Dakota has more local roads and minor arterials. It might be expected that crash distribution in those areas would reflect those differences. Wyoming has 72% more crashes on rural interstates than North Dakota. It can also be observed that most of the crashes in both states happen on interstates and arterials. North Dakota has more crashes on rural local roads than Wyoming, but this is most likely due to the fact that North Dakota sees more traffic on those facilities. Figure 4-6 shows the crashes by functional classification for both fatal and total crashes.

The fatal crash information is more evenly split in terms of urban and rural crashes. Severity of crashes is lower in urban areas. In Wyoming only 12% of fatal crashes occur in urban areas. Crashes on interstates are a major cause for concern in Wyoming, while crashes on local roads make up the largest percentage of crashes in North Dakota.

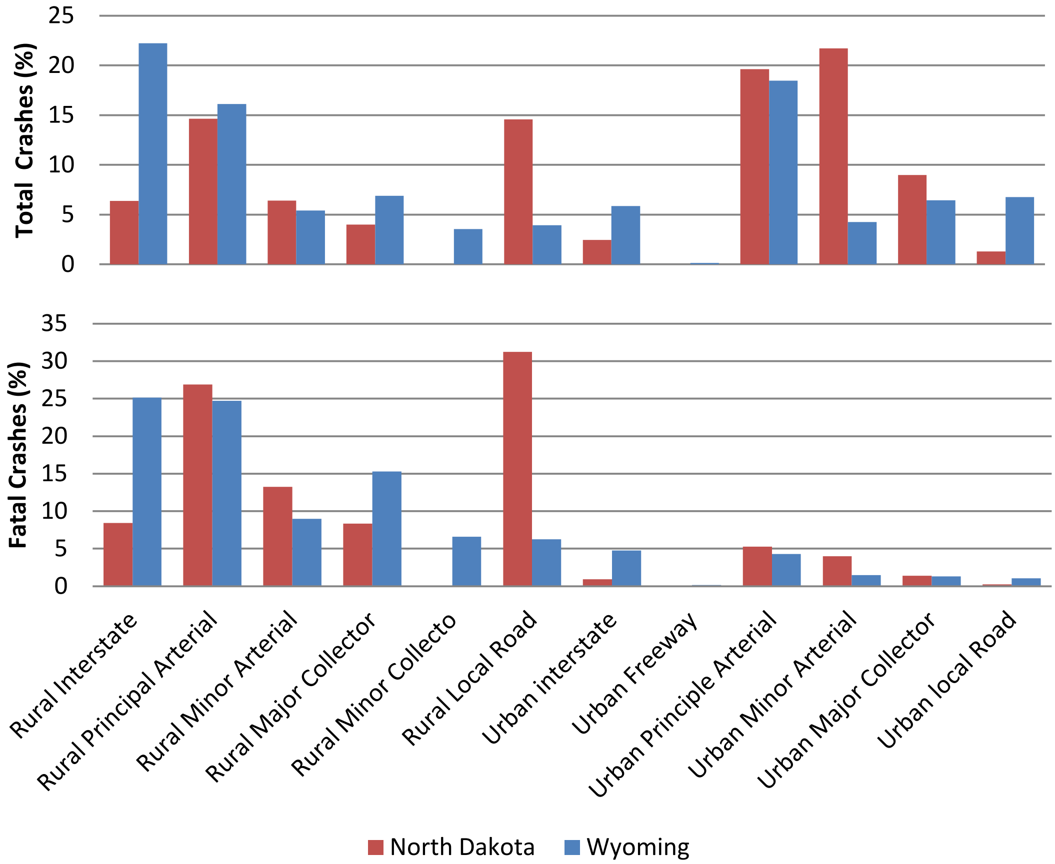

Figure 4-6 Crashes Based on Functional Classification in Wyoming and North Dakota

4.3.4 Gender

When the aggregated crashes are sorted by the gender of the drivers, it is evident in both states that females experience less crashes than males. Wyoming has approximately 5.8% more total crashes involving males than North Dakota. The same is true for fatal crashes. Wyoming also had more fatal male crashes than North Dakota. Figure 4-7 illustrates the number of fatal crashes and total crashes for male and female drivers in Wyoming and North Dakota between 2002 and 2009. In both states, it might be surprising to see males make up almost three quarters of fatalities. This could be due to higher levels of exposer by male drivers. If the reason for more male crashes is not an increased number of trips by males, education may be needed to show that males are at higher risk of a crash.

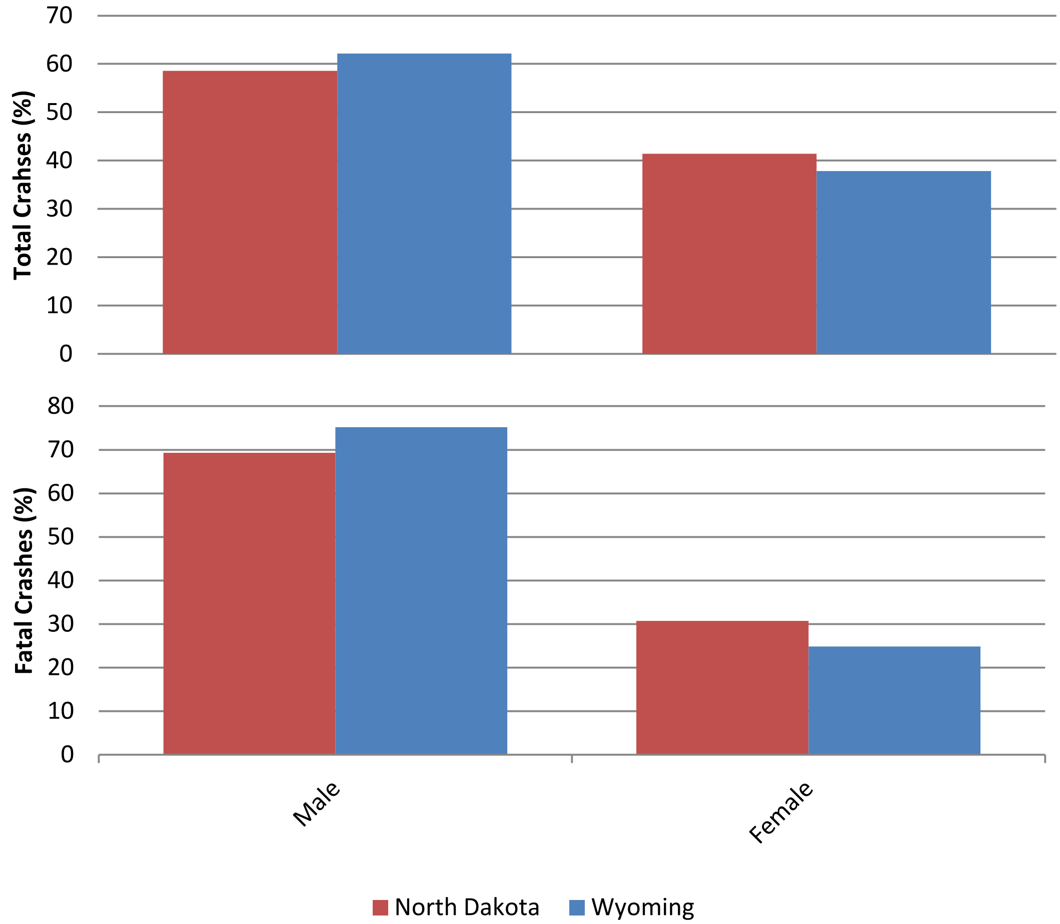

Figure 4-7 Crashes Based on Gender in Wyoming and North Dakota

4.3.5 Month

The percentage of total crashes in each month in Wyoming and North Dakota are similar. North Dakota incurs slightly more crashes in the winter months: November, December, and January. Wyoming has a larger proportion of its crashes in July and August. In both states, a larger percentage of all crashes occur in the winter months. In regard to fatal crashes, the monthly distribution is quite different. Figure 4-8 shows the number of crashes occurring in each month for both states from 2002-2009.

The months with the smallest percentage of fatal crashes are January and February where both Wyoming and North Dakota saw less than 6% of their fatal crashes. The months with larger proportions of fatal crashes include June, July, and August, with Wyoming achieving 15% and 23% more fatal crashes in July and August, respectively. North Dakota has higher fatal crash percentages in September and October before decreasing to 8% of its fatal crashes happening in each of the last two months.

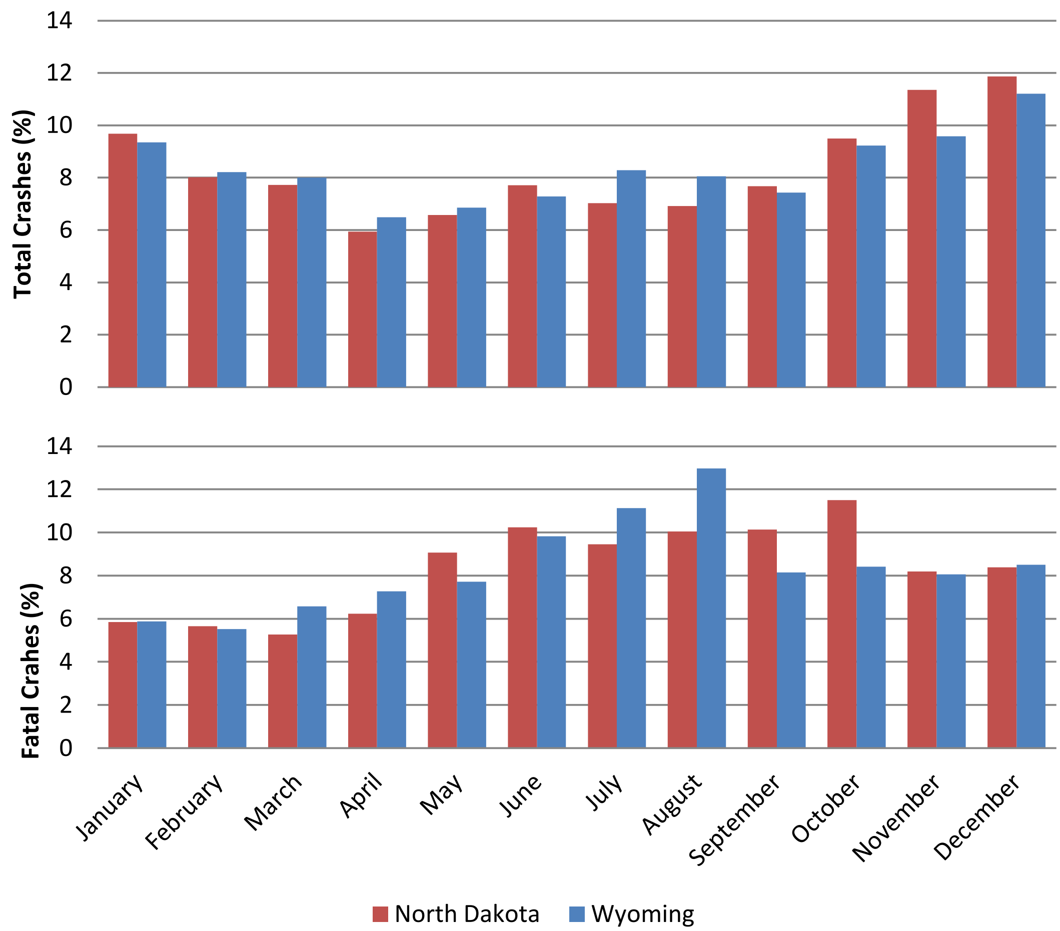

Figure 4-8 Crash Distribution Based on Months of the Year

4.3.6 Age Group

Drivers under the age of 25 caused almost 30% or approximately 60,000 crashes from 2002 to 2009 in Wyoming. North Dakota experienced slightly more crashes among younger drivers than Wyoming, but as a proportion both states have nearly twice as many crashes amongst younger drivers than any other category. The age group comprising the least amount of total crashes was the oldest with 4% in North Dakota and 3% in Wyoming. Figure 4-9 shows fatal and total crashes per each age group from 14 to 75+. It also shows the number of registered drivers in those age groups for North Dakota and Wyoming.

Drivers under the age of 25 make up slightly less of the fatal proportions than they did the total crashes. They still, however, cause a significantly higher percentage of the fatal crashes than the percentage of registered drivers in that age group. The age groups over 25 years all have lower crash percentages than the percentage of registered drivers, aside from Wyoming for the 26-35 age group and North Dakota for the 75+ group. North Dakota experienced a larger amount of its crashes in the two groups over 66 than Wyoming. It may also be important to note that as far as fatal crashes are concerned, the age groups from 55-75 years old are less than the percentage of registered drivers in both states.

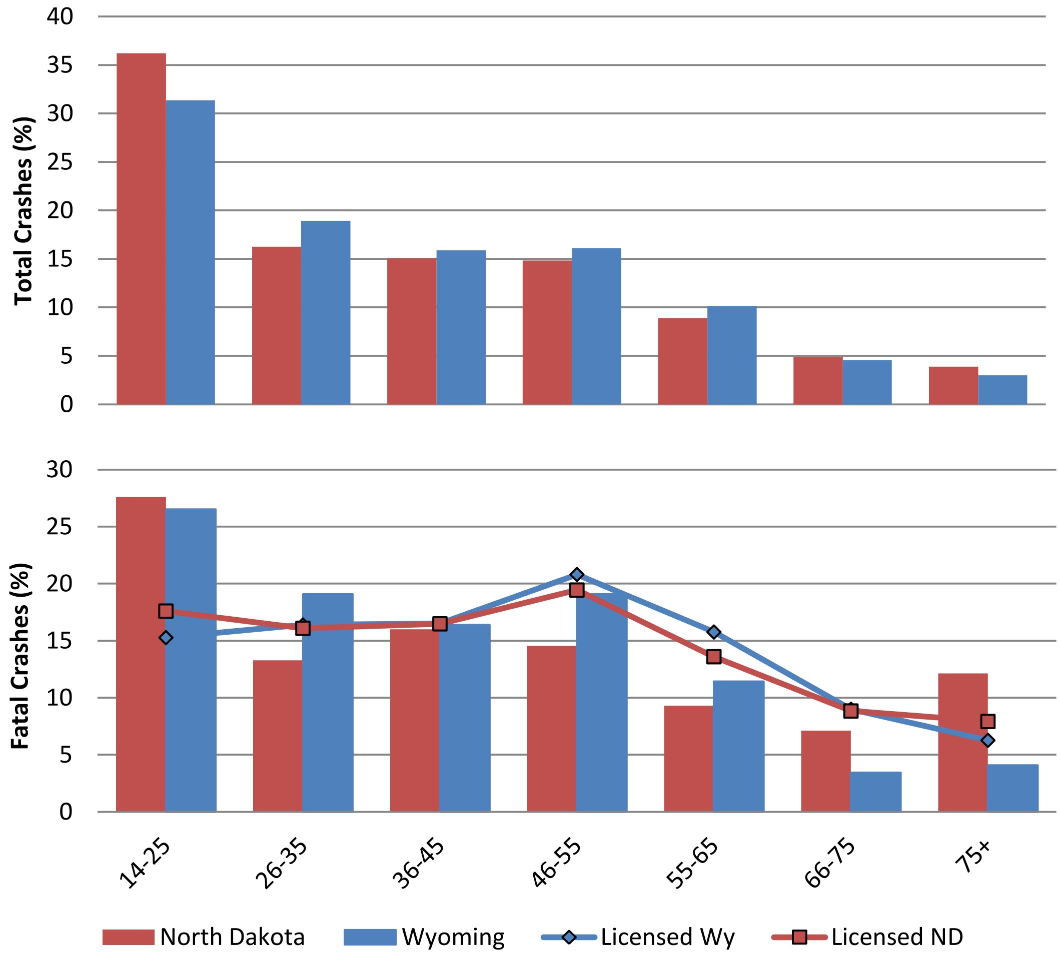

Figure 4-9 Age Group Crashes

4.3.7 Impaired Driving

It is well known that impaired driving is dangerous and many countermeasures have been put into place in both states to insure drivers do not drive impaired. Wyoming and North Dakota differ from each other slightly in terms of the percentage of crashes involving impaired drivers. Figure 4-10 shows that the percentage of total crashes happening in both states with some sort of impairment is less than the percentage of fatal crashes involving impairment.

A very small percentage (4-7%) of total crashes involve impaired people. When it comes to fatal crashes, the percentages are different. Impairment was a factor in 38% of crashes in Wyoming and 36% of crashes in North Dakota. The change in the proportions of impaired driver involvement in fatal and non-fatal crashes in both states is overwhelming. With DUI enforcement already an identified and stated goal of the Wyoming Highway Patrol, it is important to continue to seek opportunities for mitigation of impairment related crashes.

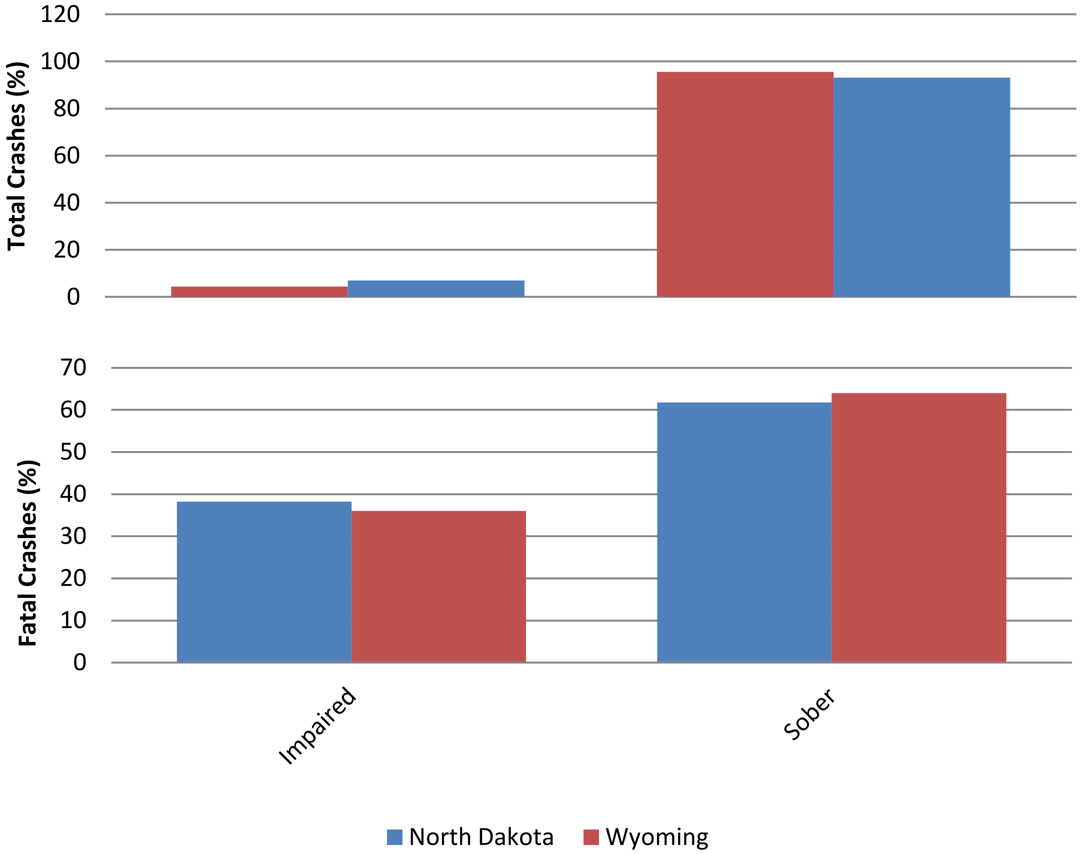

Figure 4-10 Crashes Based on DUI

All data provided in this section was extracted from the database in the aggregated format. It represents aggregated data from 2002 through 2009 in both states. Due to the nature of the method for extraction of aggregated data, some data loss occurs due to null or unknown values. Crash values in this section, or Appendix A, may not equate to crash numbers represented elsewhere in this report.

The method in this section is useful for a visual representation of different categories and to compare both states. Because all years were totaled, this evaluation does not take into effects certain events that could have happened within one of the years in the analysis period. For example, a natural disaster, implementation of a highway safety plan, or law change would not be detected in this method. It was also difficult to determine an adequate level of significance at which to compare the two states. It did reveal that Wyoming has more fatal crashes on interstates and this notion will be the basis for the next level of analysis.

4.4 Logistic Regression

Regression modeling is used to establish a connection between an outcome and one or several indicator variables. For the purpose of this research, it would be beneficial to identify factors associated with higher severity crashes. This model would show statistically which types of crashes as well as certain environmental factors that relate to higher severities. The use of regression analysis will allow the researcher to establish which factors are the most important. If these sorts of relationships could be established, it would allow policy makers to prioritize projects and tailor them to fit the needs of the roadway.

The logistic regression model is similar to the linear regression model. Both are obtained by seeking a best fit to describe the relationship between an outcome and a set of independent covariates. The primary distinction between these two methods is that the response or dependent variable in logistic regression is binary or dichotomous. The logistic regression model could be applied to crash data with a response of crash or no crash to assess the probability or likelihood of a crash. However, modeling the likelihood of a crash is difficult due the fact that there is no record of crashes that do not happen. Because of the non-existence of data pertaining to the crashes that do not happen, the response was established as a critical crash against a non-critical crash.

4.4.1 Data Selection

In this study, it was found that Wyoming has more fatal crashes on interstate highways, so an exploratory model of fatal crashes on Wyoming interstates would be logical. Interstate 80, which runs east and west across the southern half of the state, was selected because of the traffic volumes, and availability of data. It was found that out of over a 100,000 crashes, that occurred in Wyoming from 2002 through 2010, one-fifth occurred on Interstate 80. With so many of Wyoming crashes occurring on Interstate 80, this highway was a good fit for use with the logistic regression model.

The CARE 9 system produces a detailed report of crashes by milepost on selected routes that includes many fields of information. One of these detailed reports was used to create the data set for this model. It was later found that these reports have some limitations and those will be discussed near the end of this chapter. Severity was selected as the outcome rather than frequency since the premise of this study was to determine avenues for the reduction of fatal crashes. Instead of modeling only fatal crashes against all others, critical crashes were modeled against non-critical crashes.

The covariates selected for the model were those included in the detailed report from CARE. Exposure factors as well as location and identification information were included in addition to specific crash details. Covariates included in the model were: number of vehicles, lighting conditions, time of day, weather, speed, road surface condition, age, gender, vehicle type, and sobriety. Each variable was coded for use within the statistical software program entitled Statistical Analysis Software (SAS). Some of those variables were split out in terms of age group, allowing for the model to determine if separate ages were a factor in crash severity rather than analyzing age a continuous variable. The same was done for vehicle type. A separate variable was used for motorcycles and trucks to see if they affect the model separately. For instance, the model may not include trucks as a variable but motorcycles may be included based on the method of analysis. Table 4-2 gives all of the variables, identifiers, and codes assigned to each one.

Table 4-2 Parameters Included and Assigned Coding

Variable Name	Column Heading	Code/ Value
Response	Severity	1 = Fatal crash 1 = Incapacitating injury 0 = Non incapacitating injury 0= Property Damage Only
Milepost	Milepost	Miles
Average Daily Traffic	ADT	0 = Below mean 1 = Above mean
Average Daily Truck Traffic	ADTT	0 = Below mean 1 = Above mean
All Vehicle Miles Traveled	AVMT	0 = Below mean 1 = Above mean
Truck Vehicle Miles Traveled	TVMT	0 = Below mean 1 = Above mean
County	County	County Name
Number of Vehicles	Vehiclesm	0 = Single vehicle crash 1 = Multi-vehicle crash
Lighting Conditions	Lighting	0 = Daylight 1 = Dark
Time	Time	Hours
Weather Conditions	Weather	0 = Clear 1= Adverse
Speed	Speedm	0= <70 mph 1 = >70 mph
Surface Condition	Condition	0 = Dry 1 = Wet, snow, sand, etc.
Age	14-25 26-35 36-45 46-55 56-65 66-75	1= Driver is this age 1= Driver is this age 1= Driver is this age 1= Driver is this age 1= Driver is this age 1= Driver is this age
Gender	Gender	0 = Female 1 = Male
Vehicle Type	Known Truck Known Motorcycle	1= Vehicle is this type 1= Vehicle is this type
Sobriety	Sobriety	0 = Sober 1 = Impaired

4.4.2 Interstate 80 Crash Model Building

A forward stepwise selection process was used to select to covariates that were significant enough to be included in the model. P values represent the probability that the test statistic is comparable to the observed value. The significance level of 0.05 is the most commonly used value in transportation engineering and so it was used for this study. This model-building tool selects variables with the lowest p values and incorporates them into the model. In order to enter the model, the p values for that variable must be lower than 0.10. This process continues until an added covariate's p value once entered in the model is above a given predetermined limit of .05, then that term is removed from the model. This process stops once no more covariates are selected. When the selection process was run, all variables were included, as well as certain interaction terms between those variables. The final model selection produced the I-80 model with the following variables in this order:

1. Sobriety
2. Motorcycle
3. Condition
4. Speed
5. Truck
6. ADT
7. Lighting
8. Gender
9. Vehicles
10. ADTT
11. Lighting*Gender (Interaction Term)

Once the variable selection process has been completed, coefficient estimates are obtained. The logistic regression model produces coefficients for use in the logit function that can be seen in Equation (1) .

The logit function is then used in the logistic regression transformation that modeled the

$$\boldsymbol{g(x) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n} \qquad (1)$$

probability that the outcome will be a critical crash, as seen in Equation (2).

$$\boldsymbol{\hat{\pi}\,(x) = \frac{e^{g(x)}}{1 + e^{g(x)}}} \qquad (2)$$

When these two functions are combined, they show estimated probability of a critical crash. The model developed for the I- 80 data set can be seen in Equation (3).

$$\boldsymbol{\hat{\pi}[y] = \frac{e^{-2.423-.51L-.54C-.33G-.26ADT-.16ADTT+.21V+.72Sp+1.77S-.34T+2.17M+.38L*G}}{1 + e^{-2.423-.51L-.54C-.33G-.26ADT-.16ADTT+.21V+.72Sp+1.77S-.34T+2.17M+.38L*G}}} \qquad (3)$$

Each of the variables used in the model had to be further abbreviated to allow for simplicity. The following list describes and the meaning of the various variables:

- L =Lighting
- C = Road Condition
- V= Number of Vehicles
- Sp = Speed
- T = Truck
- M = Motorcycle
- G = Gender
- S = Sobriety

The predicted model demonstrates which factors are significantin the probability of a critical crash. This model considers the impact of the variables simultaneously on this probability. Some of the coefficients do not represent values that would necessarily be intuitive but when considered in the context of the model they become more logical. The complete representation of computer output of descriptive statistics, coefficients, model selection, and odds ratios can be found in Appendix C.

4.4.3 Interpretation

The development of a linear regression model of crash severity can be useful in many aspects. The logistic regression model uses the method of maximum likelihood to estimate the parameters of the multiple logistic response function. The maximum likelihood estimates (b_0, b_1, $b_2, \ldots,$ $b_{p\text{-}1}$) are the best estimates of the betas and are used as the coefficients in the equation (3). The model predicts the probability of the occurrence of an event. In the case of the model developed in this study, the model estimates the risk of experiencing a critical crash when a crash occurs. If a crash is going to occur, the model will estimate the probability that it will be a critical crash.

Table 4-3 shows the parameter estimates given in equation (3). If an estimate is negative, it means that the effect of that parameter would lessen the estimated probability of a critical crash. For example, the estimate for road condition is -0.542, meaning that in this model, taking into account the existence of the other variables, the likelihood of a critical crash would decrease if the surface condition is not dry. One would think that more crashes should happen if the surface condition was adverse. This may be true but is not reflected in this model because this method of logistic regression has no relation to total crash frequency, only to severity. This by no means suggests that less work should be done to clear the roads during times of adverse road conditions, just that it has no effect in increasing the probability of a critical crash. This also could reflect other factors as well. It could mean that the roadways are simply closed when the road surface conditions are adverse enough to increase the severity. It also may show that drivers are more cautious during adverse surface conditions, thereby reducing the probability of a critical crash.

Table 4-3 Intestate 80 Parameter Estimates and Odds Ratios

Parameter	Maximum Probability Estimate	Odds Ratio
Intercept	-2.423	
Lighting	-0.51	
Condition	-0.542	0.851
Gender	-0.339	
ADT	-0.265	0.767
ADTT	-0.159	0.853
Vehicles	0.213	1.237
Speed	0.728	2.072
Sobriety	1.77	5.927
Truck	-0.354	0.708
Motorcycle	2.167	8.737
Lighting*Gender	0.385	

There are other factors which decrease the estimated probability of a critical crash that at first glance seems counterintuitive. Lighting, surface condition, gender, ADT, ADTT, and trucks all decrease the probability of a critical crash on I-80. It must be remembered that it only decreases the likelihood of a critical crash and that these factors effects on crash frequency may be very different. As can be found in Table 4-2, female drivers are coded as 0 and males as 1. This means that the critical crash likelihood is higher for female drivers than male drivers.

It can also be seen in Table 4-3 that factors with positive estimates increase the likelihood with an increase in that parameter. The parameter estimate for sobriety is 1.77 which means that when the crash event involves impairment it is more likely that it will be a critical crash. The odds ratios quantify the effects in a similar way. Similarly if a motorcycle is involved, the estimated probability of a critical crash is 8.7 times more likely to be critical than if no motorcycle is involved. The odds ratio for speed means the estimated probability of a critical crash is 2.07 times more likely to be critical if the speed is higher than 70 than below 70. This may be a reflection of urban and non-urban areas as well. In urban areas the speed limit on interstates is usually decreased below 70 mph for some reason or another, whether it is geometrics or higher volumes. So although there is no urban or rural variable in the model, there still may be variables that indirectly reflect those conditions.

An interaction term is also included in the model meaning that gender and lighting do not affect the probability of a critical crash separately. When interpreting the effects of one of those variables, the other must be considered. Thus the probability of a critical crash is higher when a male is driving at night. Notice that the gender and lighting parameters are negative, but the interaction parameter is positive. This shows that an adjustment must be made when both of these terms are used so that they do not always have a decreasing effect on the critical crash probability. Several other interaction terms were evaluated, but no other significant interactions were found. The output for the Interstate 80 model can be found in Appendix C.

4.4.4 I-25 Model

The same modeling procedure was employed for Interstate 25, and was used to compare with the I-80 model. The motivation behind using the logistic regression model was to determine the factors that were affecting crash severity to be able to pinpoint specific areas for safety improvement statewide. It was identified earlier in the study that interstates were a facility on which Wyoming had significantly more crashes than in North Dakota. Through the development of the I-25 model, it was found that both interstates were similar in their parameter characteristics. Table 4-4 shows the parameters selected in the forward stepwise selection process for Interstate 25. The selected parameters are basically a subset of the I-80 model. The estimates are also very similar to the I-80 estimates. The variables appear to differ only in areas where the traffic characteristics change. No interaction terms were significant in the I-25 model, and some of the variables in the I-80 model were not included in the I-25 model.

Table 4-4 Interstate 25 Parameter Estimates and Odds Ratios

Parameter	Maximum Likelihood Estimate	Odds Ratio
Intercept	-2.378	
Lighting	-0.269	0.763
Gender	-0.305	0.737
ADTT	-0.448	0.639
Speed	0.726	2.067
Sobriety	1.994	7.351
Motorcycle	2.358	10.578

Some notable variables in the I-25 model were sobriety and motorcycles. The model shows that if a motorcycle is involved, the crash is estimated to be 10.5 times more likely to be critical and if impairment is involved, the crash is estimated to be 7.4 times more likely to be critical. These two odds ratio estimates are both higher than on Interstate 80. One reason for this increase for motorcycles could be that I-25 is the primary route used to commute to Sturgis. There is an annual motorcycle rally in Sturgis, South Dakota. This is a very good indication that the regression modeling process is detecting individual road variances and showing the areas of concern specific to each facility. This type of analysis could prove very powerful in detecting areas for improvement specific to highway system, individual route, geographic location, or traffic type.

The model shown in equation (4) represents the probability of a crash being critical on I-25 when a crash occurs. The abbreviations of the variables for the I-25 model are as follows:

- L =Lighting

- Sp = Speed
- M = Motorcycle
- G = Gender
- S = Sobriety

The model indicates that speed, sobriety, and motorcycle usage all increase the probability of a critical crash, while lighting, gender, and ADTT decrease the probability of a critical crash. The I-25 model uses less variables but the estimates for those variables that are included are similar to the estimates for I-80 aside from ADTT, and it is close to the sum of the estimates of ADT and ADTT for the I-80 model. Both models are similar enough to show what areas are of concern and where emphasis should be placed. The complete output related to the I-25 model is provided in Appendix C.

$$\hat{\pi}[y] = \frac{e^{-2.38-.27L-.31G-.44ADTT+.72Sp+1.99S+2.35M}}{1+e^{-2.38-.27L-.31G-.44ADTT+.72Sp+1.99S+2.35M}} \quad (4)$$

4.4.5 Limitations of the Models

Logistic regression modeling can sometimes be difficult with small sample sizes. Fortunately, both I- 80 (20,309 observations) and I-25 (8,817 observations) had enough observations that sample size was not a concern. It is also important to remember that the results of the model should always be interpreted within the context of the model building process. All parameters and odds ratios were developed with the other variables in consideration. If a model was to be developed using only one variable, the parameter estimate and odds ratio would not be the same, and would ignore the impacts of the other variables on the response and one another.

When the modeling was started, only variables presented in the CARE detailed report were used. It became evident late in the process that certain factors were left out of that report. Some factors of importance to safety officials were not considered in this analysis. Safety belt usage, emergency response time, cell phone usage, and roadway geometrics would all be very important factors for consideration when considering crash severity. The models developed in this study explore some of the most critical crash factors, but is not completely inclusive. It would beneficial to develop a way to include this additional information for use in future models.

4.5 Chapter Summary

In this chapter, many aspects of crash analysis were explored. Vehicle miles traveled, population, highway miles, vehicle registrations, and registered drivers by age group were all compared in an attempt to see how similar the two states really are. While North Dakota leads in roadway miles, population, and vehicle registrations, Wyoming has the edge in vehicle miles traveled. This is a peculiar reversal that was unexpected especially when compared to the number of fatalities and total crashes.

When a comparison of aggregated crash data was conducted, some fatal crash trends became more evident. Wyoming has a higher percentage of its fatalities on the rural interstate highways whereas a higher percentage of lower severity crashes happen on urban roads. The general age group of Wyoming fatalities is younger than North Dakota and fatalities amongst young drivers (14-25 years) in both states are still much higher than the percentage of exposure. Because Wyoming fatalities were higher on interstates, it was decided that an in-depth statistical analysis should be conducted on those facilities to help pinpoint critical crash factors.

The logistic regression function used in the analysis of specific factors was used to determine several areas for improvement on interstate facilities in terms of critical crashes. Sobriety, motorcycles, and speed were the most influential in increasing the probability of a critical crash when an incident occurs. This shows that education or other countermeasures could be helpful in those areas to reduce the severity of overall crashes. This modeling process also indicated some additional factors that should be included in future efforts.

CHAPTER 5 ENFORCEMENT ANALYSIS

5.1 Introduction

Wyoming and North Dakota are similar geographically and in population. North Dakota has only slightly more people with an average population from 2000-2009 of 650,000. The effects of enforcement on crashes have been debated and this chapter investigates the differences between the two states. It will look at traffic safety laws as well as citations, contacts, and hours spent patrolling in an attempt to measure and compare the amount of enforcement in both states. Only state patrol enforcement was compared; in some instances, information reporting was inconsistent between the two states and was not available.

5.2 Traffic Safety Laws

Traffic safety laws in Wyoming and North Dakota differ only slightly from each other simply because the Federal Highway Administration mandates compliance in order to qualify for funding. The driving under the influence laws are very similar, but a detailed evaluation of slight differences in both states is outlined. Impaired driving laws were the most different of all of the laws. The first offense of driving under the influence (DUI) is punishable in North Dakota with a fine of at least $250 and an order for an addiction evaluation. Wyoming's punishment can be up to 6 months imprisonment, a fine of at most $750, and an order for a substance abuse evaluation.

The second offense of impaired driving in Wyoming earns a minimum sentence of 7 days and a maximum of 6 months to be determined by a judge. North Dakota dictates a minimum sentence of 5-days imprisonment in minimum security facility where 48-hours must be served consecutively, or 30-days community service. There is a definite difference in sentencing, and one can see that Wyoming's code is much harsher than that of North Dakota. The fine in Wyoming is at least $200 and at most $750. Compared to North Dakota's minimum of $500, Wyoming's minimum fine is less, but can be greater. For a second offense to be considered consecutive in North Dakota, it must occur within 5 years of the first. In Wyoming, a second offense can be considered consecutive if it occurs within ten years of the first offense.

For the third offense in North Dakota, a minimum of 60 days in prison or minimum security detention center is mandated as well as a fine of $1000. For Wyoming, a minimum of 30 days in jail but no more than 6-months is specified as well as a fine of $750 to $3000. This shows the penalty for the third offense is greater for Wyoming than North Dakota.

Fourth and subsequent offenses for North Dakota require a 180 day detention time and a $1000 fine. Wyoming requires a fine of up to $10,000 and a prison term of up to 2 years. These sentences are also accompanied by ignition interlock device consequences for life in Wyoming for the fourth sentence, but no ignition interlock is mandated in North Dakota.

5.3 Roadmap to State Highway Safety Laws

The Advocates for Highway and Auto Safety recently published the 7th Annual Roadmap to State Highway Safety Laws. Every year, an evaluation is performed on 15 state laws that the advocates feel are essential in helping every state effectively save lives, prevent injuries, and reduce health care and other costs. The laws are based on government and private research, crash data and states' experience.

Advocates have determined the following traffic safety laws to be priorities in reducing motor vehicle deaths and injuries. States are only given full credit if their law meets the optimal provisions as defined below. Half credit is given to states with booster seat, some teen driving, and some impaired driving laws that only partially meet the advocates' definition.

Section 1:Adult Occupant Protection

1) Primary Enforcement Seat Belts
2) All-Rider Motorcycle Helmets

Section 2: Child Passenger Safety

3) Booster Seats

Section 3: Teen Driving (GDL)

4) Minimum Age 16 for Learner's Permit
5) 6-Month Holding Period
6) 30-50 Hours Supervised Driving
7) Nighttime Driving Restriction
8) Passenger Restriction
9) Cell Phone Use Restriction
10) Age 18 for Unrestricted License

Section 4: Impaired Driving

11) Ignition Interlock Devices for All Offenders
12) Child Endangerment
13) Mandatory BAC Testing
14) Open Container

Section 5: Distracted Driving

15) All-Driver Text Messaging Restriction

5.3.1 Laws in Place

The report shows that Wyoming currently has only complied with 4 of the 15 recommended laws, and is half compliant in 3 others. Gaining a point apiece for laws in which Wyoming is fully compliant and a half of a point for partial compliance, Wyoming's overall rating, out of a possible 15, was 5.5 points. Wyoming is not partially compliant in eight other laws. The advocates have listed Wyoming as being a RED state. This means Wyoming is dangerously behind in the adoption of the advocates' recommended laws. As noted, there are more regulatory safety laws that are not on the advocates' top 15 laws. Wyoming has a few other key safety laws in place,

The report shows that North Dakota currently has only complied with four of the laws, and is half compliant in one other. North Dakota's overall rating, out of a possible 15, was 4.5 points.

The advocates' have listed North Dakota as being a RED state. This means North Dakota is dangerously behind in the adoption of the advocates' recommended laws. Table 5-1 shows the overall safety rating by the advocates including all laws and recommendations. Table 5-2 shows the progress that Wyoming has made towards compliance.

Table 5-1 The Advocates for Highway and Auto Safety Overall Safety Rating

OVERALL RATING BASED ON NUMBER OF SAFETY LAWS (out of 15 possible points)		Meets Compliance* WY	ND
	Primary Enforcement Seat Belt Law		
	All-Rider Motorcycle Helmet Law		
	Booster Seat Law	Yes	Half
Teen Driving Laws	Minimum Age 16 for Learner's Permit		
	6 Month Holding Period		Yes
	30-50 hours Supervised Driving	Yes	
	Nighttime Restriction	Half	
	Passenger Restriction	Yes	
	Cell Phone Restriction		
	Age 18 for Full License		
Impaired Driving	Ignition Interlock for All Offenders	Half	
	Child Endangerment Law	Yes	Yes
	Mandatory BAC Test	Half	Yes
	Open Container Law		Yes
	All-Driver Text Messaging Restriction		
	Total Credit for Number of Laws 2009	5.5	4.5
	Overall Safety Rating 2009	RED	RED
	*Yes = Law Currently Being Implemented by State (1 point)		
	*Half = Law does not fully satisfy recommendations (0.5 pts)		
	RED: State falls dangerously behind in adoption of key laws		

Table 5-2 Status of Key Wyoming Safety Laws

Safety Belt Law	Yes, secondary enforcement
Administrative license revocation	Yes
0.08 BAC *per se* law (Section 163)	Yes
Zero tolerance for drivers < age 21	Yes (0.02)
Graduated licensing	Yes
Open Container (Section 154)	Yes (Note: Not compliant with Section 154)
Repeat Intoxicated Driver Laws (Section 164)	Partial (Note: Not compliant with Section 164)
Child Safety Seat Law	Yes
Booster Seat Law	Yes

5.3.2 Laws Needed

There are some general laws that differ between each state. Child restraint definitions are different in each state. In North Dakota, a passenger is considered a child if they are under the age of 12. This means that if a teenage driver meets all of the weight and height requirements is using a safety belt, it is recorded as a child restraint citation rather than a seatbelt citation. In Wyoming, child restraint laws and citations pertain only to those children eligible for the use of supplementary seats and restraint systems.

Both states are compliant with a small number of the traffic safety laws recommended by the Advocates for Highway safety. Each state is listed as "red" meaning that they are behind in the adoption of the recommended Safety laws. Below is a list of laws that each state will need to enact before being declared compliant.

The laws that Wyoming needs to enact to be completely compliant are:

- Primary Enforcement Seat Belt Law
- All-Rider Motorcycle Helmet Law
- GDL - Minimum Age 16 for Learner's Permit
- GDL - 6-Month Holding Period Provision
- GDL - Nighttime Restriction Provision**
- GDL - Cell Phone Restriction Provision
- GDL - Age 18 for Unrestricted License
- Ignition Interlock Law for All Offenders**
- Mandatory BAC Test Law - Drivers Killed**
- Open Container Law
- All-Driver Text Messaging Restriction

** Law that Wyoming partially complied with

The laws that North Dakota needs to enact still to be completely compliant are:

- Primary Enforcement Seat Belt Law
- All-Rider Motorcycle Helmet Law
- Booster Seat Law Through Age 7**
- GDL - Minimum Age 16 for Learner's Permit
- GDL - 30-50 Hours Supervised Driving Provision
- GDL - Nighttime Restriction Provision
- GDL - Passenger Restriction Provision
- GDL - Cell Phone Restriction Provision
- GDL - Age 18 for Unrestricted License
- Ignition Interlock Law
- All-Driver Text Messaging Restriction

**Law that North Dakota is partially complied with

(Safety, Advocates for Highway and Auto)

5.4 Organizational Goals

The highway patrols of both Wyoming and North Dakota have been very helpful in providing the necessary information needed to complete this study. Both states provided information on citations, hours spent patrolling, budgets, and number of sworn officers. A detailed look into the specific goals of each of the organizations was also conducted to determine any differences. The objectives of the Wyoming Highway Patrol are laid forth every year in their annual report. The 2010 annual report lists those objectives as follows:

I. Reduce Highway Fatalities
II. Reduce (Driving While Under the Influence) D.W.U.I.s
III. Increase Employee Satisfaction
IV. Maximize Service to the Public

These objectives indicate that the foremost concern of the Wyoming highway patrol is to reduce the number of fatalities on highways within their jurisdiction. They have over the past several years seen a reduction in fatalities to a 15 year low as can be seen in Figure 1-2. Whether or not that reduction can be attributed solely to the highway patrol and not to other efforts within the Wyoming DOT is unknown.

The North Dakota Highway Patrol objectives are much broader and all-encompassing than the objectives set forth by Wyoming. The use of such a broad guiding statement allows them to be more flexible and change their road patrolling tactics as they see fit. The North Dakota objective is stated as follows: "The primary objective for field operations personnel is to ensure that citizens can safely travel on our state's highway system." In 2009 when the spike in highway fatalities became apparent, they began patrolling more frequently and increased patrol saturations in rural areas. This is just one example of how adaptable the North Dakota Highway Patrol has been.

5.4.1 Sworn Officers

The first area of comparison of the highway patrol programs in Wyoming and North Dakota was determining the number of officers in each state's employ. The technical term for the number of highway patrolmen is "number sworn." Figure 5-1 shows the number sworn for each state between 2002 and 2009. Over that time period, the number of officers in Wyoming has grown while the number of officers in North Dakota has stayed relatively even. In fact, the only reason that the number of officers in North Dakota is changing from year to year is because the turnover of officers; not because of hiring changes.

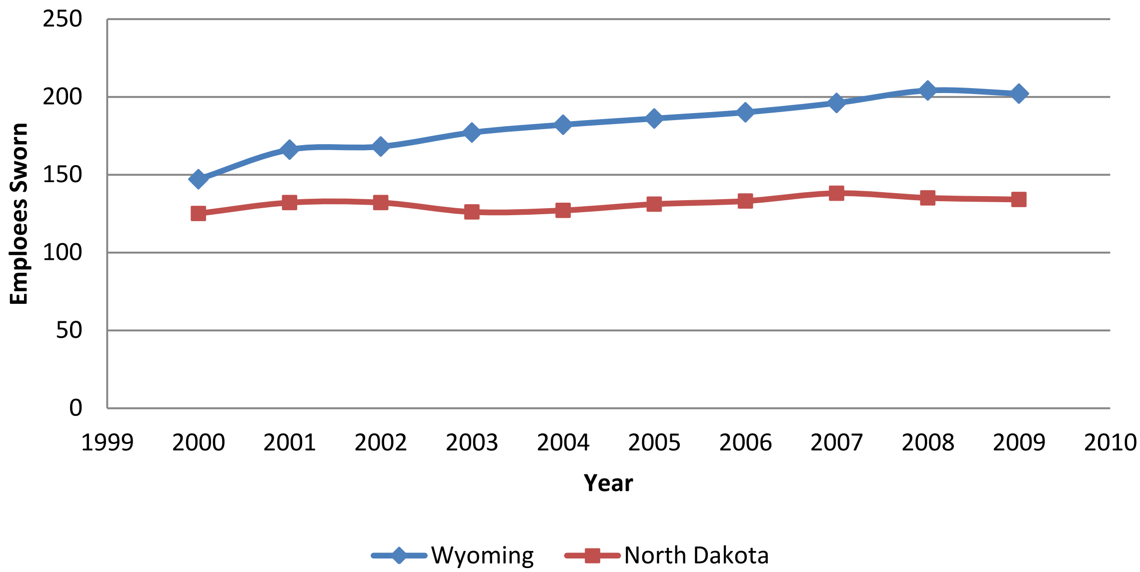

Figure 5-1 Sworn Officers in Wyoming and North Dakota

5.4.2 Hours Spent Patrolling

The amount of time spent by each of these officers on the road is also a concern. Data on the number of hours spent patrolling was provided by each state. Wyoming provided the data as an actual number of hours as well as the number of administrative hours to show what percentage of departmental time was actually spent on the roads. North Dakota provided data for the first five years in an actual hour figure and the rest of the years were provided as a percent of the patrolmen's time spent on the road enforcing. Figure 5-2 demonstrates the number of total hours spent patrolling in the field for both Wyoming and North Dakota in relation to the number of sworn officers.

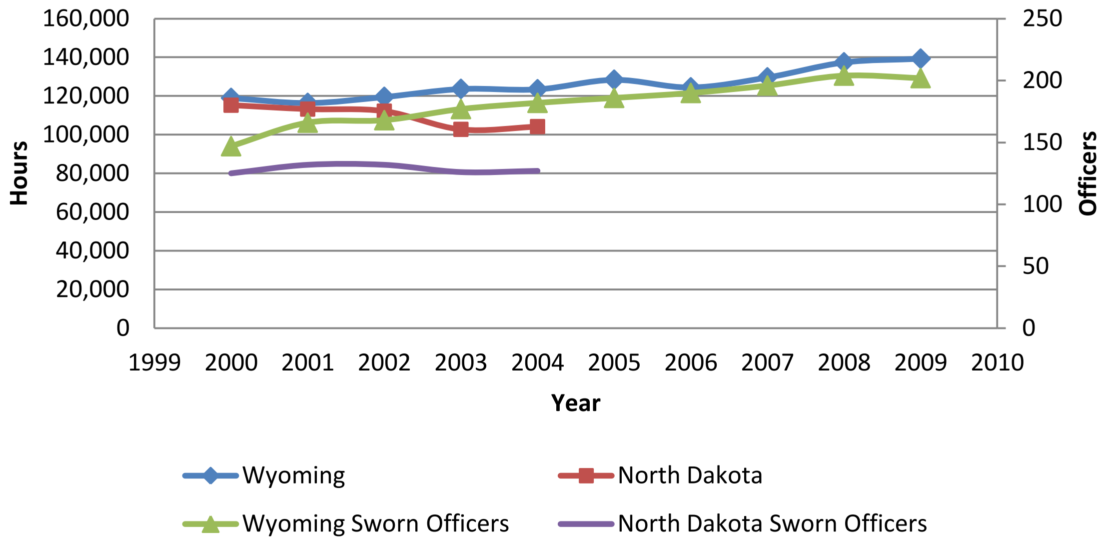

Figure 5-2 Hours Spent Patrolling in Wyoming and North Dakota

Wyoming patrolmen spend more hours on the road than North Dakota but with more officers and less saturation. Figure 5-3 shows the hours as a percent of the patrolman's time spent patrolling. This allows a look into the effectiveness of the use of each officer's time. It shows that North Dakota spends many more of the patrolman's hours on the roadway than Wyoming does. There are some limitations to this procedure because the North Dakota percentage shows only the time of the patrolman whereas the Wyoming figure is a percentage of the total department's time including truck enforcement and port of entry employees.

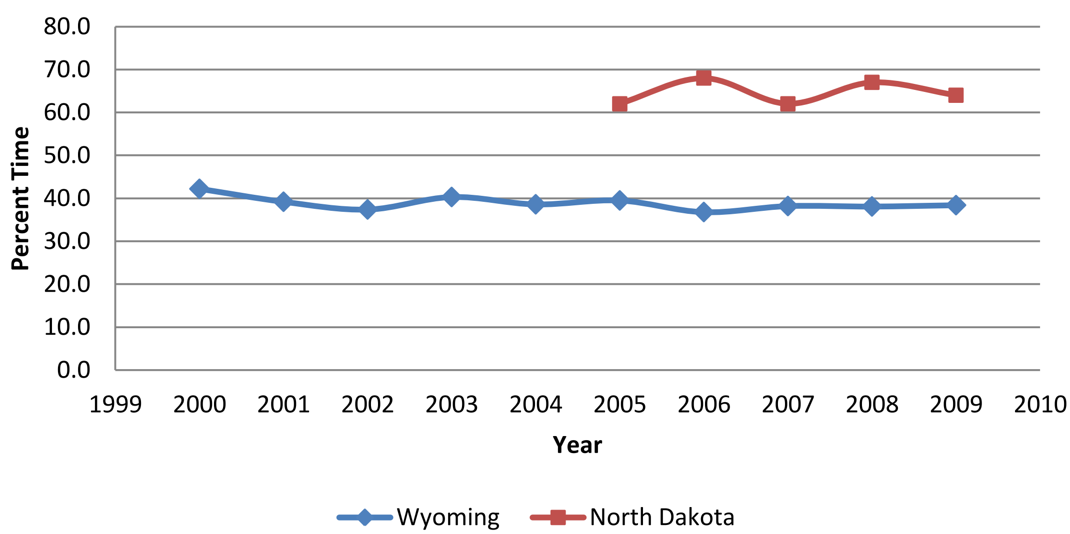

Figure 5-3 Percent Time Spent Patrolling in Wyoming and North Dakota

5.5 Citations

This section presents a comparison of the number of citations each state's highway patrol has given over the past 10 years. Some things to keep in mind are the fact that North Dakota employs a point system for some offenses. For some citations, the first fine is zero and a point or several points are added to the violator's record with serious consequences happening after multiple points have been added. If 6-12 points are accumulated, a driver's license will be suspended, depending on the driver's age.

5.5.1 Contacts

Highway enforcement officers preform many duties in the course or their work. Wyoming and North Dakota record every act performed by a highway patrolman as a contact. Contacts can consist of citations, warnings, highway assists, crash investigations, motor carrier inspections, and service calls among other duties. This section compares the amount of contacts in certain areas between the two states.

During the study period, Wyoming consistently averaged 31% more contacts per year than North Dakota. This averages to over 66,000 more citations a year. Figure 5-4 shows the number of contacts in Wyoming and North Dakota over the study period of 2000-2009. The amount of contacts for Wyoming increased in that period by 19% which is expected due to the increase in VMT as well as number of officers on the roadway. North Dakota saw no increase in contacts over the ten year period.

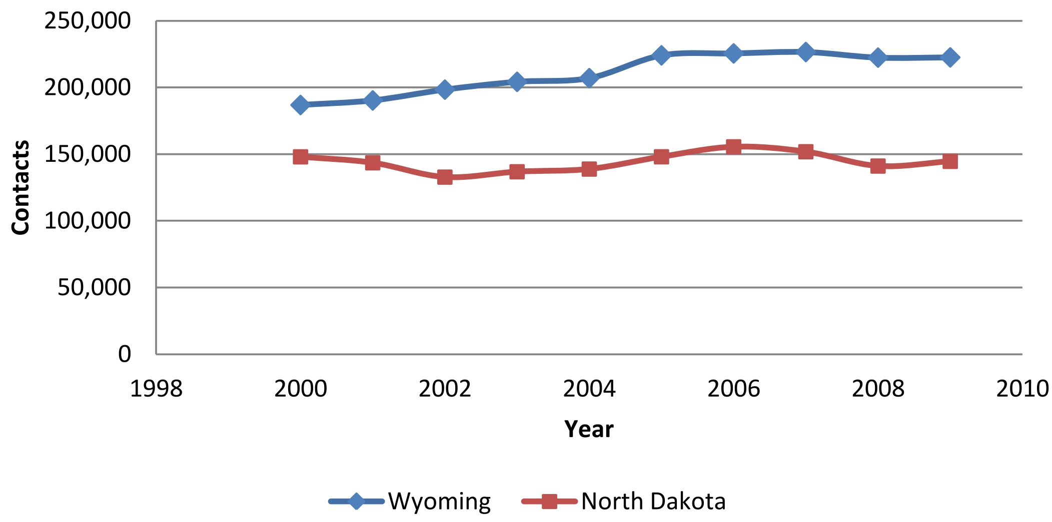

Figure 5-4 Total Contacts in Wyoming and North Dakota

5.5.2 Speeding Citations

Figure 5-5 summarizes the speeding citations in both states. In 2009, Wyoming issued 15,588 more speeding citations than North Dakota, which was the largest difference in speeding citations between the two states. Wyoming cited more drivers for speedinng than North Dakota every year of the study. North Dakota has been decreasing the amount of citations issued since 2003. When comparing speed laws between the two states, it is clear that North Dakota has more stringent restrictions on speeds for intersections and railroad crossings where sight distance is obstructed. In North Dakota, a speed limit of 20 miles per hour is required where sight may be obstructed. Wyoming does not have this specific language but rather includes in section 31-5-302 that a superintendent may lower the speed limit based on an engineering and traffic investigation. Wyoming also includes a provision in 31-5-301 d that speeding violations less than six miles per hour over the posted speed limit shall not be made a part of the records kept by the department of transportation. Those citations are accounted for in Figure 5-5, but not included on permanent records.

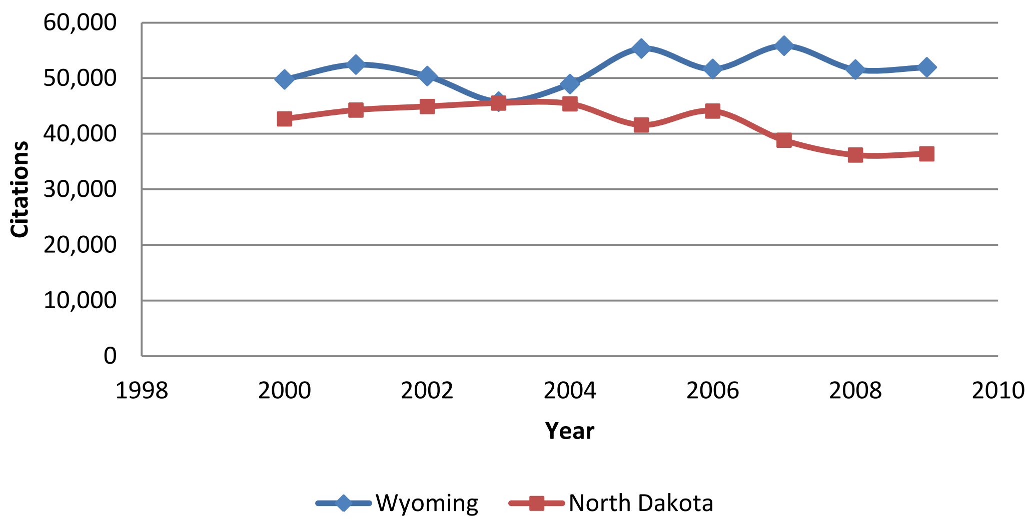

Figure 5-5 Speeding Citations in Wyoming and North Dakota

5.5.3 Impaired Driving Arrests

As can be seen in Figure 5-6, starting in 2001, North Dakota began making more driving under the influence (DUI) arrests than Wyoming. Since that year, North Dakota has made consistently more arrests for drunk driving than Wyoming has. During this time period, Wyoming and North Dakota both had 36% of fatalities linked to a blood alcohol level at illegal levels, i.e. above a blood alcohol percentage of .08%. Both states impose laws for certain levels of punishment for and what constitutes driving under the influence as can be seen in section 5.2. In 2008, Wyoming had 47% of fatalities linked to suspected alcohol usage and North Dakota had 50% of fatalities suspected to be linked to alcohol usage.

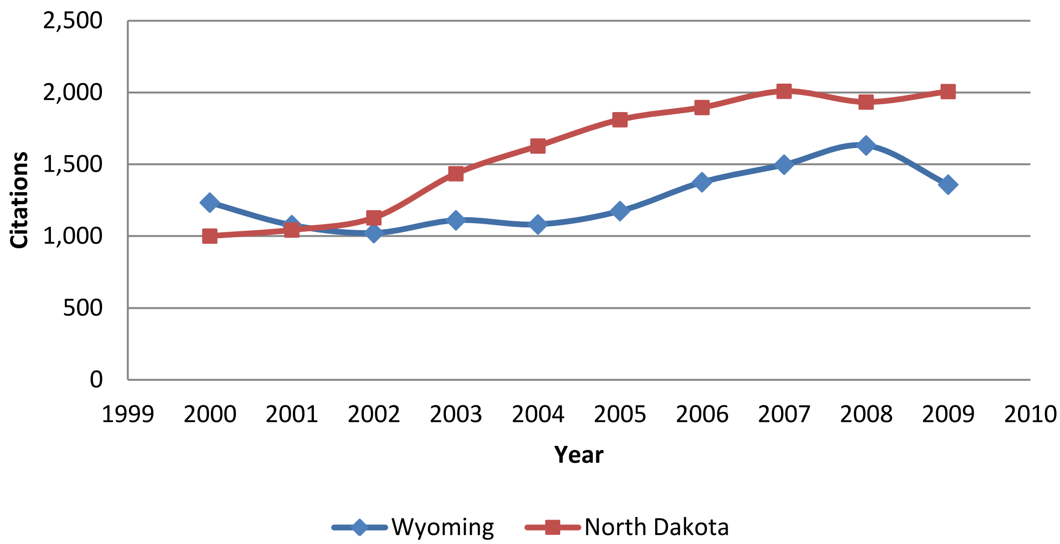

Figure 5-6 Driving while Under the Influence Arrests

5.5.4 Child Restraint Citations

Figure 5-7 demonstrates the number of child restraint citations between the two states. North Dakota has issued nearly double the amount of child restraint citations that Wyoming has within the study period. A few reasons are attributed for this large difference in citations. Wyoming's child restraint laws apply to children only under the age of nine, whereas North Dakota has strict child restraint laws for all children under the age of 12. Wyoming's punishments are also two to four times greater than North Dakota's fines for child restraint citations. These high penalties encourage officers to give warnings rather than citations. North Dakota also employs a point system in which the amount of citations accumulated takes away a certain number of points rather than a hefty fine. This may mean that officers are more willing to issue these types of citations in North Dakota.

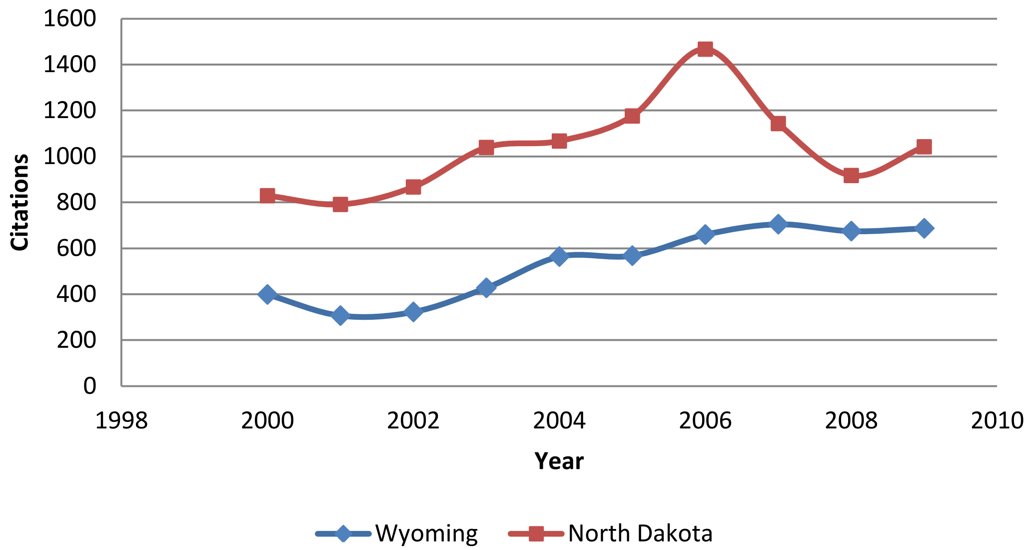

Figure 5-7 Child Restraint Citations in Wyoming and North Dakota

5.5.5 Seatbelt Citations

There is a $20 penalty for driving without a seatbelt in the front seat in North Dakota as a secondary offense. There is a benefit of $10 toward another ticket (e.g. speeding) in Wyoming and a maximum fine of $25 for not having it on as driver and $10 for not having it on as a passenger. According to the NHTSA Seat Belt Use in 2009, 67.6% of the population in Wyoming use seatbelts, and North Dakota has 81.5% of the population using seatbelts.
In 2009, the lowest state for seatbelt usage was Wyoming, a fact that may contribute to a higher fatality rate. North Dakota is not as high as the national leader Michigan (98%), but they show more of a dedication to safety that may contribute to a lower fatality rate.

Figure 5-8 shows the number of seatbelt citations in each state. North Dakota data was not available for years prior to 2006. For the years that are represented North Dakota ticketed almost twice the number of seatbelt offenders than Wyoming did. Although Wyoming's seatbelt citations are lower than North Dakota's, they were steadily increasing during the study period.

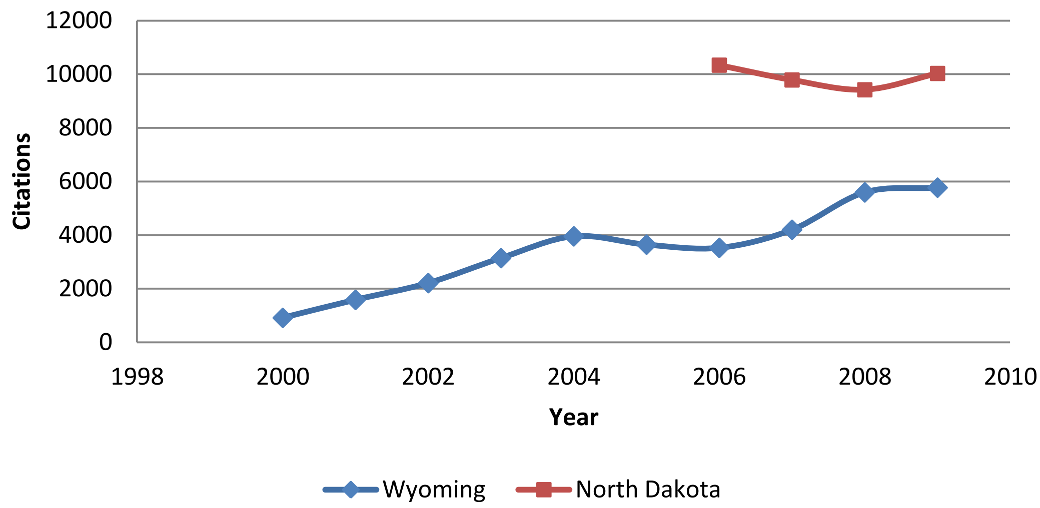

Figure 5-8 Seatbelt Citations in Wyoming and North Dakota

5.5.6 Warnings

While it appears that North Dakota has made more efforts in the areas of child restraints and DUI citations, the remainder of the large amounts of contacts in Wyoming is attributed to warnings. Wyoming issued almost twice the number of warnings that North Dakota did every year in the study period. This could be due to differences in practice by the patrolman as to what situations deserve a warning as opposed to an actual citation. Figure 5-9 shows the drastic difference in the number of warnings that the two states have experienced.

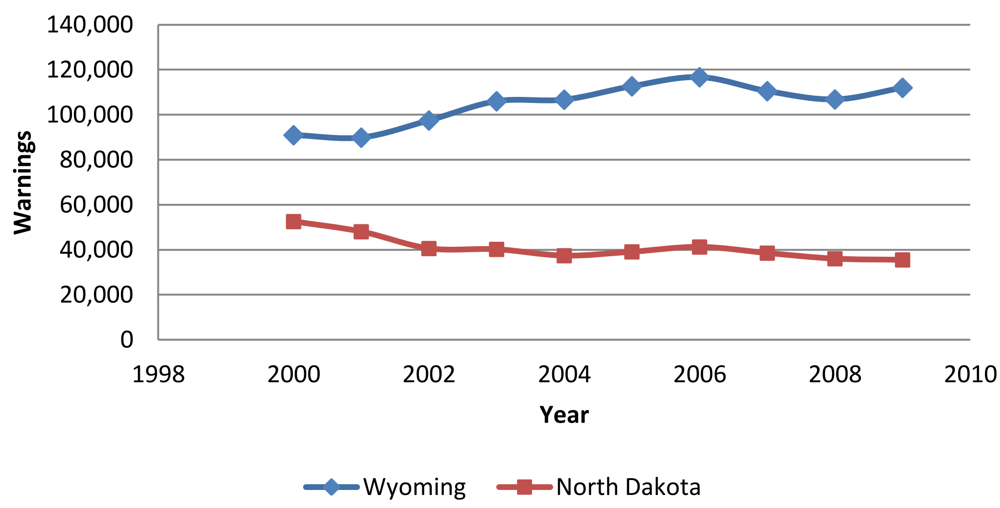

Figure 5-9 Warnings Issued in Wyoming and North Dakota

5.6 Motor Carriers

Wyoming has more miles of interstate than North Dakota, some of which are very heavily traveled truck routes. Wyoming's Interstate 80 has more truck traffic than it does passenger vehicles. Figure 5-10 demonstrates the number of motor carrier violations in both states. Wyoming has had a larger number of motor vehicle violations than North Dakota by no less than 2000 violations every year. Wyoming also has more hazardous materials violations and spends a larger percent of its time on truck enforcement at its ports of entry. It is almost certain that the Wyoming Highway Patrol spends more time and resources on enforcement of trucks than North Dakota.

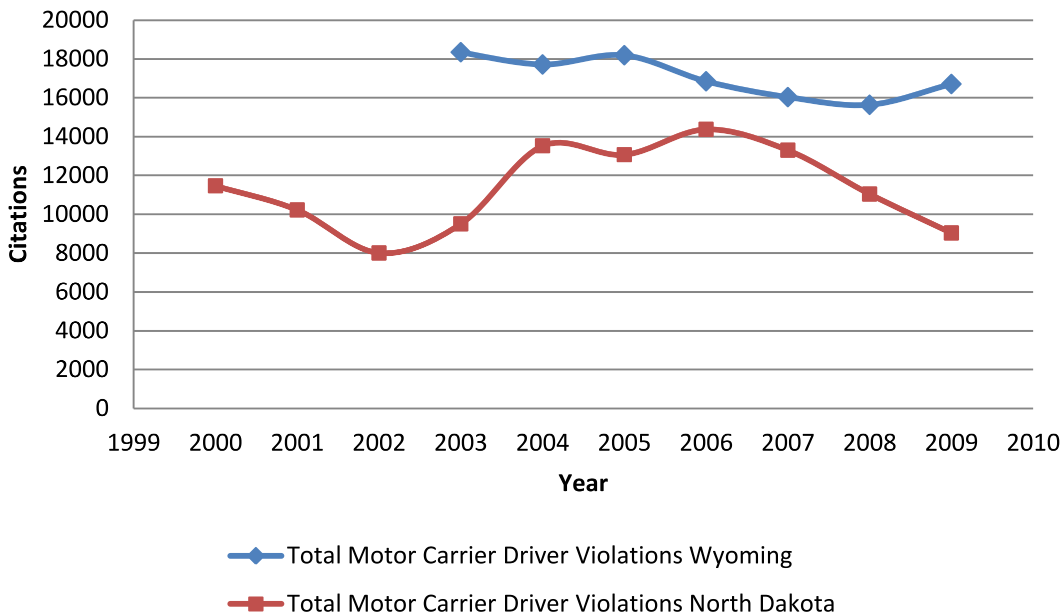

Figure 5-10 Motor Carrier Violations

The amount of vehicle miles traveled in each state by different vehicle classifications has not been recorded and is difficult to find. According to recent numbers provided by the WYDOT supervisor of traffic statistics, the average percentage of vehicle miles traveled by trucks in the entire state of Wyoming is 24% during the entire study period. The percentage of VMT by heavy trucks has been decreasing over the study period from 26% in 2000 to 22% in 2009. The reason for this being that the number of VMT trucks had not increased rather the total number of VMT has increased over that period making the percentage less. Information on percentage of VMT by trucks from North Dakota is currently being researched and is not yet available.

5.7 Budget

Budget information for both states was not available for the entire span of the study period. The only years that this information was available for both states was between the years 2006 and 2009. Wyoming operates on a biennium fiscal year and therefore the budget was split in equal parts for each of the years within that biennium. This is why 2006 and 2007 have the same budgeted amounts and expenditure amounts. The same is true for 2008 and 2009. A comparison of the budgets and expenditures for both Wyoming and North Dakota shows that Wyoming spends a larger amount of resources on the enforcement of their roadways than does North Dakota. In 2009, Wyoming budgeted $33 million dollars while North Dakota budgeted only $19 million. There was no specific information provided on what types of efforts and activities these higher levels Wyoming funds are being spent on. Figure 5-11 illustrates the trends in budgets for both states.

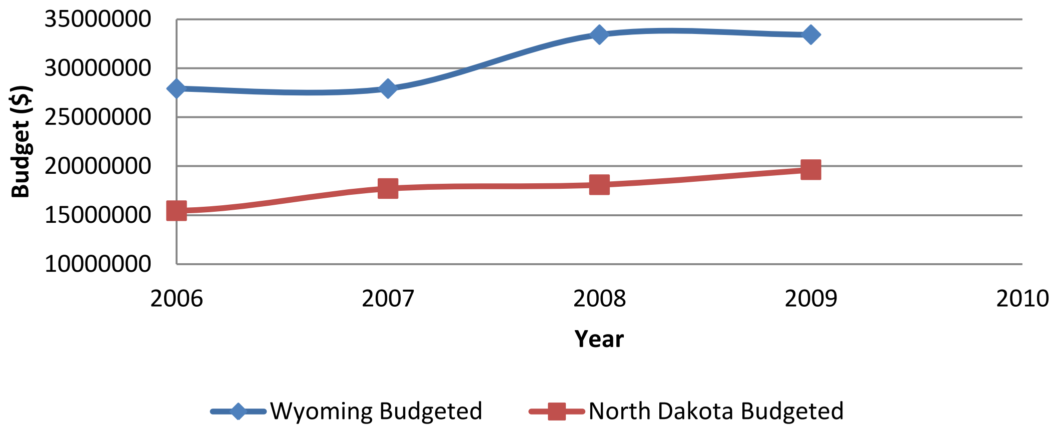

Figure 5-11 2006 to 2009 Budgets in Wyoming and North Dakota

5.8 Chapter Summary

The effects of enforcement on crashes are a bit harder to pinpoint. When simply comparing the differences in enforcement between the two states it becomes very evident that there are differences in practice. North Dakota has more vehicle registrations and fewer fatalities. They give more DUI, seatbelt, and child restraint citations and fewer warnings. They also have recently split the motor carrier department from the Highway Patrol while Wyoming spends much more time on port of entry operations. Wyoming has more trucks and higher altitude interstates, which may contribute to the higher fatality rates. The biggest result found in this portion of the research is that both states are different and require different enforcement techniques.

CHAPTER 6 ECONOMIC ANALYSIS

6.1 Introduction

North Dakota experienced an increase in the fatality rate in 2009 of 24%, with the larger amount of crashes in the western part of the state where increased oil extraction is occurring. It is thought that the increase in mining may be associated with an increase in crashes in North Dakota and the high mining numbers may also be coming into play in Wyoming crashes. Wyoming has a significantly larger amount of mining and drilling activity than North Dakota and it is thought that this may be one of the reasons leading to more critical crashes in Wyoming. This chapter explores different areas of employment as potential factors in crash frequency.

6.2 Gross Domestic Product

Gross domestic product is the measure of an economy's goods and services produced within a specific period of time. GDP refers to only those goods and services that a country or state produces within its borders and not that which is produced by residents while in other states. Historically, Wyoming has ranked very low in economic output due to its low population in comparison to other states in the nation. Wyoming is the least inhabited state with just over half a million people, lower even than the District of Columbia. North Dakota ranks 48th in population with approximately 72,000 more residents.

The GDP in Wyoming is slightly higher than in North Dakota. Figure 6-1 shows the GDP per capita in both states from 1997 to 2009 according to the Bureau of Economic Analysis. Both states are very similar in GPD which is adjusted here to the value of the 2005 dollar. Each state has increased in GDP by nearly the same amount in that time period, but Wyoming has consistently been higher.

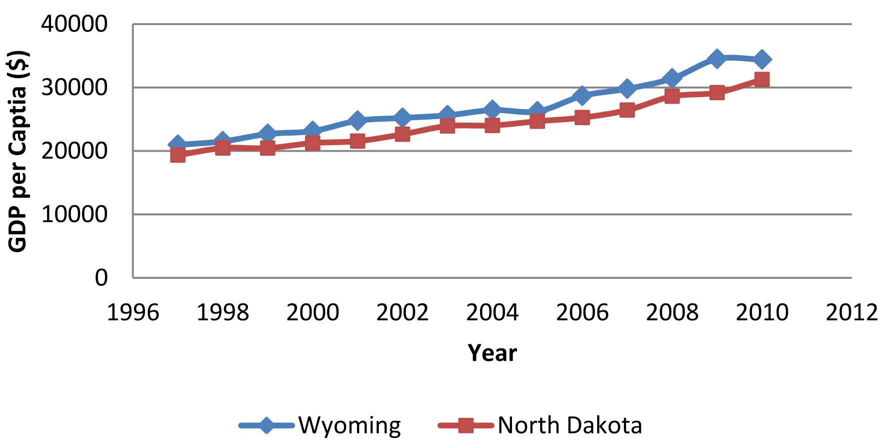

Figure 6-1 State GDP per Capita for All Industries

In terms of GDP per capita, Wyoming and North Dakota rate very differently compared to other states. Wyoming ranks 5th of all states in GDP per capita while North Dakota ranks 20th. Economically, Wyoming has more activity per person and there are larger amounts of industrial activity than in North Dakota.

6.3 Employment Categories

The industry breakdown for Wyoming and North Dakota is very different. Mining is Wyoming's largest industry followed by real estate and government. In North Dakota, government rates as the top economic driver followed closely by real estate and wholesale trade. Because these two states contain such a different distribution of industry, it became apparent that this could be a factor in higher fatality rates in Wyoming. Coupled with the fact that North Dakota also experienced a fatality rate increase in 2009, when the growth in the mining and extraction field was at its highest in that state, points to the probability that employment categories are a factor.

To measure the effects of a certain industry on crash rates, it was determined that employment numbers would be the most applicable measure of an industry within each state. Employment numbers are easily obtained and can give an accurate look at the industry within a state or county because if that industry is significant in an area, employment will be high. This research also explored the construction industry because of its similarities to the mining industry, and the fact that it did not rank within the top industries in either state.

Figure 6-2 illustrates the increase in employment for both construction and mining in North Dakota and Wyoming. The employment numbers have decreased in Wyoming over the past two years, consistent with the number of fatalities in that state. In North Dakota, the employment in both mining and construction increased, corresponding to the increase in fatalities in that state. The time period of 2001 through 2009 was selected because it provides for four years prior to and four years after the implementation of the 2005 strategic highway safety plan in Wyoming. That is also the period in which the employment data is the most consistent and was collected in a uniform manner. Employment in both industries increased over the time period, but Wyoming experienced a decrease in the final year of the study period. If a correlation can be found between employment in certain fields, and the amount of crashes in that area, new initiatives for education and safety should be implemented to mitigate this rise in crashes.

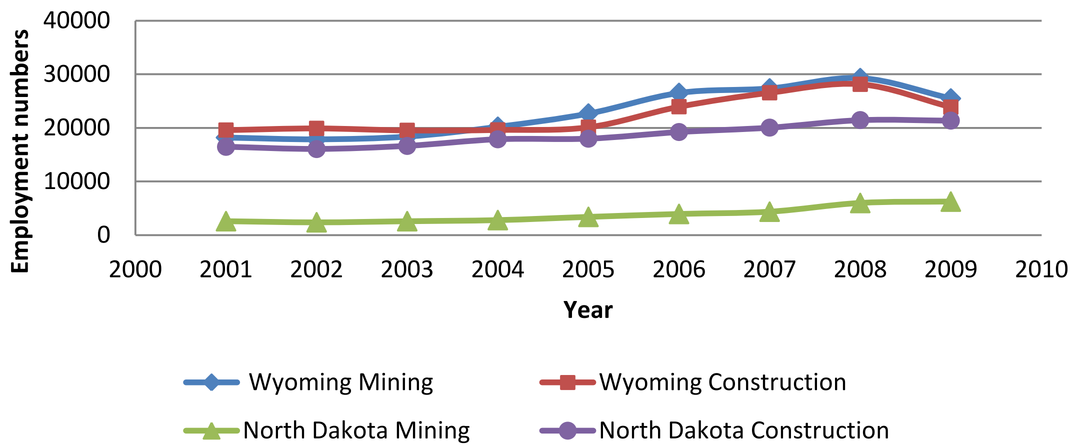

Figure 6-2 Wyoming and North Dakota Employment

The employment in mining and construction statewide has risen 25% from 2002-2008. As can be seen in Table 6-1, the fatal crash trend from 2002-2008 has been decreasing in Laramie County, where there is little employment in the mining industry. The largest employment in mining and extraction in the state occurs in Campbell County. Table 6-1 shows how Campbell County has experienced an increase in fatal crashes of 250% in the same period. Wyoming on the whole has had a decrease in total fatal crashes, while in counties where drilling and mining activities are taking place, fatal crashes are increasing.

Table 6-1 Yearly Fatal Crashes in Select Wyoming Counties

Year	Statewide	Laramie County*	Campbell County
2002	151	23	4
2003	141	6	9
2004	142	22	9
2005	147	13	6
2006	169	16	15
2007	136	7	13
2008	139	3	14

*Mining is not currently heavy in Laramie County

The CARE 9 database is able to filter the data by driver occupation and one of the possible occupation categories is mining. This information only shows data for those employed specifically and wholly by a mining employer. These occupation statistics are therefore partially underrepresented because there are many service industries that provide goods and services to the mining industry, but would not be considered in that industry when an accident report is being filed. In Wyoming, 3.39% of all fatalities from 2000 to 2009 involved someone employed in the mining industry. The industry making up the largest percentage of fatalities was transportation bringing 8.37% of fatal crashes. The largest severity category involving those employed by the mining industry were PDO crashes with 4,655 crashes from 2000 to 2009.

These are conservative estimations due to the limitations of that database and the procedure in which the data is imported.

6.3.1 Mining

The mining GDP for each state reveals a significant disparity between the two states. Figure 6-3 shows the GDP for mining in North Dakota and Wyoming in terms of 2005 dollars. The graph shows that Wyoming is more dependent on mining than North Dakota. It also indicates that both states have seen growth in this industry in the past few years. The disparity between North Dakota and Wyoming reaffirms the speculation that mining has some sort of impact on crashes.

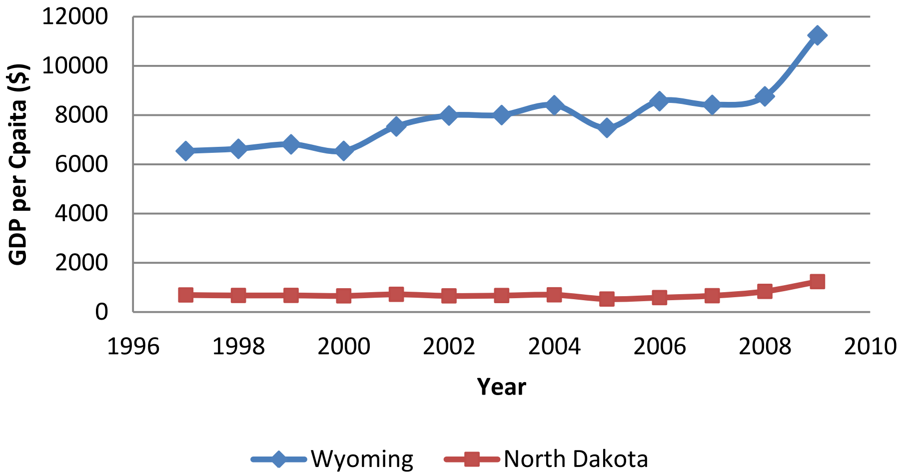

Figure 6-3 GDP per Capita for Mining

In each state, counties were identified as either having large amounts of resource extraction or as having little or no mining. The distinction between large and small amounts of employment was made when employment in the mining sector was over 1,000 people on average per month. Table 6-2 shows the counties selected from each state and the category in which they belong. North Dakota has only one county with mining employment over 1,000. Williams County is easily the most rapidly growing county. The remaining counties were included because of their involvement in the current expansion of the industry.

Table 6-2 Selected Counties

State	High Mining Employment	Low Mining Employment
North Dakota	Burleigh	Adams
	McKenzie	Grand Forks
	Mercer	LaMoure
	Ward	Nelson
	Williams	Stark
Wyoming	Carbon	Albany
	Campbell	Big Horn
	Sublette	Laramie
	Natrona	Weston
	Sweetwater	

The crash and employment data were combined in a comprehensive database for each quarter from 2002 to 2010. Once the data set was complete, the amount of employment in each county was graphed against the number of crashes in each severity level to evaluate the relationship between the two variables. Williams and Campbell Counties have the highest mining employment in their respective states. Figure 6-4 and Figure 6-5 show the employment in those counties with respect to the number of total crashes. The figures show that when there is higher employment in the mining field, there are a larger number of crashes in that county. North Dakota employment information was only available on a yearly basis and therefore there is less data available for those counties. There is an observation for every quarter of each year within the study period of 2002-2010 for Campbell County as well as every county in Wyoming.

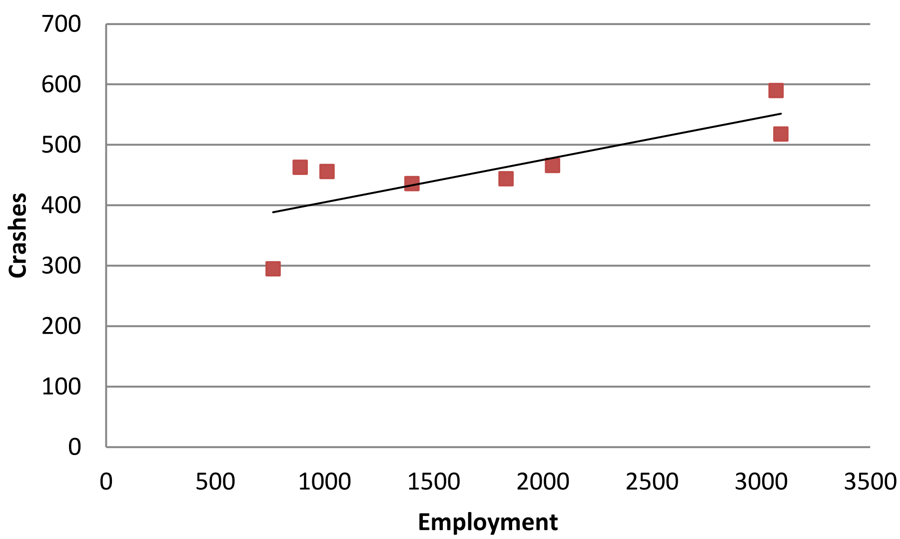

Figure 6-4 Williams County Mining Employment and Crashes

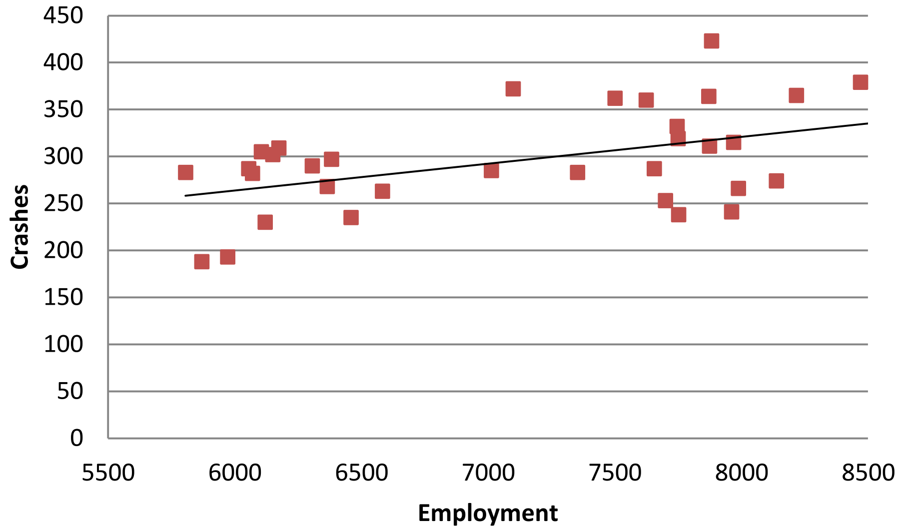

Figure 6-5 Campbell County Mining Employment and Crashes

6.3.2 Construction

The same analysis was used for the construction portion of the economy. The GDP in that field for each state is much more similar and does not show the large disparity that occurs in mining between the two states. Construction is a field that is more dependent on the economy than mining, but similar in the fact that they employ from the same workforce pool, perform similar types of work, and is seasonal in nature. The difference between mining and construction is that construction must happen in any economy and therefore it is more of an indication of population and growth. Figure 6-6 illustrates the construction GDPs for both Wyoming and North Dakota. Wyoming shows more gain over the time period but also faltered the most in the recent economic recession. North Dakota decreased over the study time period, but was less affected by the recession.

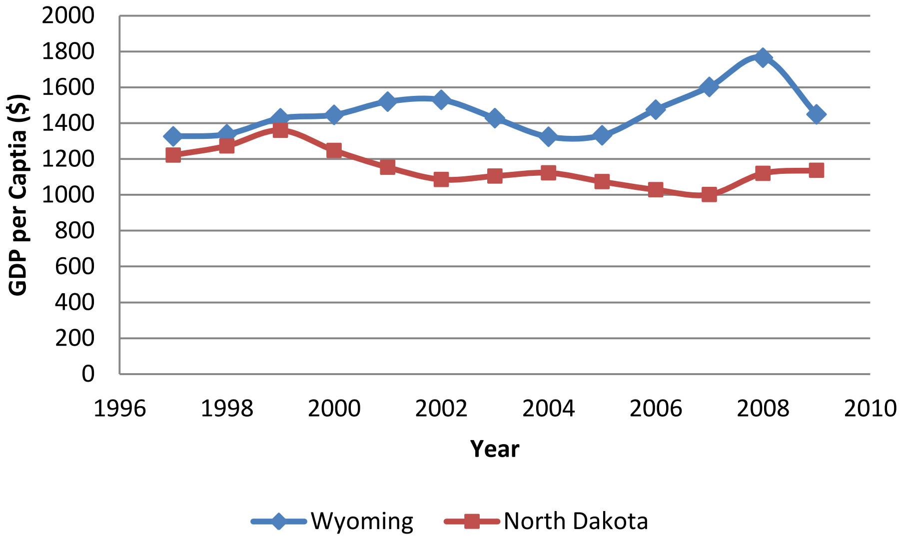

Figure 6-6 GDP per Capita for Construction

Construction employment and crash data were examined in the same way as the mining data for both states. The results show that as construction employment increases, so do crashes. Figure 6-7 shows the results from Williams County in North Dakota and Figure 6-8 indicates the results form Campbell County in Wyoming. The crashes shown are the total crash count on non-interstate roadways. When the amount of employment in construction increased, the total number of crashes in both counties also increased.

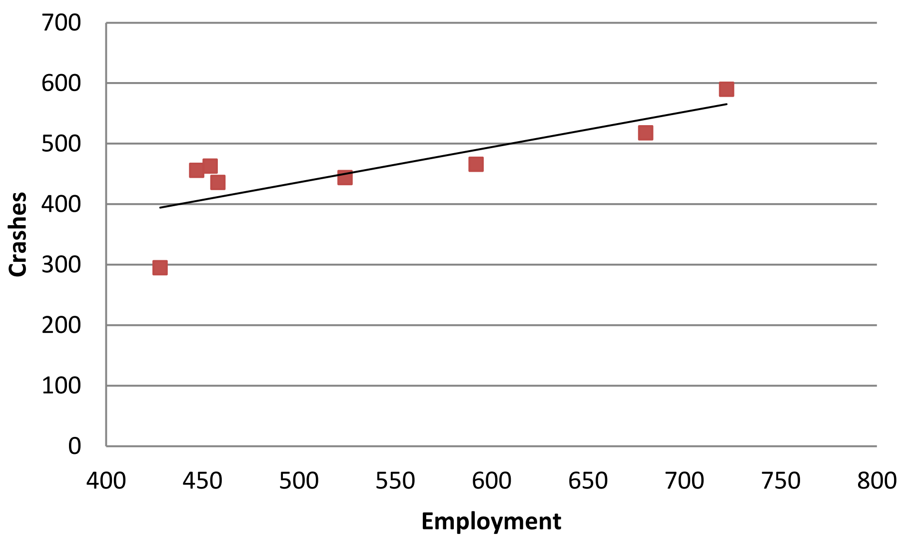

Figure 6-7 Williams County Construction Employment and Crashes

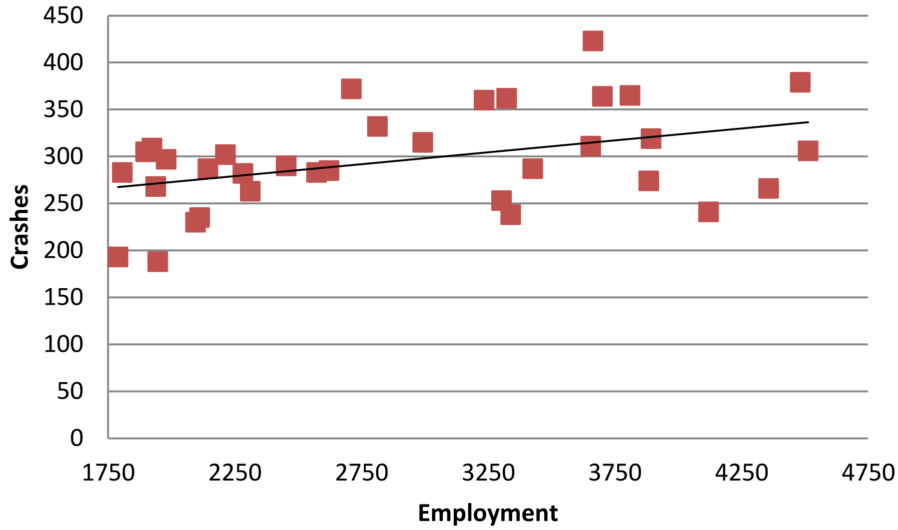

Figure 6-8 Campbell County Construction and Employment

6.4 Statistical Analysis

To further investigate the relationship between mining and crash rates, a statistical one tailed t-test was conducted on all counties for every crash type: serious, fatal, injury, PDO, and total crash count. This analysis was selected to test the difference between two population means. The statistical approach of a one-tailed t-test was used to detect if there was an increase in crashes where the mining or construction employment was higher. The t-test was conducted by splitting the data at the median employment level and performing the test to determine if the population means are the same for high and low employment. One set represented those quarters with employment values less than the median and the second set represented those quarters with employment figures higher than the median. This amounted to approximately 16 observations in each set. The t-test was then performed to determine if the mean number of crashes in the set below the median was lower than the number of crashes in the set above the median for each county. A test was completed for all crash types for both interstate and non-interstate classifications. The level of significance applied to this test was .05 and it was assumed that the variances were unequal.

Each sample was also graphed set show visually the difference in the means between the lower employment set and the higher. Figure 6-9 shows the mining crash sample means for all Wyoming counties included in the study. The figure shows that the means for each of the crash severity categories is higher in the sample with higher employment than in the sample with lower mining employment. The tests for all counties that correspond to Figure 6-9 show that the mean crashes for quarters with low employment was lower than the mean crashes in counties with higher employment. This could reflect a larger sample size. North Dakota mining levels were so low and observations so few that aside from Williams County, the results of the t-test were inconclusive. Note that the average number of fatalities was so low that it could not be represented on the current scale of the graph.

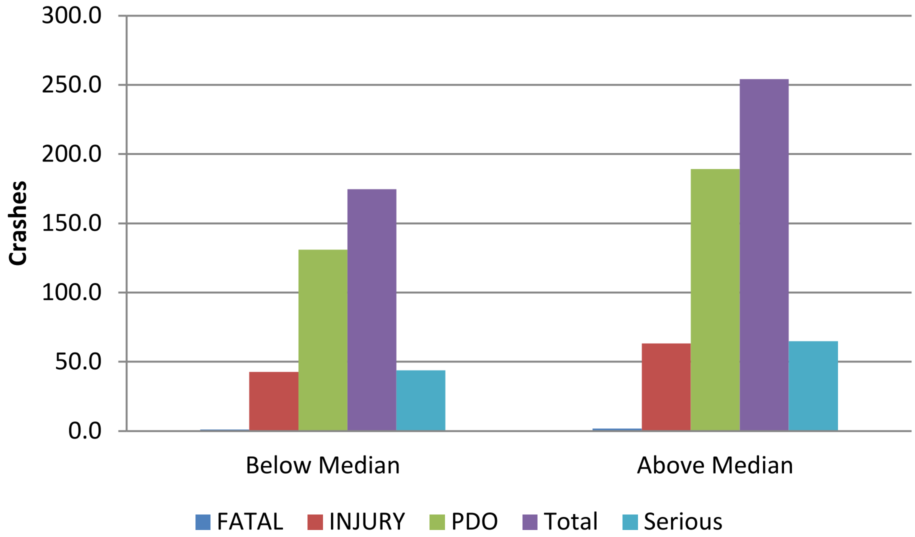

Figure 6-9 Sample Means for All Wyoming Counties Mining

In counties where mining is the most prominent industry, both in Wyoming and North Dakota, the results show that there is a statistically significant difference in mean crash rates between high and low highway employments. As can be seen in Table 6-3, those counties showing differences in crashes between high and low levels of mining employment were Campbell, Natrona, McKenzie, Sweetwater, Ward, and Williams. All of these counties had p values less than .05. Four of those counties' economies are primarily driven by mining: Campbell, Natrona, Sweetwater, and Williams. The other two were North Dakota counties considered to have high levels of mining, but the economies in those counties are not completely dependent upon the industry.

Table 6-3 Wyoming Mining P- Values

County	Interstate					Other				
	Total	PDO	Injury	Fatal	Serious	Total	PDO	Injury	Fatal	Serious
Albany	0.37	0.47	0.14	0.50	0.15	0.21	0.18	0.28	0.21	0.31
Big Horn						0.14	0.40	**0.01**	0.38	**0.01**
Laramie	0.33	0.50	0.09	0.29	0.09	0.17	0.14	0.48	0.18	0.49
Weston						0.10	0.32	**0.04**	0.31	**0.04**
Campbell	0.25	0.48	**0.02**	0.16	**0.02**	**0.00**	**0.00**	0.10	**0.05**	0.08
Carbon	0.26	0.18	0.35	0.21	0.33	0.27	0.16	0.20	0.27	0.22
Natrona	0.11	0.25	**0.00**	**0.03**	**0.01**	**0.00**	**0.00**	**0.00**	0.11	**0.00**
Sublette						0.31	0.32	0.34	0.35	0.48
Sweetwater	0.13	0.08	0.47	0.25	0.45	0.12	0.17	0.17	**0.01**	0.10
All counties	**0.01**	**0.01**	**0.00**	**0.04**	**0.04**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

When the t-test was performed on construction employment populations, the results again confirmed that crashes increase as construction employment increases. It was found in both states that the mean number of crashes with employment below the median was significantly different than the mean number of crashes above the median employment. Figure 6-10 (Wyoming) and Figure 6-11 (North Dakota) show the differences in sample means for all counties combined in construction.

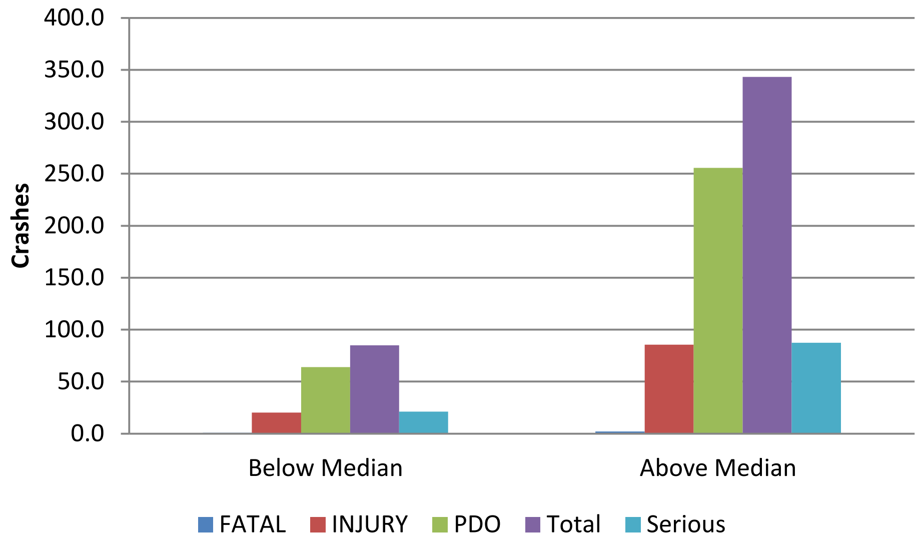

Figure 6-10 Wyoming All Counties Sample Means Construction

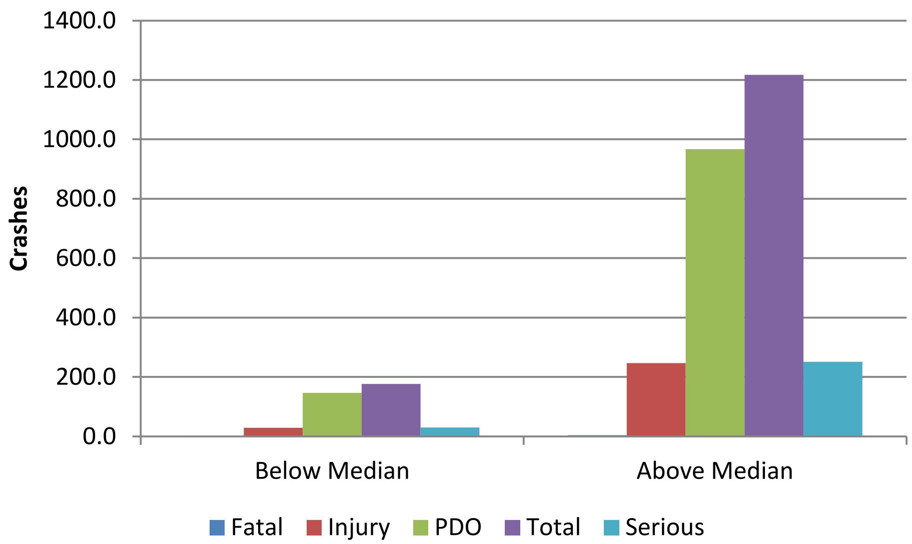

Figure 6-11 North Dakota All Counties Sample Means Construction

Those counties showing p values in Table 6-4 below .05 for construction on non-interstate highways were Big Horn, Campbell, Carbon, Natrona, and Sweetwater. Mercer, McKenzie Williams, and Ward were the counties in North Dakota that showed a difference in crashes between when employment was high and when employment was low. Table 6-4 shows the Wyoming p-values for the tests conducted on interstate and non-interstate roadways. P values for North Dakota counties were not available because of the smaller size of the dataset and instead are shown for all counties combined in Table 6-5. When all data was combined, those figures with high employment were always significantly different than those without high employment for all crash severities.

Table 6-4 Wyoming Construction P - Values

County	Interstate					Other				
	Total	PDO	Injury	Fatal	Serious	Total	PDO	Injury	Fatal	Serious
Albany	**0.03**	0.06	**0.02**	**0.01**	**0.01**	0.14	0.15	0.31	0.31	0.30
Big Horn						0.28	**0.05**	**0.02**	**0.03**	**0.01**
Sublette						0.07	0.09		0.20	0.91
Weston						0.94	0.22		**0.05**	0.12
Campbell	0.25	0.48	**0.02**	0.16	**0.02**	**0.00**	**0.00**	**0.10**	**0.05**	0.08
Carbon	0.22	0.16	0.49	0.21	0.47	**0.03**	**0.02**	0.29	0.38	0.28
Laramie	0.07	0.11	**0.05**	0.29	**0.04**	0.24	0.07	0.07	0.46	0.07
Natrona	0.11	0.08	0.31	0.21	0.34	0.18	0.28	**0.04**	0.22	**0.04**
Sweetwater	0.47	0.47	0.27	0.07	0.23	**0.01**	**0.03**	**0.00**	0.23	**0.00**
All Counties	0.16	0.13	0.34	0.39	0.27	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Table 6-5 North Dakota P - Values

Type	Interstate					Other				
	Total	PDO	Injury	Fatal	Serious	Total	PDO	Injury	Fatal	Serious
Construction	0.28	0.40				**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Mining	0.36	0.35	0.99		0.93	0.54	0.66	0.21	0.13	0.23

Construction is a field that is affected by economic growth and population. This research shows that there is correlation between construction and the number of crashes in a county. It shows that the severity type does not change based on the level of construction employment. Wyoming has both more construction and more mining than North Dakota and also has more fatal and injury crashes.

6.5 Chapter Summary

This chapter presents the results of the analysis of economic factors as well as the employment information that was used to evaluate the relationship between employments in certain fields to the number of crashes in an area. The chapter shows that in Wyoming counties where mining is a large part of the economy, crashes are higher than in counties where mining is not as prominent. It also shows that in both states where construction employment is high, there are more crashes. In addition, it shows that the method of analysis was not sensitive enough for effect of mining in North Dakota to be detected due to the small number of years that mining has been established there. Mining and construction employment numbers also did not have a large effect on interstate crashes due to the large amount of thru traffic occurring on those facilities rather than local traffic. The effects of the mining and construction industries can be noticed on the local roadways and this may be the key to reducing crashes on those roadways.

CHAPTER 7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

This study shows that despite general similarities, Wyoming and North Dakota have some differences in driving habits, traffic, crashes, and enforcement. The crash data distributions show many dissimilarities between the two states and have identified areas for improvement in Wyoming. This chapter highlights those differences and provides succinct and usable information to the decision makers on all topics discussed in the report. Enforcement and traffic implications due to mining activities are equally important in showing areas for improvement within Wyoming. The conclusions of the research are presented below.

7.1.1 Crash Analysis Conclusions

The crash analysis portion of this study yielded many observations pertaining to the nature of crashes in both Wyoming and North Dakota as well as some of the differences between the two states. Wyoming historically has had more fatalities and a higher fatal crash rate. The injury rate in Wyoming was higher than North Dakota until 2008, and the trend has been constantly decreasing, but is still higher than in North Dakota. The puzzling piece of information is that North Dakota still has more total crashes and a higher total crash rate.

North Dakota has had a higher population than Wyoming since Wyoming has been a state. There are more miles of highway in North Dakota than in Wyoming, especially in the local category. Wyoming has more interstates and more crashes on the interstates. The number of vehicle miles traveled in Wyoming is larger than in North Dakota and Wyoming has fewer motor vehicle registered. The main question being posed is what factors lead to Wyoming having more fatalities and less total crashes.

It was found that interstates and rural roads were major contributors to fatal crashes in Wyoming. North Dakota experienced more fatal crashes on local roads and arterials. It was also found that a higher portion of fatal crashes happened when a seatbelt was not in use. Seatbelt usage is very important and key in reducing fatal crashes. If seatbelt usage were to increase, more fatal crashes could possibly be avoided.

Fatal crashes also happened more often on weekends and during summer months in both states. Fatalities among younger drivers are still overrepresented and North Dakota has a higher percentage of fatalities among older drivers. Male drivers make up a large percentage of fatal crashes, and alcohol is involved in a significantly larger percentage of fatal crashes than other severities.

With crashes on interstates being identified as large contributors to fatalities in Wyoming, the logistic regression model was used to determine crash factors specific to I-80 and I-25. It was found the number one contributor was sobriety and that 33% of crashes involving alcohol ended with a critical severity. This does not seem high until it was determined that only 7% of sober crashes resulted in a critical crash. Nearly 47% of crashes involving motorcycles on Interstate 80 were critical. Motorcycle crashes are a low frequency event, but they often lead to critical severity. Speed also proved to be a large contributor to severity where the crash likelihood increased when drivers were traveling over 70 miles per hour. These results were further reinforced when a model was developed for Interstate 25.

This modeling procedure is useful and can be modified for use in many applications. It could be used on a statewide level with functional classification as a factor. The upside of using the logistic regression model is that it utilizes binary response variables and lends itself very nicely to severity. In a study such as this one where severity is such a key issue, this method of modeling is perfectly suited for pinpointing factors for improvement.

7.1.2 Enforcement Conclusions

In the course of this study, it has become apparent that North Dakota consistently issues more citations than Wyoming for child restraints, DUIs, and seatbelts despite the fact that there are less vehicle miles traveled within that state. The highway patrol annual report states that they strive for the safety of the public and increase patrol saturation hours when an upward trend is seen in crash data. It can be observed that North Dakota has made an extra effort to enforce traffic safety laws such as child restraints, seatbelts, and DUIs. They also have an additional law concerning children ages 9-12 that Wyoming does not have. This law allows North Dakota officers to ticket drivers if children below the age of 12 are not properly restrained.

Wyoming penalties are also much higher than those in North Dakota. In North Dakota, a first offense for misuse of a child restraint is 0 dollars where in Wyoming fines are much greater. At the same time, North Dakota employs a point system for repeat offenders and after a certain number of points are accumulated, driving privileges are taken away.

North Dakota spends a larger percentage of its patrolmen's time on actual patrol hours rather than administrative or inspection work. Wyoming has more sworn officers and spends more hours on the road, but as a percentage of the total time in the department, Wyoming falls short of North Dakota in enforcement hours. Wyoming issues more warnings than North Dakota which means that Wyoming does not ticket as frequently and rather is more lenient when they make a traffic stop.

Wyoming also issues more motor carrier citations and spends more time on truck inspections than North Dakota. It is certain that the Wyoming Highway Patrol is forced to dedicate more time and resources to truck enforcement and inspections. This leaves less time for other areas of enforcement, such as traffic stops.

North Dakota had fewer fatalities than Wyoming every year until 2009 and has the lowest fatality rate in the northern Rocky Mountain Region. The level of enforcement is greater in more areas than that of Wyoming with less total amount of vehicle miles traveled. There are more total miles of roadway in North Dakota and yet they still have fewer fatalities.

Wyoming does have several differences from North Dakota that could be factors contributing to the higher crash severities. The higher number of interstate miles across steep grades and high mountains, weather, industry, geometrics, and roadway factors could all effect crash rates. However, if Wyoming wanted to take a comprehensive approach to reducing fatalities, enforcement efforts should be included in this method. If the Wyoming Highway Patrol could spend less time on motor carriers or could have more funding to patrol at the levels of North Dakota, they may see fatality decreases within the state.

7.1.3 Economic Factors Conclusions

There are several variables that can have an effect on the number of crashes in a region. Human factors, roadway conditions, weather, and traffic volume, among other factors could all make different contributions to the number and severity of crashes on a single roadway. This study investigates economic indicators as factors in crash rates in two states.

When employment in mining increases in a county, the number of crashes also increase. This can be seen where mining employment is the highest in Campbell, Natrona, and Sweetwater counties in Wyoming, and Mercer, McKenzie, Ward, and Williams Counties in North Dakota. In Campbell County, the p values for total, fatal, and PDO crashes are less than the established level of significance, 0.05. This means that the crashes occurring for employment numbers above the median are statistically higher than crashes occurring when mining employment is below the median. The number of fatal crashes in Campbell County has increased over the past eight years, as has the mining employment. Several other counties have shown similar results. Natrona, a county rich in petroleum, produced p values of 0.00 for all severities, but fatal for non-interstate roadways. The same cannot be said for construction in the Natrona County, where only non-interstate injuries has a p value less than 0.05.

For those counties having low employment in mining, there is no trend when compared to crash levels. It is likely that these counties have some other factors that are more prevalent, and therefore, mask the effect of mining on construction employment. Weather could be a contributing factor because when employment in these two fields is highest during the summer months, weather is favorable for roadway conditions. When employment is down in the winter, weather creates roadway problems and therefore crashes go up.

Construction employment and GDP show an even higher correlation to increased crash rates. When an economy is robust, expansion and growth occurs. Because of this, more people are attracted to an area causing more trips, unfamiliar drivers, more congestion, and higher traffic volumes. Thus, a strong economy could have an inverse effect on traffic safety.

The data does not suggest that only those employed in the mining or construction industry are the individuals in the crashes, just that in areas where these types of employments are high, so are the crashes. Any kind of economic growth brings in more workers, and therefore more families; this increase in population requires an increase in services. With more people in the area, there is an increase in trips. It is this increase in activity that is contributing to the higher crash rates. Any additional funding towards education of risk or roadway improvements where these conditions exist would be very helpful in increasing the safety of these areas.

The data shows that in Wyoming and North Dakota there are more crashes in counties where there is more mining and construction, regardless of population. Wyoming has always had high levels of employment in these fields and therefore has not seen an increase. But the correlation in the data confirms why the crashes in Wyoming have been higher. With the increase in drilling in North Dakota, there has been a corresponding increase in crashes.

7.2 Recommendations

The research completed in this study exposes many areas for improvement within Wyoming that may help to mitigate high severity crashes in Wyoming as well as North Dakota. Wyoming is a unique state because of its low population and large area. If any other state is similar to Wyoming in this way, it is North Dakota. The population per square mile in North Dakota is the closest to Wyoming. There are some observations taken from North Dakota that could be used to help lower crash rates in Wyoming. In some cases, like mining development, North Dakota has begun to struggle. This is a factor that Wyoming has been working with for a long time and may be able to help North Dakota.

7.2.1 Crash Analysis Recommendations

As with any safety countermeasure, care must be taken to balance high cost and low cost solutions as well as leniency and solutions that may be too strict. In the case of solutions to the irregularities found in the crash data, there is no easy fix. The logistic model suggests that sobriety, motorcycles, and speed are all aspects that contribute to higher crash severities. Statistics show that twice as many motorcycle fatalities occur when a helmet is not used. It would be beneficial if Wyoming were to become completely compliant with the recommended safety laws by the Advocates for Highway Safety. They suggest an all-rider motorcycle helmet law, as well as stricter open container laws and mandatory blood alcohol tests. These are low cost countermeasures that have been implemented elsewhere and have been very successful.

The logistical modeling portion of this research shows that each facility does not perform the same from a safety and severity standpoint. The Interstate 25 data shows more emphasis on sobriety and motorcycles than Interstate 80, while Interstate 80 included an interaction terms and truck traffic. These differences show that this form of modeling can be very helpful in determining the specific safety needs of a certain section or corridor of roadway. Further development of this method is very important and would be critical in determining where to distribute funding for safety related improvements.

It would benefit Wyoming to complete severity models for all systems and roads in the state. Those models should include more detailed factors to provide a clearer representation of critical crash factors. Some additional variables that were not used in this model and should be included are seatbelt usage, geometric conditions, cell phone usage, emergency response time, occupation, and state of driver’s license. The use of such a safety model would be vital in identifying facilities or roadway sections that were at risk of high severity crashes and provide the possible measures for improvement. This kind of tool would fit well within the safety management system currently being implemented and provide for strategic treatment of safety concerns.

7.2.2 Enforcement Recommendations

Highway patrol enforcement in Wyoming is doing very well with the resources that they have and the large area that they must cover. Where the patrols differ in the two states is that North Dakota has a group of officers dedicated to the enforcement of motor carriers and they deal with a smaller volume of trucking within their state. The Interstate 80 corridor is the largest and heaviest used truck route in the region. No other corridor even compares to the amount of truck traffic that Wyoming has to inspect and deal with on a daily basis.

Enforcement on I-80 consumes so much of the patrol's budget and resources that it is difficult to completely fulfill the fourth goal identified in their annual reports to: "Maximize service to the public." It would be beneficial to consider additional officers and personnel to help with the burden of higher amounts of trucking, and the enforcement and inspections that go along with that. One of the main areas where Wyoming has higher fatalities than North Dakota is on the interstates and particularly I-80 where approximately one-fifth of all crashes occur. North Dakota has been very proactive with the development that has been happening in the Bakken formation. They have added new officer positions and attempted to keep ahead of the expansion.

A point system may also be very productive in Wyoming. North Dakota has employed one for some time and it seems to have been very effective. Different citations equate to a certain amount of points and once a cutoff level has been met, a driver loses their license for some time. This gives additional consequences for citations aside from the standard fine. This may serve to keep drivers from purposely committing infractions like speeding and seatbelt violations when there is a risk of losing their license.

7.2.3 Economic Factors Recommendations

Both mining and construction work can attract workers from other regions who are not familiar with the roads or the area. These two lines of work also regularly require those employed to be out on the roads traveling to and from job sites. These types of activities can lead to serious consequences for both the employer and the employee. A roadway crash, no matter the severity, is expensive and is sometimes preventable. It is recommended that the states of Wyoming and North Dakota take measures to mitigate the number of crashes where economic indicators show high levels of employment in these fields.

The Occupation Safety & Health Administration (OSHA) has published a joint document in collaboration with the Network of Employers for Traffic Safety (NETS) and the National Highway and Traffic Safety Administration (NHTSA) intended to assist employers in providing a safe and healthful workplace. It documents the costs to an employer of a work or non-work related vehicle crash and steps to decrease those crashes. (OSHA)

NETS outlines a 10 step program to minimize crash risk through managing, educating, and training not only employed drivers but all employees. The ten steps are:

1. Senior management commitment and employee involvement
2. Written policies and procedures
3. Driver agreements

4. Motor vehicle record checks
5. Crash reporting and investigation
6. Vehicle selection, maintenance, and inspection
7. Disciplinary action system
8. Reward/incentive program
9. Driver training/communication
10. Regulatory compliance

Details outlining these ten steps as well as employer-related safety information can be found in the OSHA document *Guidelines for Employers to Reduce Motor Vehicle Crashes.* If employers in both mining and construction in Wyoming follow the recommendations outlined in that report, they will be able to decrease the likelihood of crashes and save money. (OSHA)

Education is the first step in decreasing crashes. If states require employers to educate the workforce so that they know that by commuting in these areas, crashes are more likely to occur, many workers would drive more cautiously which can hopefully reduce crashes. It is recommended that a safety program similar to the one described above be implemented to decrease the number of crashes, specifically fatalities, in these states.

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APPENDIX A: CRASH DATA

Wyoming Fatal Crash Data

All crash data shown in this section does not reconcile with each category due to the inconsistency in recording systems. Some years totals may show different numbers depending on the category. This is because of inaccurately recorded information, null values, unknown values, or missing information. Some crashes may have a day of the week recorded but not the functional classification of the roadway. If all data that had one missing field was excluded, there would be a signnificant loss in data. It was decided to use all information that had a recoded response in each category to preserve as much information as possible.

Wyoming Fatal Crash Data By Day Of the Week									
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
Saturday	25	31	26	27	20	21	16	20	186
Sunday	23	10	18	24	21	15	15	15	141
Monday	18	18	17	18	22	13	20	20	146
Tuesday	21	13	17	14	25	14	12	19	135
Wednesday	18	19	21	15	24	16	19	17	149
Thursday	18	25	17	22	26	22	19	10	159
Friday	28	25	26	27	31	35	38	15	225
Total	151	141	142	147	169	136	139	116	

Wyoming Fatal Crash Data By Seatbelt Usage									
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
No	88	80	78	90	92	71	84	68	651
Yes	63	61	64	57	77	65	55	48	490
Total	151	141	142	147	169	136	139	116	

Wyoming Fatal Crash Data By Functional Classification									
	2002	2003	2004	2005	2006	2007	2008	2009	Total
Rural Interstate	44	31	41	39	42	27	23	26	273
Rural Principal Arterial	31	36	31	36	37	31	40	24	266
Rural Minor Arterial	11	11	11	15	13	13	17	8	99
Rural Major Collector	21	24	14	18	30	20	17	21	165
Rural Minor Collector	6	5	9	5	13	9	11	12	70
Rural Local Road	7	3	9	8	7	6	12	10	62
Urban interstate	8	12	10	2	4	7	5	4	52
Urban Freeway	1	0	1	0	0	0	0	0	2
Urban Principle Arterial	11	5	5	6	4	8	3	4	46
Urban Minor Arterial	1	2	2	3	2	3	2	2	17
Urban Major Collector	2	1	0	2	0	1	5	2	13
Urban local Road	0	1	0	1	1	0	4	3	10
Total	143	131	133	135	153	125	139	116	

Wyoming Fatal Crash Data By Gender									
	2002	2003	2004	2005	2006	2007	2008	2009	Total
Male	106	101	106	111	130	109	103	88	854
Female	45	40	35	36	37	26	36	27	282
Total	151	141	141	147	167	135	139	115	

Wyoming Fatal Crash Data By Month									
	2002	2003	2004	2005	2006	2007	2008	2009	Total
January	7	8	7	9	10	11	11	4	67
February	3	5	8	10	9	11	6	11	63
March	10	7	8	15	13	8	8	6	75
April	11	15	16	11	10	9	2	9	83
May	17	9	14	10	10	12	7	9	88
June	14	16	10	17	15	10	15	15	112
July	22	14	12	13	19	17	18	12	127
August	20	20	18	18	20	15	20	17	148
September	9	12	9	14	16	10	16	7	93
October	13	14	14	9	17	12	11	6	96
November	14	9	11	11	14	10	12	11	92
December	11	12	15	10	16	11	13	9	97
Total	151	141	142	147	169	136	139	116	

Wyoming Fatal Crash Data By Age Group									
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
14-25	43	31	39	45	43	31	40	38	310
26-35	34	23	24	20	37	31	33	17	219
36-45	26	31	22	29	30	19	22	16	195
46-55	21	32	34	26	25	21	22	24	205
55-65	13	12	13	12	20	23	12	11	116
65-75	5	3	4	10	2	5	9	5	43
75+	6	9	5	5	9	5	0	3	42

Wyoming Fatal Crash Data By Impairment									
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
Crash Involved Alcohol	53	43	50	51	58	46	65	48	414
Crash did not Involve Alcohol	98	98	92	96	111	90	74	68	727
Total	151	141	142	147	169	136	139	116	

Wyoming Fatal Crash Data By Vehicle Type									
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
Passenger Car	81	53	65	66	81	56	40	26	468
Pickup/Van/Utility	46	56	50	51	55	47	59	67	431
Bus									0
School Bus									0
Motorhome					2		1		3
Snowmobile					1		1		2
All-terrain Vehicle							2	2	4
Motorcycle	11	18	12	19	14	24	16	10	124
bicycle	1			1					2
Construction Equipment									0
Emergency Vehicle	0	1			1				2
Farm Equipment			1						1
Modified Vehicle									0
Hit and Run									0
Roadway Main Vehicle									0
Other publicly owned Vehicle									0
Pedestrian	1	2	0	1	1	0	3	1	9
Truck 2-axle	3	0	2	3	2		3	1	14
Truck 3 or more axle	8	11	12	6	12	9	12	6	76
Single Unit Truck							2	3	5
Truck Tractor									0
Total	151	141	142	147	169	136	139	116	

Wyoming Total Crash Data

Wyoming Fatal Crash Data By Day Of the Week									
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
Saturday	1833	1955	1900	1808	2179	2079	1992	1766	15512
Sunday	2161	2516	2088	2351	2433	2384	2623	2406	18962
Monday	2459	2123	2120	2344	2481	2308	2495	2184	18514
Tuesday	2263	2255	2248	2296	2492	2483	2495	2292	18824
Wednesday	2239	2496	2292	2433	2482	2575	2487	2478	19482
Thursday	2582	2749	2616	2557	2695	3022	2638	2549	21408
Friday	2164	2223	2306	2107	2212	2577	2894	1907	18390
Total	15701	16317	15570	15896	16974	17428	17624	15582	

Wyoming Total Crash Data By Seatbelt Usage									
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
No	1986	1739	1444	1561	1544	1489	1293	1134	481
Yes	10780	11645	11381	11612	12547	13118	12775	11353	5793
Total	12766	13384	12825	13173	14091	14607	14068	12487	

Wyoming Total Crash Data By Functional Classification									
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
Rural Interstate	2535	2860	2502	2351	3081	2979	3425	2546	22279
Rural Principal Arterial	1926	1997	1959	2002	2081	2179	2182	1895	16221
Rural Minor Arterial	679	676	671	649	753	744	696	619	5487
Rural Major Collector	872	868	805	874	969	924	852	784	6948
Rural Minor Collector	452	454	433	433	431	472	498	373	3546
Rural Local Road	350	346	351	434	422	437	844	659	3843
Urban interstate	682	795	730	735	773	791	691	667	5864
Urban Freeway	13	22	20	16	19	14	19	20	143
Urban Principle Arterial	2427	2353	2504	2503	2511	2616	1937	1833	18684
Urban Minor Arterial	271	269	267	291	318	366	1089	1096	3967
Urban Major Collector	205	164	167	187	227	241	2417	2145	5753
Urban local Road	37	67	52	57	71	98	2954	2597	5933
Total	10449	10871	10461	10532	11656	11861	17604	15234	

Wyoming Total Crash Data By Gender									
	2002	2003	2004	2005	2006	2007	2008	2009	Total
Male	14100	14406	13793	14110	15061	15594	15527	12984	115575
Female	8523	8794	8568	8681	8896	9104	9091	8335	69992
Total	22623	23200	22361	22791	23957	24698	24618	21319	

Wyoming Total Crash Data By Month									
	2002	2003	2004	2005	2006	2007	2008	2009	Total
January	1256	1157	1231	1442	1494	1851	2119	1684	12234
February	1162	1487	1360	986	1517	1404	1774	1056	10746
March	1395	1291	1014	1217	1344	1284	1634	1300	10479
April	1143	965	1105	1070	1004	1003	1124	1080	8494
May	1091	1118	1105	1135	1151	1139	1260	975	8974
June	1229	1156	1143	1207	1323	1212	1138	1121	9529
July	1369	1318	1398	1441	1372	1363	1295	1288	10844
August	1322	1350	1377	1302	1335	1406	1244	1194	10530
September	1219	1240	1196	1252	1254	1298	1183	1078	9720
October	1614	1701	1328	1303	1720	1461	1402	1534	12063
November	1502	1775	1787	1669	1521	1537	1517	1223	12531
December	1399	1759	1526	1872	1939	2470	1949	1749	14663
Total	15701	16317	15570	15896	16974	17428	17639	15282	

Wyoming Total Crash Data By Age Group									
	2002	2003	2004	2005	2006	2007	2008	2009	Total
14-25	7788	7684	7405	7362	7397	7258	7104	6092	58090
26-35	3970	4144	3966	4135	4518	4753	4908	4339	34733
36-45	3739	3797	3500	3531	3774	3857	3936	3289	29423
46-55	3330	3657	3592	3631	3894	4131	4009	3462	29706
55-65	1898	2053	2057	2219	2445	2660	2746	2414	18492
65-75	1012	1008	933	1051	1025	1160	1103	1052	8344
75+	690	671	712	701	685	674	672	656	5461
Total	22427	23014	22165	22630	23738	24493	24478	21304	

Wyoming Total Crash Data By Impairment									
	2002	2003	2004	2005	2006	2007	2008	2009	Total
Crash did not Involve Alcohol	14689	15288	14625	14771	15882	16316	13551	11987	117109
Crash Involved Alcohol	1012	1029	945	1125	1092	1112	1217	1161	8693
Total	15701	16317	15570	15896	16974	17428	14768	13148	

Wyoming Total Crash Data By Vehicle Type									
	2002	2003	2004	2005	2006	2007	2008	2009	Total
Passenger Car	8517	8918	8528	8632	9004	8907	5580	5062	63148
Pickup/Van/Utility	5289	5272	5106	5305	5613	5951	6569	6152	45257
Bus	21	26	22	25	23	39	20	15	191
School Bus	17	13	9	14	13	13	34	25	138
Motorhome	54	46	40	36	37	40	26	34	313
Snowmobile	0	3	3	4	2	0	4	2	18
All-terrain Vehicle	0	0	0	0	0	0	39	37	76
Motorcycle	215	263	250	288	345	378	286	240	2265
bicycle	46	38	34	48	46	44	0	0	256
Construction Equipment	37	49	46	49	44	62	25	34	346
Emergency Vehicle	64	67	47	79	86	75	0	0	418
Farm Equipment	1	2	6	2	3	4	8	5	31
Modified Vehicle									0
Hit and Run									0
Roadway Main Vehicle	0	0	0	0	0	0	0	3	3
Other publicly owned Vehicle									0
Pedestrian	22	31	39	33	30	31	94	87	367
Truck 2-axle	164	174	216	142	134	143	162	64	1199
Truck 3 or more axle	887	996	815	850	1189	1308	1252	733	8030
Single Unit Truck	0	0	0	0	0	0	222	202	424
Truck Tractor	352	415	408	389	405	433	341	320	3063
Total	15686	16313	15569	15896	16974	17428	14662	13015	

North Dakota Fatal Crash Data

North Dakota Fatal Crash Data By Day Of the Week									
	2002	2003	2004	2005	2006	2007	2008	2009	Total
Saturday	18	14	19	16	23	15	25	18	148
Sunday	20	12	11	14	18	12	14	20	121
Monday	13	11	22	15	29	10	12	27	139
Tuesday	17	23	20	21	8	12	13	8	122
Wednesday	36	13	21	39	16	18	12	13	168
Thursday	22	11	27	20	13	17	19	36	165
Friday	22	13	19	13	20	33	24	19	163
Total	148	97	139	138	127	117	119	141	

North Dakota Fatal Crash Data By Seatbelt Usage									
	2002	2003	2004	2005	2006	2007	2008	2009	Total
No	118	80	114	106	102	76	106	108	810
Yes	30	17	25	32	25	41	13	33	216
Total	148	97	139	138	127	117	119	141	

North Dakota Fatal Crash Data By Functional Classification									
	2002	2003	2004	2005	2006	2007	2008	2009	Total
Rural Interstate	9	5	6	14	9	5	7	10	65
Rural Principal Arterial	23	20	33	18	27	25	25	29	200
Rural Minor Arterial	11	7	10	14	16	12	14	15	99
Rural Major Collector	13	16	8	5	2	4	3	11	62
Rural Local Road	13	24	31	36	43	36	41	27	251
Urban interstate	1	2	2	0	0	0	2	0	7
Urban Principle Arterial	8	6	8	5	1	5	5	5	43
Urban Minor Arterial	4	3	6	7	2	4	4	1	31
Urban Major Collector	1	0	3	3	1	1	2	1	12
Urban local Road	0	0	0	1	0	1	0	0	2
Total	83	83	107	103	101	93	103	99	

North Dakota Fatal Crash Data By Gender									
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
Male	113	61	95	99	91	74	90	87	710
Female	35	36	44	38	36	43	29	54	315
Total	148	97	139	137	127	117	119	141	

North Dakota Fatal Crash Data By Month									
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
January	7	7	8	6	13	5	9	5	60
February	7	1	11	14	7	4	8	6	58
March	4	5	5	11	2	9	7	11	54
April	9	8	3	7	10	11	8	8	64
May	13	12	8	6	17	13	6	18	93
June	7	4	11	32	9	12	10	20	105
July	13	10	12	17	10	7	15	13	97
August	13	13	11	5	11	15	16	19	103
September	22	18	15	10	11	10	9	9	104
October	21	4	20	9	17	16	16	15	118
November	11	9	17	13	9	8	8	9	84
December	21	6	18	8	11	7	7	8	86
Total	148	97	139	138	127	117	119	141	

North Dakota Fatal Crash Data By Age Group									
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
14-25	39	25	34	29	42	36	34	43	282
26-35	16	5	17	12	16	15	19	17	117
36-45	19	19	16	18	19	17	24	17	149
46-55	33	9	17	28	15	8	21	23	154
55-65	15	5	16	7	12	16	7	14	92
65-75	8	9	11	16	3	12	3	3	65
75+	13	17	26	21	7	8	10	15	117
Total	143	89	137	131	114	112	118	132	

North Dakota Fatal Crash Data By Impairment									
	2002	2003	2004	2005	2006	2007	2008	2009	Total
Crash Involved Alcohol	39	24	23	39	59	37	51	36	308
Crash did not Involve Alcohol	57	62	86	66	44	60	53	70	498
Total	96	86	109	105	103	97	104	106	

North Dakota Fatal Crash Data By Vehicle Type									
	2002	2003	2004	2005	2006	2007	2008	2009	Total
Passenger Car	49	40	55	37	55	44	33	48	361
Pickup/Van/Utility	60	39	50	59	46	56	57	61	428
Bus	0	0	1	0	0	0	0	0	1
School Bus	0	1	1	0	0	0	0	0	2
Motorhome	0	0	0	2	0	0	0	0	2
Snowmobile	0	0	3	0	0	0	0	0	3
All-terrain Vehicle	0	1	0	2	4	1	3	2	13
Motorcycle	4	3	9	7	4	7	12	7	53
bicycle	1	0	1	3	0	0	1	1	7
Construction Equipment	0	0	1	0	0	0	0	0	1
Emergency Vehicle	0	0	0	0	0	0	0	3	3
Farm Equipment	1	3	1	1	2	1	0	0	9
Modified Vehicle	0	0	0	1	0	0	0	0	1
Hit and Run	4	0	1	0	0	0	0	0	5
Roadway Main Vehicle	0	0	0	0	1	0	0	0	1
Other publicly owned Vehicle	0	0	0	0	1	0	0	0	1
Pedestrian	16	4	11	18	7	4	8	8	76
Truck 2-axle	3	2	0	1	1	0	2	2	11
Truck 3 or more axle	0	1	0	0	0	1	2	3	7
Single Unit Truck	2	0	1	1	0	0	0	0	4
Truck Tractor	8	3	4	6	6	3	1	6	37
Total	148	97	139	138	127	117	119	141	

North Dakota Total Crash Data

North Dakota Total Crash Data By Day Of the Week									
	2002	2003	2004	2005	2006	2007	2008	2009	Total
Saturday	1679	1810	1908	1749	1691	1707	1819	1937	14300
Sunday	2630	2370	2463	2224	2109	2207	2228	2622	18853
Monday	2345	2225	2464	2309	2074	2382	2106	2610	18515
Tuesday	2687	2429	2687	2330	2293	2253	2304	2654	19637
Wednesday	2457	2387	2469	2346	2342	2247	2380	2628	19256
Thursday	2698	2775	2759	2857	2616	2627	2693	2978	22003
Friday	2158	2170	2501	2136	2095	2212	2240	2411	17923
Total	16654	16166	17251	15951	15220	15635	15770	17840	

North Dakota Total Crash Data By Seatbelt Usage									
	2002	2003	2004	2005	2006	2007	2008	2009	Total
No	6918	7010	6923	6332	6139	5326	4967	6349	49964
Yes	20032	18760	20684	18916	17981	18870	19116	21720	156079
Total	26950	25770	27607	25248	24120	24196	24083	28069	

North Dakota Total Crash Data By Functional Classification									
	2002	2003	2004	2005	2006	2007	2008	2009	Total
Rural Interstate	967	991	1081	997	1041	1045	1046	976	8144
Rural Principal Arterial	2191	2289	2649	2269	2196	2338	2326	2447	18705
Rural Minor Arterial	984	993	1047	1030	949	1048	1029	1059	8139
Rural Major Collector	928	1279	1013	747	547	309	277	306	5406
Rural Local Road	1632	2197	2665	2747	2689	2890	2999	1566	19385
Urban interstate	437	270	384	366	413	397	451	321	3039
Urban Principle Arterial	3608	3427	3624	3143	2374	2412	2481	3507	24576
Urban Minor Arterial	3414	2787	2752	2837	3626	3677	3552	4432	27077
Urban Major Collector	1531	1741	1764	1485	1140	1278	1383	1342	11664
Urban local Road	200	190	246	297	219	232	174	113	1671
Total	15892	16164	17225	15918	15194	15626	15718	16069	

North Dakota Total Crash Data By Gender									
	2002	2003	2004	2005	2006	2007	2008	2009	Total
Male	15780	14655	15862	14380	13992	13870	13934	16301	118774
Female	10572	10396	11069	10020	9686	10198	9921	11480	83342
Total	26352	25051	26931	24400	23678	24068	23855	27781	

North Dakota Total Crash Data By Month									
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
January	1363	1389	1876	1812	1345	1227	1259	2359	12630
February	1003	1129	1580	1025	1223	1476	1529	1500	10465
March	1291	1267	1405	1102	1101	1203	1119	1587	10075
April	1030	979	878	928	916	1065	1028	933	7757
May	1113	1162	1063	1051	1053	1115	984	1045	8586
June	1302	1406	1274	1349	1107	1252	1171	1208	10069
July	1276	1143	1207	1131	1069	1103	1112	1127	9168
August	1194	1191	1121	1081	1086	1123	1104	1126	9026
September	1345	1323	1281	1320	1138	1219	1234	1160	10020
October	1551	1598	1690	1509	1547	1515	1547	1428	12385
November	1920	1745	2010	1879	1724	1730	1875	1930	14813
December	2266	1834	1866	1764	1911	1607	1808	2437	15493
Total	16654	16166	17251	15951	15220	15635	15770	17840	

North Dakota Total Crash Data By Age Group									
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
14-25	9700	9506	10036	9162	8540	8542	8426	9529	73441
26-35	4251	3783	4146	3607	3721	3891	3964	4809	32172
36-45	4046	4079	4359	3789	3498	3426	3457	4020	30674
46-55	3670	3635	3803	3557	3525	3730	3690	4197	29807
55-65	2237	1750	2165	2035	2100	2242	2232	2801	17562
65-75	1327	1214	1330	1184	1177	1164	1127	1300	9823
75+	1009	973	989	935	951	981	892	1028	7758
Total	26240	24940	26828	24269	23512	23976	23788	27684	

North Dakota Total Crash Data By Impairment									
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
Crash did not Involve Alcohol	24021	22799	24378	22103	21370	21914	21695	25511	183791
Crash Involved Alcohol	1168	1190	1121	1074	1154	1062	1227	1134	9130
Total	25189	23989	25499	23177	22524	22976	22922	26645	

North Dakota Total Crash Data By Vehicle Type									
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
Passenger Car	13503	13275	14013	12635	12228	12665	12775	14327	105421
Pickup/Van/Utility	10345	8905	9975	8895	8715	9374	9278	11895	77382
Bus	60	38	54	51	44	42	52	58	399
School Bus	33	27	36	26	17	21	30	45	235
Motorhome	24	19	18	15	10	19	17	22	144
Snowmobile	19	17	32	11	19	14	14	8	134
All-terrain Vehicle	19	20	23	32	34	43	50	53	274
Motorcycle	164	164	174	225	224	256	291	241	1739
moped	1	5	2	5	5	6	16	16	56
bicycle	70	92	91	95	79	82	92	69	670
Construction Equipment	27	18	38	29	36	26	36	59	269
Emergency Vehicle	34	29	23	23	21	34	24	32	220
Train	1	0	0	0	0	0	0	1	2
Farm Equipment	40	41	36	44	40	43	36	41	321
Modified Vehicle	0	5	3	6	2	4	2	5	27
Hit and Run	929	1002	751	893	427	303	381	556	5242
Roadway Main Vehicle	50	19	44	18	36	28	32	104	331
Other publicly owned Vehicle	17	0	10	7	13	12	11	20	90
Pedestrian	1	7	31	47	25	44	24	14	193
Truck 2-axle	126	96	112	87	112	109	84	114	840
Truck 3 or more axle	157	155	117	133	167	154	158	197	1238
Single Unit Truck	49	57	55	40	35	30	19	17	302
Truck Tractor	712	483	574	447	530	520	474	582	4322
Total	26381	24474	26212	23764	22819	23829	23896	28476	

APPENDIX B: SAMPLE MODELING I-80 DATA SET

Section	Direction	Milepost	ADT	ADTm	ADTT	ADTTm	AVMT	AVMTm	TVMT	TVMTm	Severity	County	Vehicles	Vehiclesm	Lighting	Weather	Speed	Speedm	Condition	Month	Day of Week	Time	Age	14-25	26-35	36-45	46-55	56-65	66-75	Gender	Type	Known Truck	Known Motorcycle	Sobriety
ML80D	D	143.5	6110	0	3,342	1	28,583	1	15,634	1	0	Sweetwater	2	1	0	0	5	0	0	Oct	Sa	16	56	0	0	0	0	1	0	1	P	0	0	0
ML80I	I	0.5	6031	0	2,481	0	13,449	0	5,533	0	0	Uinta	1	0	0	0	10	0	0	Jul	F	7	25	1	0	0	0	0	0	1	T	1	0	0
ML80D	D	0.1	6184	0	2,811	0	13,403	0	6,128	0	0	Uinta	2	1	0	0	10	0	0	May	Su	13	27	0	1	0	0	0	0	1	T	1	0	0
ML80D	D	0.4	6184	0	2,811	0	13,403	0	6,128	0	1	Uinta	2	1	0	0	10	0	0	Jun	M	13	32	0	1	0	0	0	0	1	T	1	0	0
ML80I	I	0.4	6031	0	2,481	0	13,449	0	5,533	0	0	Uinta	2	1	0	0	10	0	0	Oct	Su	7	34	0	1	0	0	0	0	1	T	1	0	0
ML80I	I	0.4	6031	0	2,481	0	13,449	0	5,533	0	0	Uinta	2	1	1	0	10	0	0	May	T	1	35	0	1	0	0	0	0	1	T	1	0	0
ML80D	D	0.4	6184	0	2,811	0	13,403	0	6,128	0	0	Uinta	2	1	0	0	10	0	0	Aug	Sa	12	42	0	0	1	0	0	0	1	T	1	0	0
ML80D	D	0.4	6184	0	2,811	0	13,403	0	6,128	0	0	Uinta	1	0	0	0	10	0	0	Jul	Su	14	44	0	0	1	0	0	0	1	T	1	0	0
ML80I	I	267.19	5155	0	2,667	0	25,105	0	12,988	0	0	Carbon	2	1	1	1	10	0	1	Dec	T	6	44	0	0	1	0	0	0	1	T	1	0	0
ML80I	I	0.4	6031	0	2,481	0	13,449	0	5,533	0	0	Uinta	1	0	0	0	10	0	0	Oct	Su	11	46	0	0	0	1	0	0	1	T	1	0	0
ML80I	I	0.4	6031	0	2,481	0	13,449	0	5,533	0	0	Uinta	2	1	0	0	10	0	0	Jun	M	12	48	0	0	0	1	0	0	1	T	1	0	0
ML80I	I	0.4	6031	0	2,481	0	13,449	0	5,533	0	0	Uinta	2	1	0	0	10	0	0	Jun	T	14	64	0	0	0	0	1	0	1	T	1	0	0
ML80I	I	0.4	6031	0	2,481	0	13,449	0	5,533	0	.	Uinta	1	0	0	0	10	0	0	Apr	W	10	.	0	0	0	0	0	0	.	T	1	0	0
ML80I	I	59	5407	0	2,329	0	24,602	0	10,597	0	0	Sweetwater	2	1	0	1	10	0	1	Oct	Su	8	.	0	0	0	0	0	0	.	T	1	0	0
ML80I	I	267.19	5155	0	2,667	0	25,105	0	12,988	0	0	Carbon	2	1	0	0	15	0	0	Oct	T	12	21	1	0	0	0	0	0	1	T	1	0	0
ML80I	I	144	5688	0	3,048	1	26,608	0	14,259	1	0	Sweetwater	2	1	1	1	15	0	1	May	Sa	22	24	1	0	0	0	0	0	1	P	0	0	0
ML80D	D	267.19	5236	0	3,023	1	25,499	0	14,722	1	0	Carbon	2	1	1	0	15	0	0	Sep	F	5	24	1	0	0	0	0	0	1	T	1	0	0
ML80I	I	272.06	5155	0	2,666	0	40,224	1	20,803	1	0	Carbon	2	1	0	0	15	0	0	Aug	R	13	26	0	1	0	0	0	0	0	P	0	0	0
ML80D	D	267.2	5236	0	3,023	1	25,499	0	14,722	1	0	Carbon	1	0	1	1	15	0	1	Jun	W	23	29	0	1	0	0	0	0	1	T	1	0	0
ML80D	D	371.89	4690	0	2,231	0	14,672	0	6,626	0	0	Laramie	2	1	0	0	15	0	0	Aug	Su	14	33	0	1	0	0	0	0	1	T	1	0	0
ML80I	I	267.19	5155	0	2,667	0	25,105	0	12,988	0	0	Carbon	2	1	1	0	15	0	0	May	Sa	1	34	0	1	0	0	0	0	1	T	1	0	0
ML80D	D	267.2	5236	0	3,023	1	25,499	0	14,722	1	0	Carbon	2	1	1	0	15	0	0	Jul	W	24	34	0	1	0	0	0	0	1	T	1	0	0
ML80I	I	144.2	5688	0	3,048	1	26,608	0	14,259	1	1	Sweetwater	2	1	1	0	15	0	1	Jan	Su	17	38	0	0	1	0	0	0	1	P	0	0	0
ML80D	D	371.7	4690	0	2,231	0	14,672	0	6,626	0	0	Laramie	1	0	0	0	15	0	0	Aug	Su	9	42	0	0	1	0	0	0	1	T	1	0	0
ML80I	I	267.19	5155	0	2,667	0	25,105	0	12,988	0	0	Carbon	2	1	0	0	15	0	0	Sep	Su	7	42	0	0	1	0	0	0	1	T	1	0	0
ML80D	D	267.19	5236	0	3,023	1	25,499	0	14,722	1	0	Carbon	2	1	1	0	15	0	0	Jul	T	1	43	0	0	1	0	0	0	0	T	1	0	0
ML80I	I	267.19	5155	0	2,667	0	25,105	0	12,988	0	0	Carbon	1	0	1	0	15	0	0	Jun	M	4	45	0	0	1	0	0	0	1	P	0	0	0
ML80D	D	143	6110	0	3,342	1	28,583	1	15,634	1	0	Sweetwater	2	1	1	0	15	0	0	Sep	M	6	45	0	0	1	0	0	0	1	T	1	0	0
ML80I	I	267.4	5155	0	2,667	0	25,105	0	12,988	0	0	Carbon	1	0	0	0	15	0	0	May	F	13	47	0	0	0	1	0	0	1	T	1	0	0
ML80D	D	146.75	6110	0	3,342	1	28,583	1	15,634	1	0	Sweetwater	1	0	0	0	15	0	0	Dec	R	12	48	0	0	0	1	0	0	1	T	1	0	0
ML80I	I	267	5165	0	2,673	0	35,917	1	18,588	1	0	Carbon	2	1	1	0	15	0	0	Sep	Sa	23	50	0	0	0	1	0	0	1	T	1	0	0
ML80I	I	33.9	5758	0	2,355	0	8,977	0	3,671	0	0	Uinta	2	1	0	0	15	0	0	Apr	M	14	52	0	0	0	1	0	0	1	T	1	0	0
ML80D	D	323	6880	1	3,053	1	38,728	1	17,185	1	0	Albany	2	1	0	1	15	0	1	Dec	Su	6	52	0	0	0	1	0	0	1	T	1	0	0
ML80D	D	371.49	4690	0	2,231	0	14,672	0	6,626	0	0	Laramie	2	1	0	0	15	0	0	May	W	6	53	0	0	0	1	0	0	1	T	1	0	0
ML80D	D	267.2	5236	0	3,023	1	25,499	0	14,722	1	0	Carbon	1	0	1	0	15	0	0	Feb	W	17	57	0	0	0	0	1	0	1	P	0	0	1
ML80I	I	0.4	6031	0	2,481	0	13,449	0	5,533	0	0	Uinta	2	1	0	0	15	0	0	Jan	Sa	14	60	0	0	0	0	1	0	1	T	1	0	0
ML80I	I	215.57	6580	1	3,112	1	9,600	0	4,540	0	0	Carbon	2	1	0	0	15	0	0	May	W	13	73	0	0	0	0	0	1	1	T	1	0	0
ML80D	D	371.89	4690	0	2,231	0	14,672	0	6,626	0	.	Laramie	1	0	1	0	15	0	0	Feb	Sa	23	.	0	0	0	0	0	0	.	T	1	0	0
ML80I	I	267.1	5165	0	2,673	0	35,917	1	18,588	1	0	Carbon	2	1	1	0	15	0	0	Aug	T	5	.	0	0	0	0	0	0	.	T	1	0	0
ML80D	D	316.7	6800	1	2,676	0	23,875	0	9,395	0	0	Albany	1	0	0	0	20	0	0	May	M	12	17	1	0	0	0	0	0	1	P	0	0	0
ML80I	I	104.83	7430	1	3,086	1	16,576	0	6,885	0	0	Sweetwater	2	1	0	0	20	0	0	Feb	W	9	17	1	0	0	0	0	0	1	P	0	0	0
ML80I	I	359.6	8459	1	2,693	0	20,623	0	6,566	0	0	Laramie	1	0	0	1	20	0	1	Feb	T	7	18	1	0	0	0	0	0	0	P	0	0	0
ML80D	D	107	7639	1	3,498	1	17,043	0	7,804	0	0	Sweetwater	1	0	1	0	20	0	0	May	R	2	21	1	0	0	0	0	0	1	P	0	0	0
ML80D	D	3.45	6184	0	2,811	0	7,826	0	3,578	0	0	Uinta	2	1	0	0	20	0	1	Jan	M	15	24	1	0	0	0	0	0	1	P	0	0	0
ML80I	I	401.11	4490	0	2,109	0	45,219	1	21,240	1	0	Laramie	2	1	0	1	20	0	0	Aug	Su	7	25	1	0	0	0	0	0	1	T	1	0	0
ML80I	I	6.26	6035	0	2,474	0	3,217	0	1,319	0	0	Uinta	2	1	0	1	20	0	1	Oct	R	8	26	0	1	0	0	0	0	1	P	0	0	0
ML80I	I	215.57	6580	1	3,112	1	9,600	0	4,540	0	0	Carbon	1	0	1	0	20	0	0	Feb	T	23	27	0	1	0	0	0	0	1	P	0	0	1
ML80D	D	89.45	8130	1	3,295	1	16,967	0	6,877	0	0	Sweetwater	1	0	0	0	20	0	0	May	Su	7	29	0	1	0	0	0	0	1	T	1	0	0
ML80I	I	323	6810	1	2,806	0	38,333	1	15,795	1	0	Albany	1	0	1	0	20	0	1	Apr	Su	22	31	0	1	0	0	0	0	1	T	1	0	0
ML80I	I	144.2	5688	0	3,048	1	26,608	0	14,259	1	0	Sweetwater	2	1	0	0	20	0	1	Mar	W	11	32	0	1	0	0	0	0	1	P	0	0	0
ML80I	I	267.19	5155	0	2,667	0	25,105	0	12,988	0	0	Carbon	2	1	1	0	20	0	0	Sep	R	5	32	0	1	0	0	0	0	0	T	1	0	0
ML80D	D	313.19	8530	1	3,075	1	12,241	0	4,413	0	0	Albany	2	1	0	0	20	0	0	Jun	R	11	33	0	1	0	0	0	0	1	T	1	0	0

Sample Modeling I-25 Data Set

Section	Direction	Milepost	ADT	ADTm	ADTT	ADTTm	AVMT	AVMTm	TVMT	TVMTm	Severity	County	Vehicles	Vehiclesm	Lighting	Weather	Speed	Condition	Crash Date	Day of Week	Time	Age	14-25	26-35	36-45	46-55	56-65	66-75	Gender	Type	Known Truck	Known Motorcycle	Sobriety
25	D	0	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	1	0	1	0	1	0	5/28/2001	M	4	20	1	0	0	0	0	0	1	P	0	0	0
25	D	0.01	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	1	0	1	1	0	1	4/10/2001	T	.	26	0	1	0	0	0	0	1	P	0	0	0
25	D	0.01	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	2	1	0	0	1	0	10/5/2006	R	19	55	0	0	0	1	0	0	0	P	0	0	0
25	D	0.04	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	1	0	1	0	1	0	5/30/2002	R	23	35	0	1	0	0	0	0	0	P	0	0	0
25	D	0.06	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	2	1	0	0	0	0	4/14/2005	R	9	21	1	0	0	0	0	0	1	P	0	0	0
25	D	0.07	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	1	0	0	1	0	1	10/23/2002	W	12	31	0	1	0	0	0	0	1	P	0	0	0
25	D	0.1	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	2	1	0	1	0	1	12/5/2000	T	15	27	0	1	0	0	0	0	1	P	0	0	0
25	D	0.1	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	3	1	0	1	0	1	2/15/2006	W	10	42	0	0	1	0	0	0	1	P	0	0	0
25	D	0.1	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	1	0	0	1	0	1	4/29/2003	T	16	53	0	0	0	1	0	0	0	P	0	0	0
25	D	0.2	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	1	0	0	0	1	0	9/20/2004	M	8	40	0	0	1	0	0	0	1	P	0	0	0
25	D	0.25	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	1	0	1	0	1	0	2/29/2000	T	4	30	0	1	0	0	0	0	1	P	0	0	0
25	D	0.25	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	1	0	1	1	0	1	11/28/2004	Su	22	46	0	0	0	1	0	0	1	P	0	0	0
25	D	0.39	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	1	0	0	1	1	1	4/7/2007	Sa	10	24	1	0	0	0	0	0	1	P	0	0	0
25	D	0.43	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	1	0	0	0	1	0	6/29/2002	Sa	11	19	1	0	0	0	0	0	1	P	0	0	0
25	D	0.56	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	2	1	0	0	1	0	10/14/2001	Su	8	17	1	0	0	0	0	0	1	P	0	0	0
25	D	0.6	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	1	0	1	0	1	0	9/18/2002	W	22	41	0	0	1	0	0	0	0	P	0	0	1
25	D	0.75	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	1	0	0	0	1	0	10/29/2005	Sa	15	30	0	1	0	0	0	0	1	P	0	0	0
25	D	0.75	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	2	1	0	0	0	0	5/28/2007	M	16	73	0	0	0	0	0	1	1	P	0	0	0
25	D	1	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	1	0	0	0	1	0	9/20/2002	F	14	24	1	0	0	0	0	0	1	P	0	0	0
25	D	1.1	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	3	1	0	0	0	1	1/28/2009	W	16	52	0	0	0	1	0	0	1	T	1	0	0
25	D	1.11	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	1	0	0	0	0	0	9/15/2000	F	14	71	0	0	0	0	0	1	1	M	0	1	0
25	D	1.5	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	2	1	0	0	0	0	6/11/2008	W	14	24	1	0	0	0	0	0	1	P	0	0	0
25	D	1.5	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	2	1	1	1	0	1	9/11/2002	W	22	46	0	0	0	1	0	0	1	P	0	0	0
25	D	1.75	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	1	0	1	0	1	0	7/25/2002	R	24	19	1	0	0	0	0	0	0	P	0	0	0
25	D	1.8	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	2	1	0	1	0	1	4/23/2003	W	15	31	0	1	0	0	0	0	1	P	0	0	0
25	D	1.9	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	2	1	1	1	0	1	2/4/2010	R	6	46	0	0	0	1	0	0	1	P	0	0	0
25	D	1.91	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	1	0	1	0	1	1	11/4/2002	M	18	19	1	0	0	0	0	0	0	P	0	0	0
25	D	1.95	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	1	0	1	1	0	1	12/23/2009	W	2	19	1	0	0	0	0	0	1	P	0	0	0
25	D	2	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	2	1	0	1	0	1	7/21/2002	Su	13	41	0	0	1	0	0	0	0	P	0	0	0
25	D	2	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	1	0	1	0	0	0	10/29/2001	M	5	36	0	0	1	0	0	0	1	P	0	0	0
25	D	2	9,227	1	1,478	1	24,562	1	3,934	1	1	Laramie	2	1	1	1	0	1	12/8/2003	M	21	45	0	0	1	0	0	0	0	P	0	0	1
25	D	2	9,227	1	1,478	1	24,562	1	3,934	1	1	Laramie	1	0	0	1	0	1	3/20/2006	M	9	23	1	0	0	0	0	0	1	P	0	0	0
25	D	2	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	2	1	0	1	0	1	3/20/2006	M	17	43	0	0	1	0	0	0	0	P	0	0	0
25	D	2	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	1	0	0	1	0	1	1/23/2009	F	7	31	0	1	0	0	0	0	0	P	0	0	0
25	D	2	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	2	1	0	0	0	0	6/22/2001	F	6	31	0	1	0	0	0	0	1	P	0	0	0
25	D	2	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	2	1	1	0	0	0	9/12/2002	R	5	38	0	0	1	0	0	0	0	T	1	0	0
25	D	2	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	1	0	0	0	1	0	7/26/2001	R	17	45	0	0	1	0	0	0	1	P	0	0	0
25	D	2.1	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	2	1	0	1	0	1	12/22/2004	W	15	68	0	0	0	0	0	1	1	T	1	0	0
25	D	2.1	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	3	1	0	1	0	1	12/22/2004	W	15	54	0	0	0	1	0	0	1	T	1	0	0
25	D	2.1	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	6	1	0	1	0	1	12/22/2004	W	15	40	0	0	1	0	0	0	1	T	1	0	1
25	D	2.1	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	2	1	1	1	0	1	12/22/2009	T	23	62	0	0	0	0	1	0	1	P	0	0	0
25	D	2.1	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	8	1	0	1	0	1	12/22/2004	W	15	56	0	0	0	0	1	0	1	T	1	0	0
25	D	2.1	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	2	1	0	0	0	0	6/8/2006	R	.	.	.	.	.	.	.	.	.	.	0	0	0
25	D	2.1	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	2	1	0	1	0	1	10/9/2009	F	18	30	0	1	0	0	0	0	1	P	0	0	0
25	D	2.12	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	2	1	0	1	0	1	12/30/2000	Sa	15	45	0	0	1	0	0	0	0	P	0	0	0
25	D	2.12	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	1	0	0	0	1	0	9/20/2006	W	11	31	0	1	0	0	0	0	1	P	0	0	0
25	D	2.12	9,227	1	1,478	1	24,562	1	3,934	1	1	Laramie	2	1	0	1	0	1	12/30/2000	Sa	15	23	1	0	0	0	0	0	1	P	0	0	1
25	D	2.15	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	1	0	1	0	1	0	1/15/2005	Sa	22	51	0	0	0	1	0	0	1	P	0	0	0
25	D	2.2	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	1	0	0	0	0	0	12/13/2008	Sa	10	76	0	0	0	0	0	0	0	P	0	0	0
25	D	2.2	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	1	0	0	0	0	0	8/3/2003	Su	12	31	0	1	0	0	0	0	1	P	0	0	0
25	D	2.25	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	1	0	0	1	0	0	12/14/2006	R	10	49	0	0	0	1	0	0	1	T	1	0	0
25	D	2.25	9,227	1	1,478	1	24,562	1	3,934	1	0	Laramie	3	1	0	1	0	1	3/29/2007	R	13	55	0	0	0	1	0	0	1	P	0	0	0

APPENDIX C: MODELING OUTPUT

I-80 Logistic Regression Model Output

```
Table of Severity by Sobriety

Severity        Sobriety

Frequency,
Col Pct  ,       0,       1,  Total
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
       0 ,  18153 ,    509 ,  18662
         ,  93.16 ,  66.62 ,
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
       1 ,   1333 ,    255 ,   1588
         ,   6.84 ,  33.38 ,
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
Total       19486      764    20250

Frequency Missing = 59
```

```
Table of Severity by Condition

Severity       Road Condition

Frequency,
Col Pct  ,       0,       1,  Total
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
       0 ,   6508 ,  12116 ,  18624
         ,  88.80 ,  94.07 ,
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
       1 ,    821 ,    764 ,   1585
         ,  11.20 ,   5.93 ,
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
Total        7329    12880    20209

Frequency Missing = 100
```

```
Table of Severity by Lighting

Severity       Lighting

Frequency,
Col Pct  ,       0,       1,  Total
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
       0 ,  12174 ,   6465 ,  18639
         ,  91.77 ,  92.90 ,
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
       1 ,   1092 ,    494 ,   1586
         ,   8.23 ,   7.10 ,
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
Total       13266     6959    20225

Frequency Missing = 84
```

```
Table of Severity by Gender

Severity       Gender

Frequency,
Col Pct  ,       0,       1,  Total
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
       0 ,   4139 ,  14244 ,  18383
         ,  90.65 ,  92.54 ,
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
       1 ,    427 ,   1148 ,   1575
         ,   9.35 ,   7.46 ,
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
Total        4566    15392    19958

Frequency Missing = 351
```

```
Table of Severity by ADT

Severity      ADT

Frequency,
Col Pct  ,       0,       1,  Total
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
       0 ,   9147 ,   9515 ,  18662
         ,  91.35 ,  92.95 ,
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
       1 ,    866 ,    722 ,   1588
         ,   8.65 ,   7.05 ,
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
Total       10013    10237    20250

Frequency Missing = 59
```

```
Table of Severity by ADTT

Severity      ADTT

Frequency,
Col Pct  ,       0,       1,  Total
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
       0 ,   8905 ,   9757 ,  18662
         ,  91.23 ,  93.02 ,
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
       1 ,    856 ,    732 ,   1588
         ,   8.77 ,   6.98 ,
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
Total        9761    10489    20250

Frequency Missing = 59
```

```
Table of Severity by Motorcycle

Severity      Motorcycle

Frequency,
Col Pct  ,       0,       1,  Total
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
       0 ,  18612 ,     50 ,  18662
         ,  92.35 ,  52.08 ,
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
       1 ,   1542 ,     46 ,   1588
         ,   7.65 ,  47.92 ,
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
Total       20154       96    20250

Frequency Missing = 59
```

```
Table of Severity by Truck

Severity      Truck

Frequency,
Col Pct  ,       0,       1,  Total
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
       0 ,  12806 ,   5856 ,  18662
         ,  91.16 ,  94.42 ,
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
       1 ,   1242 ,    346 ,   1588
         ,   8.84 ,   5.58 ,
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
Total       14048     6202    20250

Frequency Missing = 59
```

Table of Severity by Vehicles

Severity (Frequency, Col Pct)	Vehicles 0	Vehicles 1	Total
0	13243	5419	18662
	92.42	91.52	
1	1086	502	1588
	7.58	8.48	
Total	14329	5921	20250

Frequency Missing = 59

Table of Severity by Speed

Severity (Frequency, Col Pct)	Speed 0	Speed 1	Total
0	1440	16835	18275
	94.86	91.87	
1	78	1489	1567
	5.14	8.13	
Total	1518	18324	19842

Frequency Missing = 467

The LOGISTIC Procedure

Model Information

Data Set	WORK.CRASH	
Response Variable	Severity	Severity
Number of Response Levels	2	
Model	binary logit	
Optimization Technique	Fisher's scoring	

Number of Observations Read	20309
Number of Observations Used	19566

Response Profile

Ordered Value	Severity	Total Frequency
1	1	1552
2	0	18014

Probability modeled is Severity=1.

NOTE: 743 observations were deleted due to missing values for the response or explanatory variables.

Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	10845.812	10107.724
SC	10853.693	10202.303
-2 Log L	10843.812	10083.724

The LOGISTIC Procedure

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	760.0874	11	<.0001
Score	1103.5074	11	<.0001
Wald	806.1141	11	<.0001

Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	-2.4233	0.1425	289.1329	<.0001
Lighting	1	-0.5100	0.1236	17.0134	<.0001
Condition	1	-0.5426	0.0560	93.7335	<.0001
Gender	1	-0.3397	0.0735	21.3829	<.0001
ADT	1	-0.2653	0.0576	21.2151	<.0001
ADTT	1	-0.1590	0.0571	7.7599	0.0053
Vehicles	1	0.2129	0.0606	12.3505	0.0004
Speed	1	0.7283	0.1268	32.9902	<.0001
Sobriety	1	1.7796	0.0891	398.5070	<.0001
Truck	1	-0.3451	0.0682	25.5860	<.0001
Motorcycle	1	2.1676	0.2316	87.5945	<.0001
Lighting*Gender	1	0.3853	0.1406	7.5124	0.0061

Odds Ratio Estimates

Effect	Point Estimate	95% Wald Confidence Limits	
Condition	0.581	0.521	0.649
ADT	0.767	0.685	0.859
ADTT	0.853	0.763	0.954
Vehicles	1.237	1.099	1.393
Speed	2.072	1.616	2.656
Sobriety	5.927	4.977	7.059
Truck	0.708	0.620	0.809
Motorcycle	8.737	5.549	13.757

The LOGISTIC Procedure

Association of Predicted Probabilities and Observed Responses

Percent Concordant	65.7	Somers' D	0.338
Percent Discordant	31.9	Gamma	0.346
Percent Tied	2.3	Tau-a	0.049
Pairs	27957728	c	0.669

Partition for the Hosmer and Lemeshow Test

		Severity = 1		Severity = 0	
Group	Total	Observed	Expected	Observed	Expected
1	1981	52	63.30	1929	1917.70
2	1901	82	80.54	1819	1820.46
3	1859	100	89.07	1759	1769.93
4	1968	123	105.08	1845	1862.92
5	1776	104	106.42	1672	1669.58
6	1917	120	126.40	1797	1790.60
7	1962	144	143.37	1818	1818.63
8	1965	160	165.19	1805	1799.81
9	1891	162	190.58	1729	1700.42
10	2346	505	482.06	1841	1863.94

Hosmer and Lemeshow Goodness-of-Fit Test

Chi-Square	DF	Pr > ChiSq
13.4717	8	0.0966

I-25 Logistic Regression Model Output

```
Table of Severity by Sobriety

Severity      Sobriety

Frequency,
Col Pct  ,       0,       1,  Total
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
       0 ,   7774 ,    306 ,   8080
         ,  93.11 ,  65.52 ,
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
       1 ,    575 ,    161 ,    736
         ,   6.89 ,  34.48 ,
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
Total        8349      467     8816

Frequency Missing = 1
```

```
Table of Severity by Lighting

Severity      Lighting

Frequency,
Col Pct  ,       0,       1,  Total
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
       0 ,   4763 ,   3317 ,   8080
         ,  91.56 ,  91.78 ,
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
       1 ,    439 ,    297 ,    736
         ,   8.44 ,   8.22 ,
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
Total        5202     3614     8816

Frequency Missing = 1
```

```
Table of Severity by Gender

Severity      Gender

Frequency,
Col Pct  ,       0,       1,  Total
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
       0 ,   2544 ,   5464 ,   8008
         ,  90.89 ,  91.99 ,
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
       1 ,    255 ,    476 ,    731
         ,   9.11 ,   8.01 ,
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
Total        2799     5940     8739

Frequency Missing = 78
```

```
Table of Severity by ADTT

Severity      ADTT

Frequency,
Col Pct  ,       0,       1,  Total
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
       0 ,   3934 ,   4146 ,   8080
         ,  90.11 ,  93.17 ,
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
       1 ,    432 ,    304 ,    736
         ,   9.89 ,   6.83 ,
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
Total        4366     4450     8816

Frequency Missing = 1
```

Table of Severity by Motorcycle

Severity / Frequency, Col Pct	Motorcycle 0	Motorcycle 1	Total
0	8041	39	8080
	92.03	49.37	
1	696	40	736
	7.97	50.63	
Total	8737	79	8816

Frequency Missing = 1

Table of Severity by Speed

Severity / Frequency, Col Pct	Speed 0	Speed 1	Total
0	5958	1962	7920
	93.53	86.39	
1	412	309	721
	6.47	13.61	
Total	6370	2271	8641

Frequency Missing = 176

```
The SAS System
15

The LOGISTIC Procedure

                     Model Information

Data Set                      WORK.CRASH
Response Variable             Severity             Severity
Number of Response Levels     2
Model                         binary logit
Optimization Technique        Fisher's scoring


Number of Observations Read        8817
Number of Observations Used        8575


          Response Profile

 Ordered                     Total
   Value     Severity     Frequency

       1            1           717
       2            0          7858

Probability modeled is Severity=1.

NOTE: 242 observations were deleted due to missing values for the response or explanatory
variables.
```

Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	4932.818	4475.293
SC	4939.875	4524.690
-2 Log L	4930.818	4461.293

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	469.5246	6	<.0001
Score	695.6623	6	<.0001
Wald	473.5705	6	<.0001

Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	-2.3789	0.0931	652.2184	<.0001
Lighting	1	-0.2699	0.0859	9.8630	0.0017
Gender	1	-0.3055	0.0863	12.5336	0.0004
ADTT	1	-0.4486	0.0856	27.4920	<.0001
Speed	1	0.7261	0.0857	71.8073	<.0001
Sobriety	1	1.9948	0.1168	291.7734	<.0001
Motorcycle	1	2.3587	0.2538	86.4008	<.0001

Odds Ratio Estimates

Effect	Point Estimate	95% Wald Confidence Limits	
Lighting	0.763	0.645	0.904
Gender	0.737	0.622	0.873
ADTT	0.639	0.540	0.755
Speed	2.067	1.747	2.445
Sobriety	7.351	5.847	9.242
Motorcycle	10.578	6.433	17.393

Association of Predicted Probabilities and Observed Responses

Percent Concordant	65.8	Somers' D	0.378
Percent Discordant	28.0	Gamma	0.403
Percent Tied	6.2	Tau-a	0.058
Pairs	5634186	c	0.689

Partition for the Hosmer and Lemeshow Test

		Severity = 1		Severity = 0	
Group	Total	Observed	Expected	Observed	Expected
1	680	28	21.93	652	658.07
2	1442	59	60.52	1383	1381.48
3	1141	70	54.45	1071	1086.55
4	838	37	46.96	801	791.04
5	1142	72	73.02	1070	1068.98
6	761	50	53.69	711	707.31
7	1057	77	95.73	980	961.27
8	749	96	91.23	653	657.77
9	765	228	219.47	537	545.53

Hosmer and Lemeshow Goodness-of-Fit Test

Chi-Square	DF	Pr > ChiSq
13.7434	7	0.0559

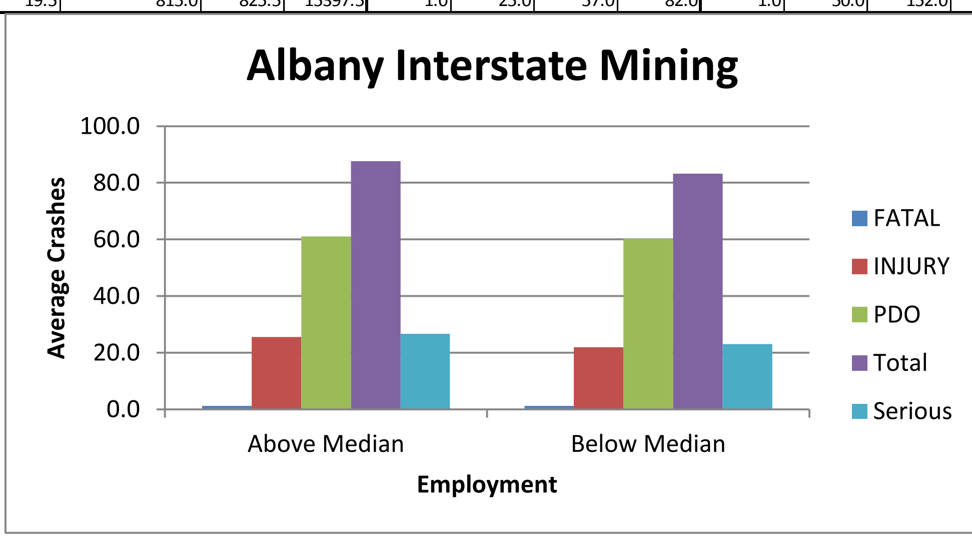
APPENDIX D: ENFORCEMENT DATA

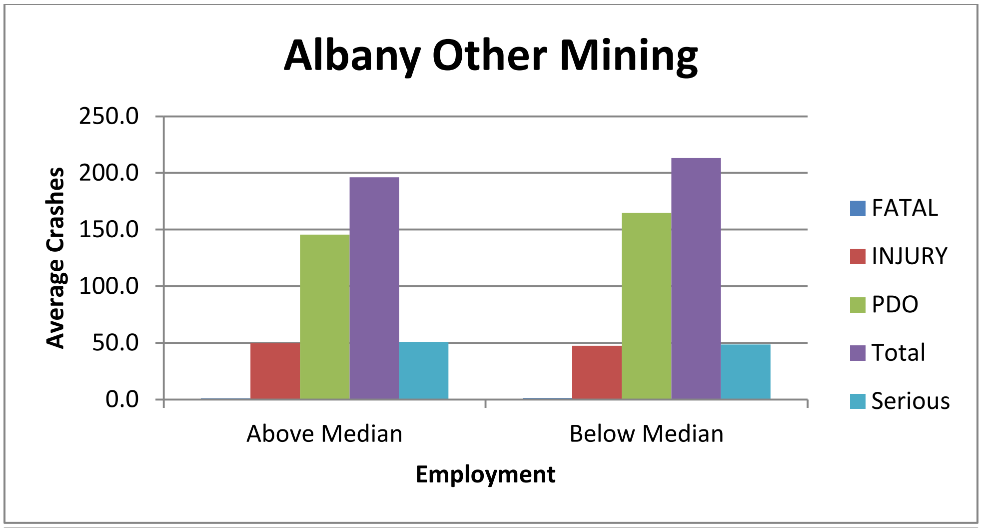
	North Dakota (2000)	North Dakota (2001)	North Dakota (2002)	North Dakota (2003)	North Dakota (2004)	North Dakota (2005)	North Dakota (2006)	North Dakota (2007)	North Dakota (2008)	North Dakota (2009)
Sworn Officers	125	132	132	126	127	131	133	138	135	134
Hours spent patrolling	115247	113232	112175	102762	104202					
Miles Of Interstate										
Miles Of Highway										
Percent Time Spent patrolling	54.4	53.9	56.3	54.3	58.1	62.0	68.0	62.0	67.0	64
Receipts	12,795,135	14,824,475	14,569,993	15,101,335	14,058,113	17,156,067	15,455,016	17,717,542	18,108,186	19,638,979
Disbursements	12,788,108	14,819,864	14,564,746	15,086,115	14,049,600	17,151,661	15,451,134	17,715,668	18,100,077	19,621,398
Fatalities (total system)	86	105	97	105	100	123	111	111	104	140
Fatal Crashes	80	96	85	95	95	105	101	95	97	116
Injury Crashes	3152	3127	3252	3244	2701	2738	2679	3001	3062	3174
Property Damage Only	11287	11531	12778	13212	14125	12974	12170	13133	13226	14376
Fatality Victims Using Safety Belts	10	23	21	15	23	25	33	25	17	40
Activity Hours										
Weigh in Motion				22	396			1	1	1
Truck Enforcement	80742	78715	69557	63394	49884	21	22	21	17	17
Sobriety checkpoints			587	4892	4258	1	1	1	1	0
Roadside Reporting					2095	4	3	3	3	3
Traffic details	6882	8140	7411	8158	7372	6	4	5	5	8
Patrol Enforcement	115247	113232	112175	102762	104202	62	68	62	67	64
Supervison						6	1	3	3	3
Accident Investigation	9058	9940	9673	10191	11135		1	4	3	4
Total	211929	210027	199403	189419	179342	100	100	100	100	100
Contacts										
Total Citations	62934	65486	67244	69588	71010	70951	77237	71119	67137	69,632
Warnings	52523	48018	40564	40177	37367	39084	41237	38510	36013	35508
Highway Assists	10337	8668	6587	7648	9028	8392	6726	6431	5102	3622
Accident Investigations	3497	4004	4077	4129	4294	3951	3935	3951	3861	4075
Motor Carrier Inspections	18650	17282	14258	15498	17064	18281	18766	17207	15129	14834
Total Contacts	147941	143458	132730	136740	138763	147981	155436	151765	141025	144563
Right of way violations							2703	2446	2818	3,705
Speeding Citations	42660	44250	44890	45510	45370	41570	44070	38820	36161	36,366
Criminal arrests							6485	6808	6179	6,609
DUI Arrests	1000	1042	1127	1434	1627	1810	1895	2008	1933	2,006
Child Restraint Citations	829	791	867	1039	1067	1176	1467	1143	917	1,042
Seatbelt Citations							10337	9785	9418	10,028
Percent Seatbelt usage										
Motor vehicle Inspectors	36	37	36	33	10	16	15	13	13	11
Total Motor Carrier permits	112056	109681	110546	117407	123927	125711		85887		137,830
Total Motor carrier driver violations	11461	10217	8001	9500	13524	13066	14374	13298	11037	9,031
Total Hazardous material violations	43	77	103	86	191	253	260	191	244	167
Total Employed	161	169	168	159	137	147	148	151	148	145

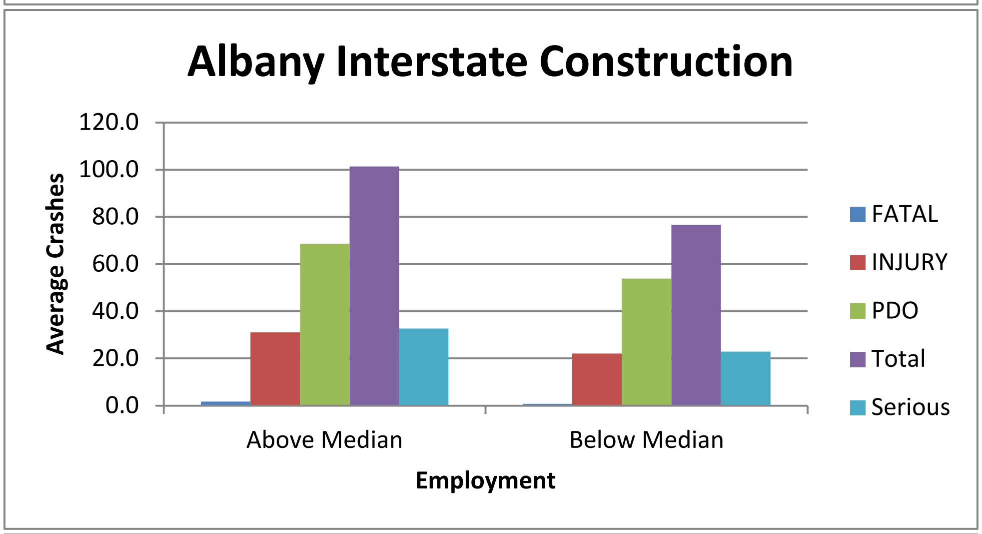
	Wyoming (2000)	Wyoming (2001)	Wyoming (2002)	Wyoming (2003)	Wyoming (2004)	Wyoming (2005)	Wyoming (2006)	Wyoming (2007)	Wyoming (2008)	Wyoming (2009)
Sworn Officers	147	166	168	177	182	186	190	196	204	202
Hours spent patrolling	119,003	116,427	119,551	123,674	123,489	128,416	124,477	129,627	137,408	139,321
Miles Of Interstate										
Miles Of Highway										
Percent Time Spent patrolling	42.2	39.2	37.4	40.3	38.6	39.5	36.8	38.2	38.1	38.4
Receipts										
Disbursements										
Fatalities (total system)										134
Fatal Crashes										116
Injury Crashes										3,361
Property Damage Only										11,801
Fatality Victims Using Safety Belts										30
Activity Hours										
Weigh in Motion										
Truck Enforcement	6,589	8,000	7,809	7,676	7,460	8,929	7,503	7,890	8,052	10,775
Sobriety checkpoints										
Roadside Reporting										
Traffic details										
Patrol Enforcement	119,003	116,427	119,551	123,674	123,489	128,416	124,477	129,627	137,408	139,321
Supervison										
Accident Investigation	14,796	14,585	15,511	15,646	15,006	14,176	15,888	16,959	19,650	17,431
Total										
Contacts										
Total Citations	73,671	77,780	77,165	73,541	76,584	85,051	82,363	88,601	86,455	84,038
Warnings	90,918	89,824	97,440	105,985	106,667	112,649	116,684	110,464	106,781	111,972
Highway Assists	7,372	7,444	7,539	8,528	8,153	8,885	9,401	9,496	11,067	8,372
Accident Investigations	6,289	6,014	6,190	6,623	6,308	6,255	7,256	7,424	7,608	6,594
Motor Carrier Inspections				20,162	18,676	19,899	18,486	17,835	17,211	19,517
Total Contacts	186,791	190,222	198,331	204,175	206,938	224,037	225,490	226,520	222,335	222,503
Right of way violations										
Speeding Citations	49,768	52,444	50,381	45,779	48,936	55,331	51,650	55,834	51,556	51,954
Criminal arrests										
DUI Arrests	1,233	1,076	1,021	1,110	1,081	1,174	1,375	1,497	1,631	1,358
Child Restraint Citations	399	307	323	428	564	568	660	705	675	687
Seatbelt Citations	913	1,583	2,209	3,141	3,954	3,643	3,523	4,196	5,592	5,768
Percent Seatbelt usage										
Motor vehicle Inspectors										
Total Motor Carrier permits	1,523	637	512	629	573	704	611	734	823	
Total Motor Carrier Driver Violations				18,344	17,712	18,189	16,846	16,031	15,634	16,706
Total Hazardous Material Violations				601	753	611	475	580	494	731
Total Employed										
Population	494,300	494,657	500,017	503,453	509,106	514,157	522,667	534,876	546,043	559,851

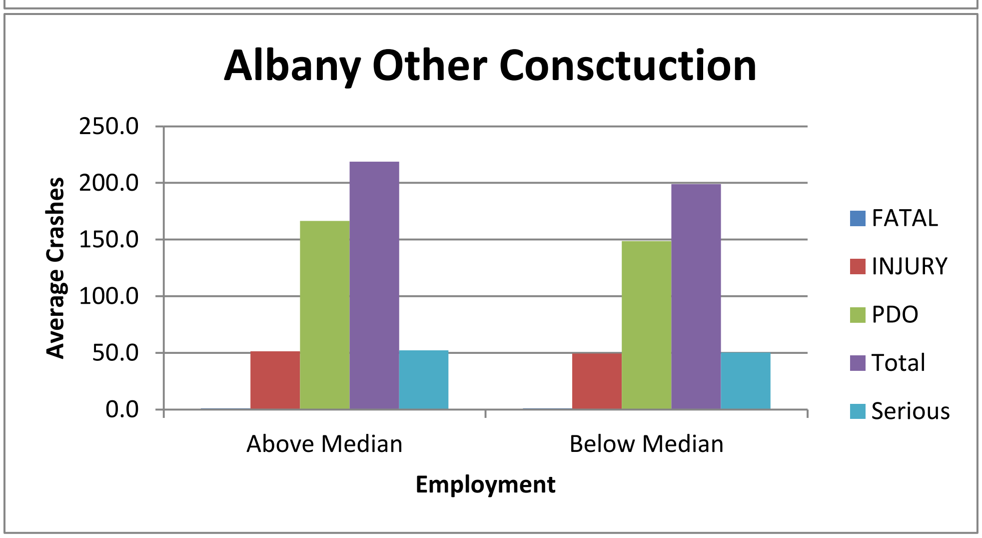
APPENDIX E: ECONOMIC DATA

Albany County													
	Employment				INTERSTATE CRASHES				Other Crashes				Total
	Mining	Construction	M+C	Total	FATAL	INJURY	PDO	Total	FATAL	INJURY	PDO	Total	
2002.00	5	673	678	14358	2	33	60	95	1	43	73	117	212
2002.25	6	784	790	14642	2	25	55	82	2	53	69	124	206
2002.50	10	846	856	14128	2	16	24	42	2	55	78	135	177
2002.75	12	756	768	14917	1	32	67	100	1	58	87	146	246
2003.00	32	613	645	14737	2	31	90	123	1	54	205	260	383
2003.25	26	714	740	14928	1	25	40	66	2	45	144	191	257
2003.50	27	773	800	14703	3	16	34	53	2	75	157	234	287
2003.75	31	707	738	15388	2	35	81	118	1	64	251	316	434
2004.00	21	654	675	16557	0	27	55	82	1	46	213	260	342
2004.25		771	771	16910	1	32	38	71	0	46	140	186	257
2004.50		808	808	16664	4	30	45	79	1	71	158	230	309
2004.75		768	768	17028	2	43	77	122	0	63	217	280	402
2005.00	13	709	722	16755	4	25	59	88	1	45	217	263	351
2005.25	17	822	839	17121	1	23	47	71	2	60	138	200	271
2005.50	15	880	895	15163	0	18	32	50	0	57	159	216	266
2005.75	15	797	812	15566	0	35	91	126	0	51	213	264	390
2006.00	14	780	794	15038	2	34	89	125	1	45	174	220	345
2006.25	15	902	917	15421	0	12	23	35	0	50	111	161	196
2006.50		944	944	14875	1	22	31	54	1	55	147	203	257
2006.75		864	864	15397	1	65	111	177	1	57	198	256	433
2007.00		779	779	15222	1	61	130	192	0	47	240	287	479
2007.25		944	944	15589	0	20	37	57	1	51	98	150	207
2007.50		1032	1032	15127	0	16	37	53	1	60	128	189	242
2007.75	19	966	985	15528	0	32	89	121	1	55	230	286	407
2008.00	19	839	858	15362	1	30	102	133	1	50	201	252	385
2008.25	20	985	1005	15768	0	18	72	90	1	49	130	180	270
2008.50	23	1024	1047	15398	1	8	24	33	2	43	136	181	214
2008.75	25	948	973	15884	1	25	87	113	0	46	159	205	318
2009.00	18	837	855	15555	0	16	55	71	0	25	141	166	237
2009.25	22	916	938	15734	1	12	48	61	0	42	119	161	222
2009.50	21	1068	1089	15626	0	12	20	32	1	48	139	188	220
2009.75	23	956	979	15818	3	31	77	111	1	38	214	253	364
2010.00	21	677	698	15028	0	31	88	119	1	35	165	201	320
2010.25	23	771	794	15255	1	13	67	81	2	31	109	142	223
Average	19.0	832.6	847.1	15505.6	1.2	26.6	61.2	89.0	0.9	50.4	157.6	208.9	297.9
ST. DEV.	6.6	116.5	115.7	748.5	1.1	12.5	28.0	38.8	0.7	10.4	50.1	52.2	81.4
Median	19.5	815.0	825.5	15397.5	1.0	25.0	57.0	82.0	1.0	50.0	152.0	202.0	270.5

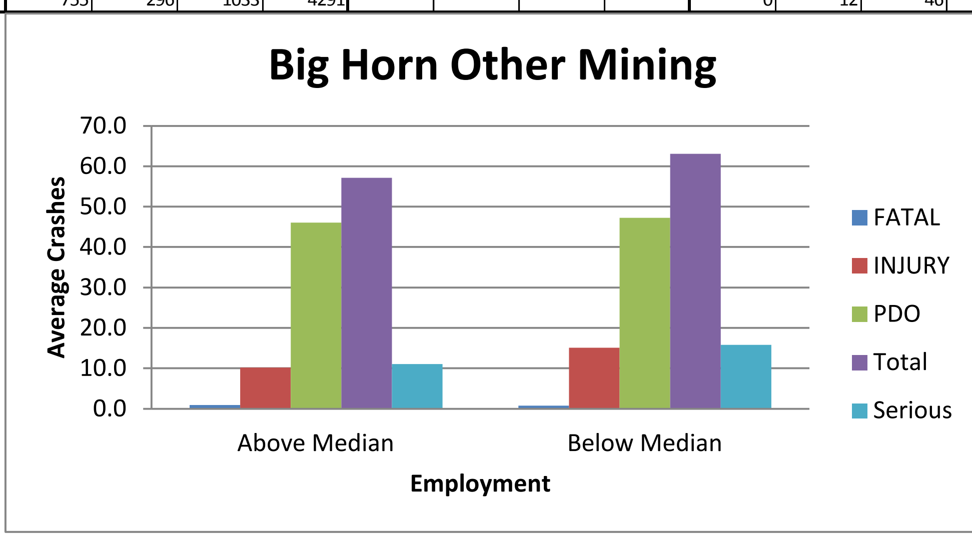


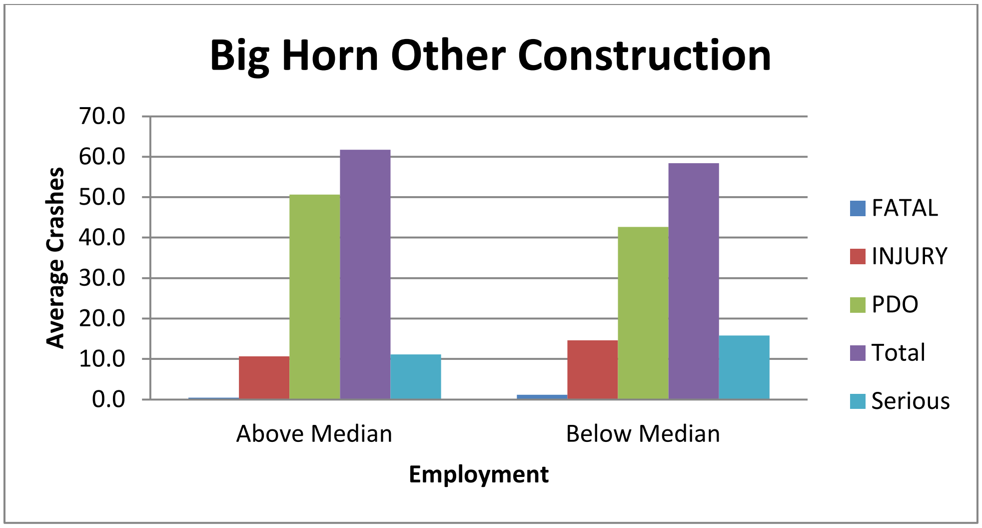

Albany Other Mining
Average Crashes
250.0
200.0
150.0
100.0
50.0
0.0
Above Median
Below Median
Employment
FATAL
INJURY
PDO
Total
Serious


Albany Interstate Construction
Average Crashes
120.0
100.0
80.0
60.0
40.0
20.0
0.0
Above Median
Below Median
Employment
FATAL
INJURY
PDO
Total
Serious

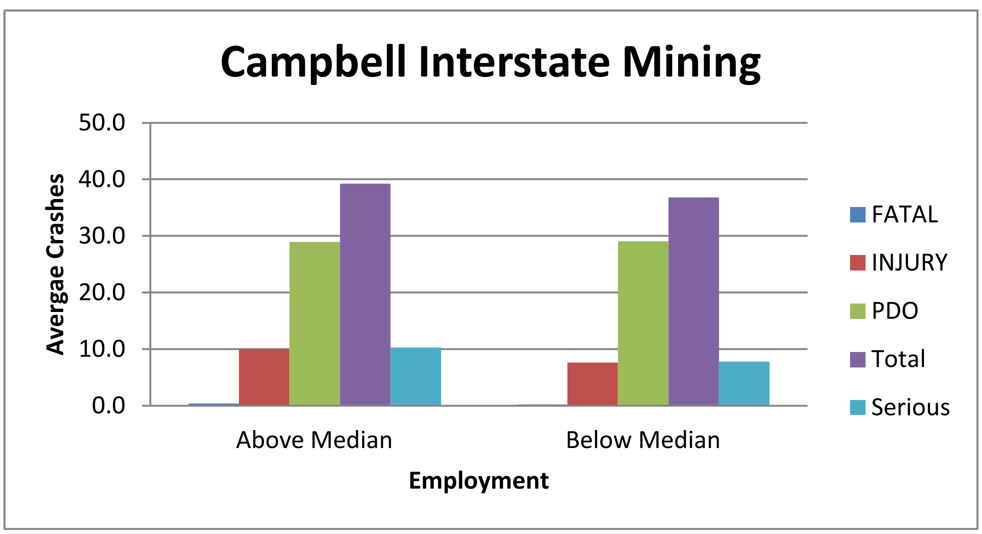

Albany Other Consctuction
Average Crashes
250.0
200.0
150.0
100.0
50.0
0.0
Above Median
Below Median
Employment
FATAL
INJURY
PDO
Total
Serious

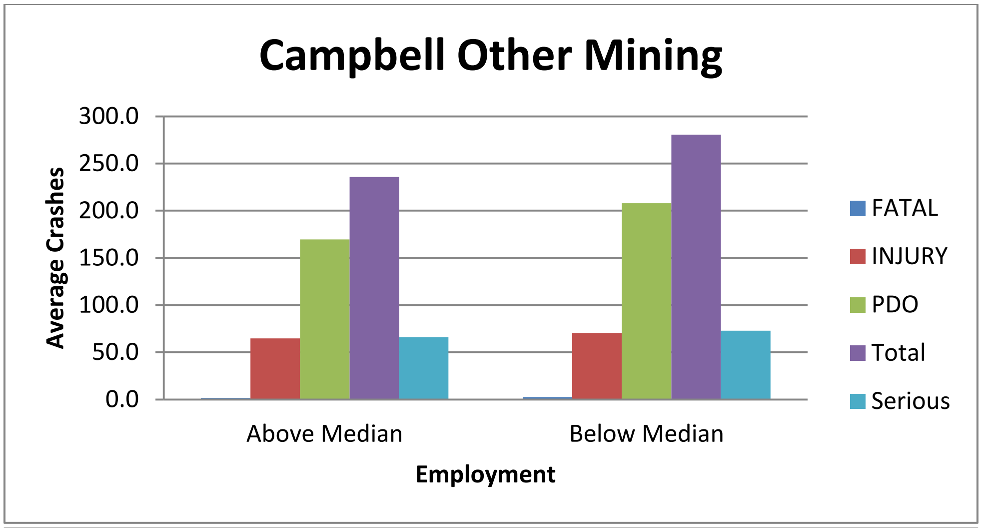
Big Horn County													
	Employment				INTERSTATE CRASHES				Other Crashes				Total
	Mining	onstructio	M+C	Total	FATAL	INJURY	PDO	Total	FATAL	INJURY	PDO	Total	
2002.00	762	197	959	3996					0	8	41	49	49
2002.25	709	267	976	4189					1	9	40	50	50
2002.50	760	303	1063	4100					3	20	36	59	59
2002.75	787	248	1035	4175					1	14	76	91	91
2003.00	732	198	930	4000					0	12	46	58	58
2003.25	750	273	1023	4280					1	10	49	60	60
2003.50	781	304	1085	4178					0	27	49	76	76
2003.75	824	278	1102	4302					0	13	59	72	72
2004.00	796	231	1027	4235					0	12	36	48	48
2004.25	828	320	1148	4455					3	14	31	48	48
2004.50	887	329	1216	4400					0	18	46	64	64
2004.75	939	285	1224	4360					1	9	63	73	73
2005.00	944	250	1194	4168					0	11	45	56	56
2005.25	951	334	1285	4560					2	13	29	44	44
2005.50	994	347	1341	4572					2	25	39	66	66
2005.75	1024	297	1321	4524					0	14	56	70	70
2006.00	1057	247	1304	4395					0	5	30	35	35
2006.25	1081	332	1413	4724					0	6	45	51	51
2006.50	1168	335	1503	4826					1	25	43	69	69
2006.75	1163	274	1437	4666					0	22	79	101	101
2007.00	630	267	897	3930					0	16	51	67	67
2007.25	657	340	997	4371					0	13	41	54	54
2007.50	680	335	1015	4360					0	14	52	66	66
2007.75	707	322	1029	4322					1	12	66	79	79
2008.00	728	249	977	4049					3	6	52	61	61
2008.25	723	329	1052	4394					2	8	20	30	30
2008.50	745	366	1111	4394					4	10	46	60	60
2008.75	713	318	1031	4326					1	8	49	58	58
2009.00	609	237	846	3913					0	7	47	54	54
2009.25	459	295	754	4063					1	7	29	37	37
2009.50	479	318	797	4197					1	15	47	63	63
2009.75	500	289	789	4158					0	14	76	90	90
2010.00	532	238	770	3884					0	6	42	48	48
2010.25	550	307	857	4252					0	6	30	36	36
Average	784	290	1074	4286					1	13	47	60	60
St. Deviation	187	43	197	230					1	6	14	16	16
Median	755	296	1033	4291					0	12	46	60	60

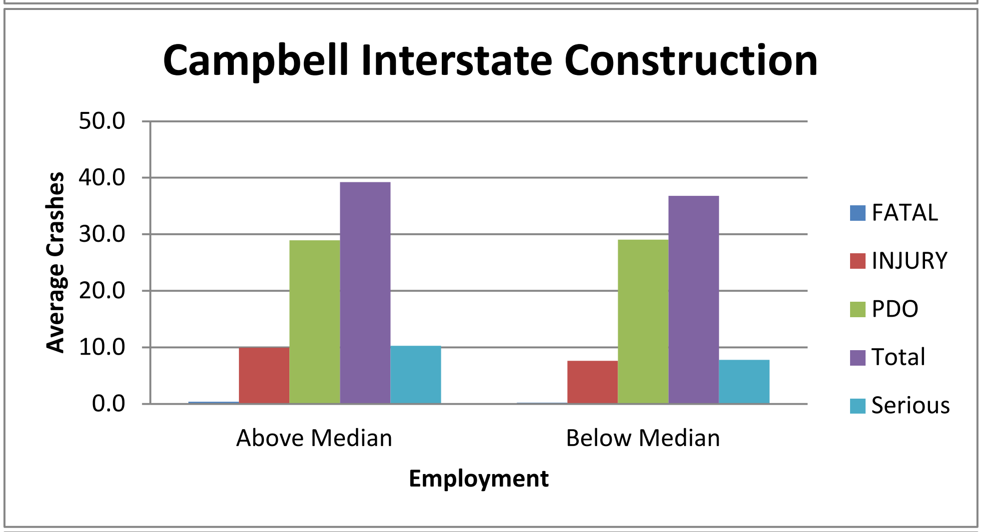


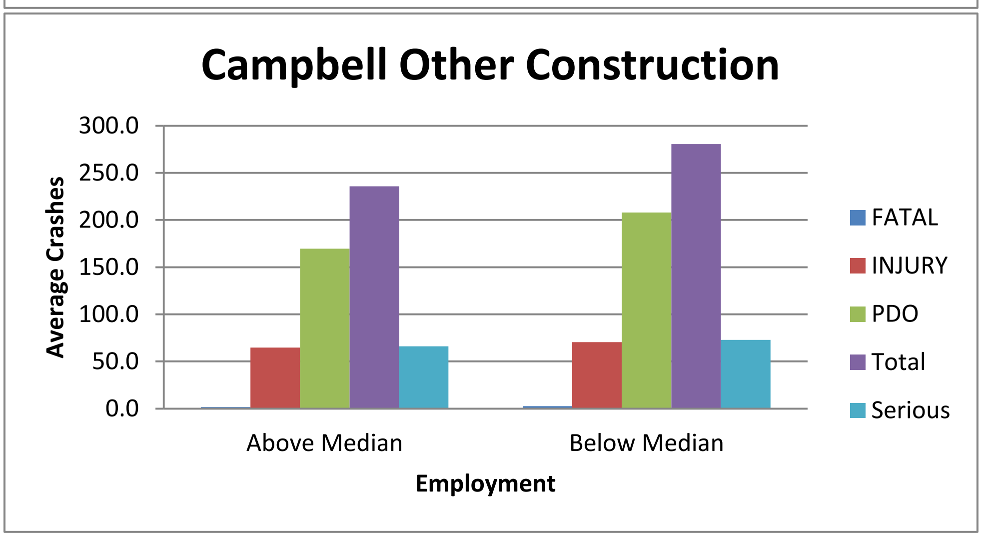

Big Horn Other Construction
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Average Crashes
Above Median
Below Median
Employment
FATAL
INJURY
PDO
Total
Serious

Campbell County													
	Employment				INTERSTATE CRASHES				Other Crashes				Total
	Mining	Construction	M+C	Total	FATAL	INJURY	PDO	Total	FATAL	INJURY	PDO	Total	
2002	6174	1923	8097	20473	0	10	28	38	0	61	210	271	309
2002.25	6070	2282	8352	21081	0	15	28	43	2	69	168	239	282
2002.5	6306	2453	8759	21252	0	11	31	42	0	80	168	248	290
2002.75	6055	2144	8199	20686	1	10	25	36	1	67	183	251	287
2003	5806	1806	7612	20021	1	10	27	38	0	58	187	245	283
2003.25	5870	1946	7816	20683	0	6	23	29	1	44	114	159	188
2003.5	6150	2213	8363	21083	0	9	44	53	5	87	157	249	302
2003.75	6105	1898	8003	20923	0	10	32	42	2	64	197	263	305
2004	5972	1789	7761	20638	0	5	11	16	0	49	128	177	193
2004.25	6120	2095	8215	21561	0	8	23	31	2	65	132	199	230
2004.5	6459	2111	8570	21604	0	9	34	43	1	60	131	192	235
2004.75	6382	1979	8361	21619	2	11	45	58	4	55	180	239	297
2005	6365	1938	8303	21907	0	12	23	35	1	57	175	233	268
2005.25	6583	2311	8894	23044	0	7	23	30	0	65	168	233	263
2005.5	7013	2622	9635	23637	0	9	40	49	2	79	155	236	285
2005.75	7099	2710	9809	23962	1	15	33	49	2	69	252	323	372
2006	7353	2573	9926	24450	1	12	22	35	1	72	175	248	283
2006.25	7746	2813	10559	25746	1	14	36	51	5	85	191	281	332
2006.5	7969	2992	10961	25812	0	6	35	41	3	85	186	274	315
2006.75	7624	3234	10858	26436	0	10	43	53	4	73	230	307	360
2007	7501	3323	10824	26615	0	8	20	28	0	72	262	334	362
2007.25	7656	3426	11082	27279	0	4	35	39	4	76	168	248	287
2007.5	7874	3655	11529	27274	1	8	29	38	5	78	190	273	311
2007.75	7871	3701	11572	27877	0	9	33	42	3	95	224	322	364
2008	7882	3664	11546	28031	0	13	38	51	5	69	298	372	423
2008.25	8138	3884	12022	28968	0	13	29	42	1	57	174	232	274
2008.5	8524	4513	13037	29327	1	4	28	33	5	81	187	273	306
2008.75	8470	4482	12952	30137	0	2	34	36	2	79	262	343	379
2009	8217	3810	12027	29103	0	8	22	30	4	53	278	335	365
2009.25	7961	4120	12081	29411	0	4	17	21	0	67	153	220	241
2009.5	7988	4357	12345	28545	0	5	37	42	1	65	158	224	266
2009.75	7750	3893	11643	28364	0	9	30	39	0	58	222	280	319
2010	7700	3303	11003	27351	0	6	11	17	0	51	185	236	253
2010.25	7752	3339	11091	27755	0	6	17	23	0	51	164	215	238
Average	7133	2921	10053	24784	0	9	29	38	2	68	189	258	296
St. Deviat	878	866	1717	3396	1	3	9	10	2	12	44	48	53
Median	7427	2762	10243	25098	0	9	29	39	2	67	182	248	289

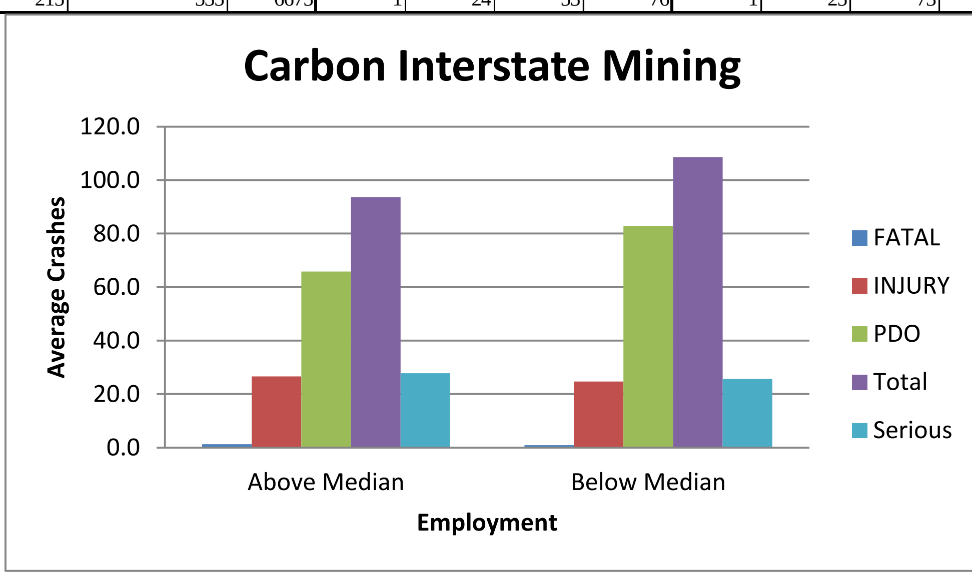


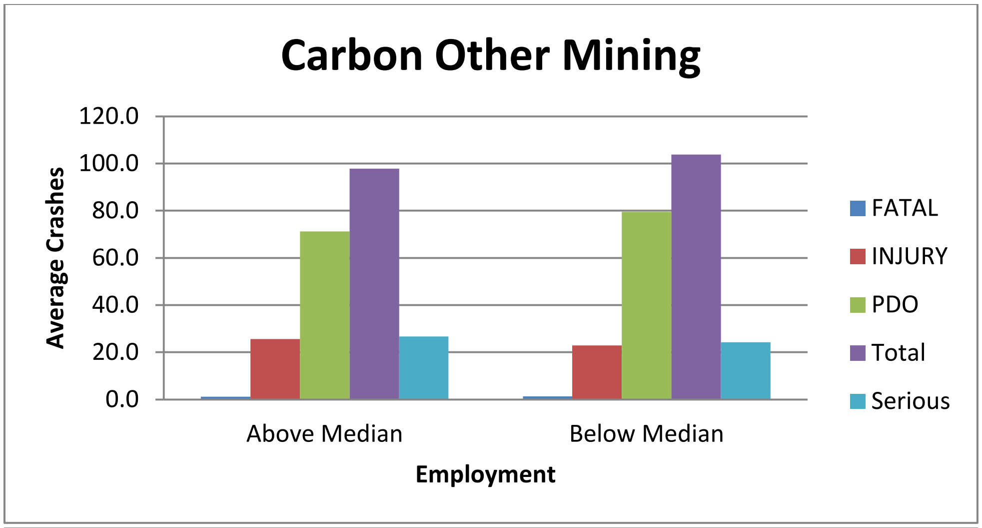

Campbell Other Mining
300.0
250.0
200.0
150.0
100.0
50.0
0.0
Average Crashes
Above Median
Below Median
Employment
FATAL
INJURY
PDO
Total
Serious


Campbell Interstate Construction
50.0
40.0
30.0
20.0
10.0
0.0
Average Crashes
Above Median
Below Median
Employment
FATAL
INJURY
PDO
Total
Serious

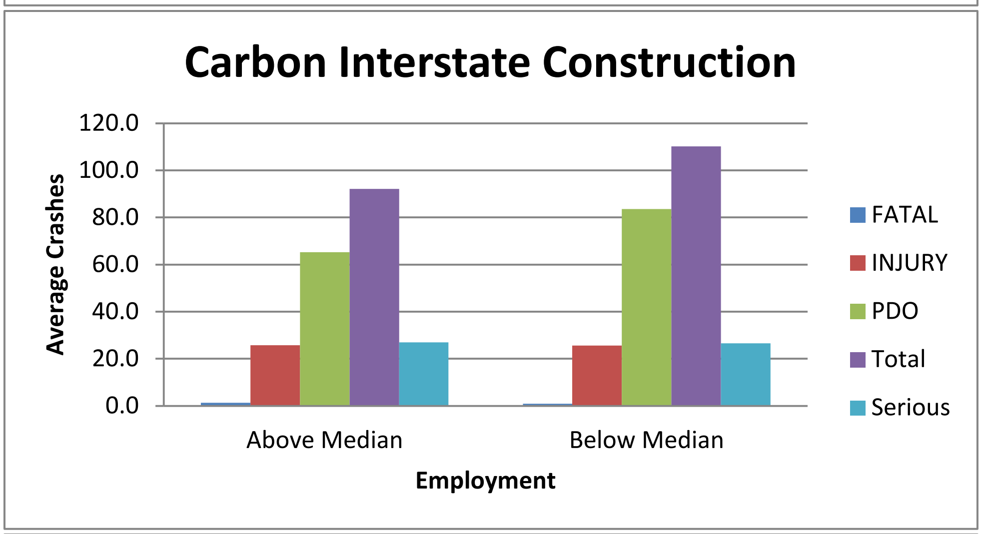

Campbell Other Construction
300.0
250.0
200.0
150.0
100.0
50.0
0.0
Average Crashes
Above Median
Below Median
Employment
FATAL
INJURY
PDO
Total
Serious

Carbon County													
	Employment			INTERSTATE CRASHES				Other Crashes				Total
	Mining	Construction	Total	FATAL	INJURY	PDO	Total	FATAL	INJURY	PDO	Total	
2002.00	138	301	5951	0	35	98	133	0	12	70	82	215
2002.25	163	391	6489	2	17	38	57	3	25	55	83	206
2002.50	149	424	6626	2	20	28	50	1	34	74	109	177
2002.75	141	354	6274	2	33	89	124	3	29	66	98	246
2003.00	108	302	5910	0	35	116	151	2	10	73	85	383
2003.25	105	404	6365	2	25	42	69	1	27	64	92	257
2003.50	112	521	6483	1	23	36	60	3	26	57	86	287
2003.75	115	424	6189	0	51	112	163	0	34	88	122	434
2004.00	152	266	5917	1	32	50	83	0	14	63	77	342
2004.25	173	397	6550	2	27	35	64	0	24	61	85	257
2004.50	193	418	6548	2	13	40	55	3	43	90	136	309
2004.75	179	397	6312	3	31	70	104	0	23	94	117	402
2005.00	184	428	6170	0	19	67	86	1	18	56	75	351
2005.25	208	525	6655	3	17	44	64	0	38	46	84	271
2005.50	220	595	6749	0	17	35	52	0	34	89	123	266
2005.75	202	640	6556	0	36	126	162	1	30	108	139	390
2006.00	162	626	6397	1	29	96	126	0	19	66	85	345
2006.25	210	726	6947	0	9	32	41	1	28	79	108	196
2006.50	221	1168	7582	3	17	48	68	2	34	92	128	257
2006.75	291	1210	7509	3	46	148	197	3	20	123	146	433
2007.00	246	952	7100	0	30	87	117	1	29	92	122	479
2007.25	244	1103	7616	1	25	46	72	0	34	75	109	207
2007.50	257	1296	7859	1	15	45	61	2	38	83	123	242
2007.75	251	1710	8205	2	40	167	209	1	27	125	153	407
2008.00	451	1505	7802	0	75	290	365	0	29	136	165	385
2008.25	445	1024	7782	0	16	63	79	2	20	48	70	270
2008.50	455	971	7776	1	13	38	52	2	21	73	96	214
2008.75	467	908	7430	0	37	80	117	1	20	87	108	318
2009.00	335	513	6695	0	28	123	151	1	14	63	78	237
2009.25	276	544	6961	1	11	43	55	1	15	46	62	222
2009.50	265	573	7045	1	12	27	40	2	16	65	83	220
2009.75	283	501	6695	0	18	65	83	1	20	76	97	364
2010.00	289	462	4428	1	13	55	69	1	6	42	49	320
2010.25	275	785	7027	2	7	50	59	3	12	37	52	223
Average	234	687	6782	1	26	74	101	1	24	75	101	298
St. Deviatio	101	369	748	1	14	53	65	1	9	24	28	81
Median	215	535	6675	1	24	53	76	1	25	73	97	271

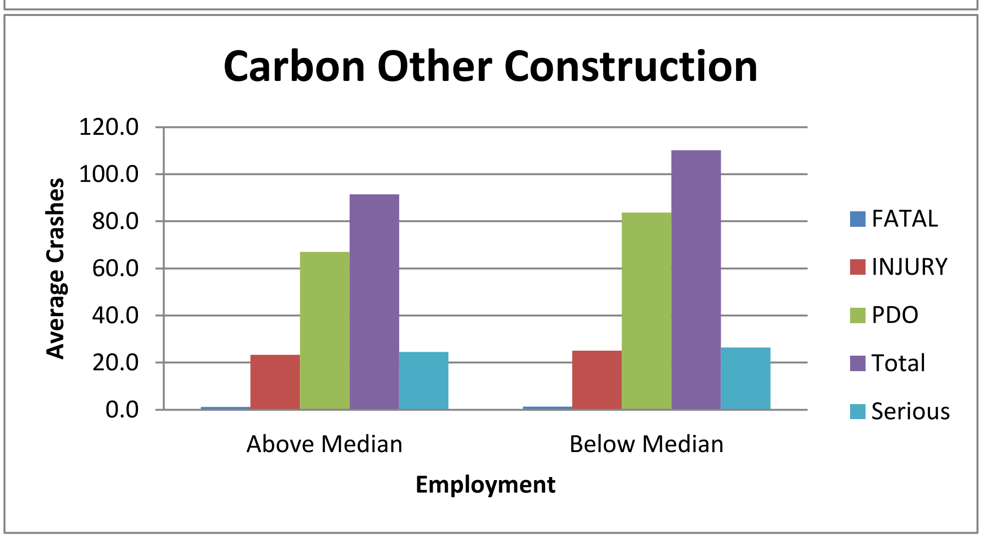




Carbon Other Mining
Average Crashes
120.0
100.0
80.0
60.0
40.0
20.0
0.0
Above Median
Below Median
Employment
FATAL
INJURY
PDO
Total
Serious

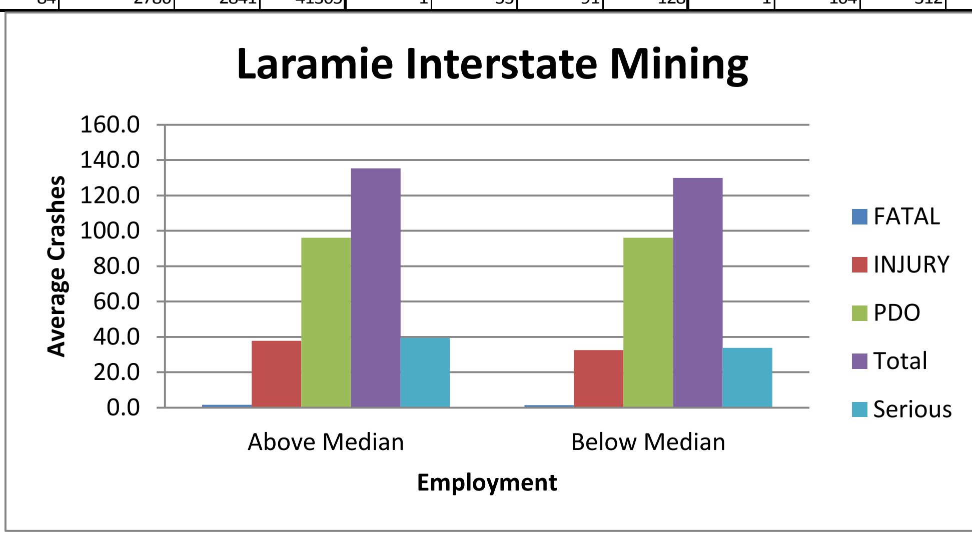


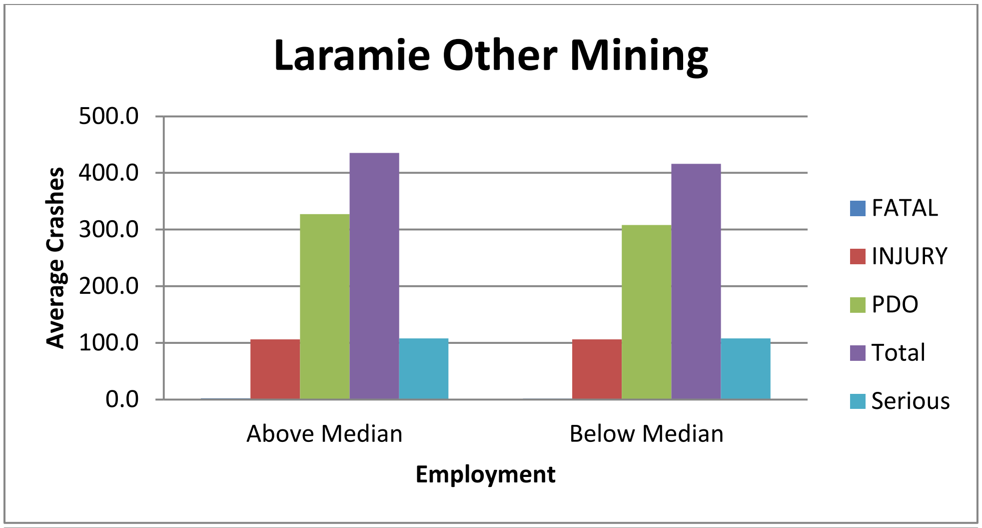
Carbon Interstate Construction
Average Crashes
120.0
100.0
80.0
60.0
40.0
20.0
0.0
Above Median
Below Median
Employment
FATAL
INJURY
PDO
Total
Serious



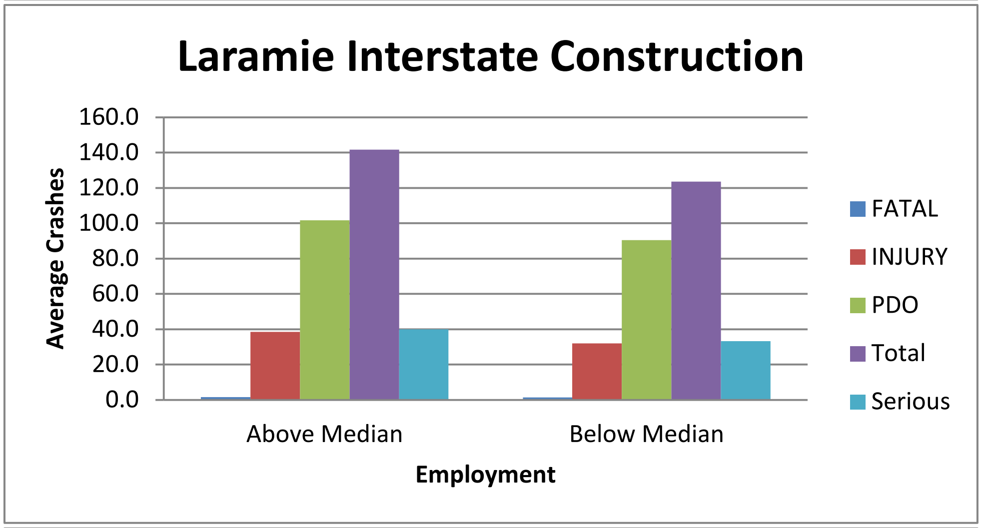
Carbon Other Construction
Average Crashes
120.0
100.0
80.0
60.0
40.0
20.0
0.0
Above Median
Below Median
Employment
FATAL
INJURY
PDO
Total
Serious

Laramie County													
	Employment				INTERSTATE CRASHES				Other Crashes				Total
	Mining	Construction	M+C	Total	FATAL	INJURY	PDO	Total	FATAL	INJURY	PDO	Total	
2002.00	78	2059	2137	36080	0	38	91	129	3	77	332	412	541
2002.25	82	2580	2662	38151	2	48	89	139	2	118	318	438	577
2002.50	88	2623	2711	38669	6	41	81	128	3	120	398	521	649
2002.75	79	2468	2547	38532	3	47	146	196	4	100	394	498	694
2003.00	85	2187	2272	37974	0	32	110	142	0	90	340	430	572
2003.25	35	2672	2707	39272	1	29	89	119	2	115	319	436	555
2003.50	36	2768	2804	39636	0	29	88	117	1	130	356	487	604
2003.75	76	2627	2703	39641	2	64	152	218	0	146	421	567	785
2004.00	73	2318	2391	38808	3	42	93	138	1	83	303	387	525
2004.25	73	2626	2699	39944	5	44	88	137	3	101	350	454	591
2004.50	74	2804	2878	39682	3	28	77	108	3	142	345	490	598
2004.75	73	2664	2737	39718	2	61	145	208	2	87	391	480	688
2005.00	70	2449	2519	39229	1	28	86	115	2	86	286	374	489
2005.25	78	2699	2777	40578	0	38	74	112	1	108	299	408	520
2005.50	76	2951	3027	41133	2	26	78	106	5	117	338	460	566
2005.75	85	2961	3046	41134	2	37	97	136	0	96	384	480	616
2006.00	85	2888	2973	40695	3	40	118	161	1	106	318	425	586
2006.25	87	3470	3557	41939	3	22	63	88	1	115	302	418	506
2006.50	88	3351	3439	41983	0	31	59	90	6	118	305	429	519
2006.75	87	3107	3194	42118	0	51	107	158	2	126	343	471	629
2007.00	74	2566	2640	41593	0	23	105	128	0	86	348	434	562
2007.25	82	3224	3306	43090	2	27	47	76	2	130	267	399	475
2007.50	100	3354	3454	43576	1	27	52	80	0	139	295	434	514
2007.75	90	2957	3047	43731	1	53	154	208	1	126	393	520	728
2008.00	90	2803	2893	43093	0	25	98	123	0	90	270	360	483
2008.25	106	3369	3475	44243	0	33	102	135	0	83	259	342	477
2008.50	105	3326	3431	44347	0	33	73	106	2	111	234	347	453
2008.75	119	3036	3155	44164	1	26	113	140	0	76	303	379	519
2009.00	108	2614	2722	42647	1	19	106	126	2	96	262	360	486
2009.25	93	2904	2997	43238	2	17	81	100	5	102	266	373	473
2009.50	97	3201	3298	43402	2	29	85	116	0	119	266	385	501
2009.75	90	2824	2914	42883	0	37	133	170	0	93	303	396	566
2010.00	48	2466	2514	41476	0	39	93	132	0	75	230	305	437
2010.25	51	2647	2698	42521	1	31	91	123	1	100	267	368	491
Average	81	2811	2892	41145	1	35	96	133	2	106	318	426	558
St. Deviatio	18	350	359	2127	2	11	27	35	2	20	50	59	81
Median	84	2786	2841	41305	1	33	91	128	1	104	312	427	548

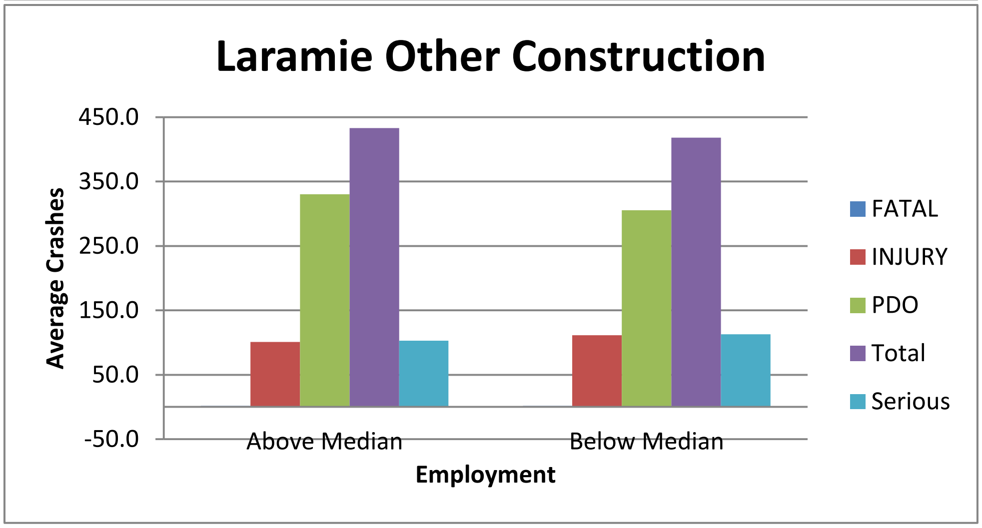




Laramie Other Mining
Average Crashes
500.0
400.0
300.0
200.0
100.0
0.0
Above Median
Below Median
Employment
FATAL
INJURY
PDO
Total
Serious

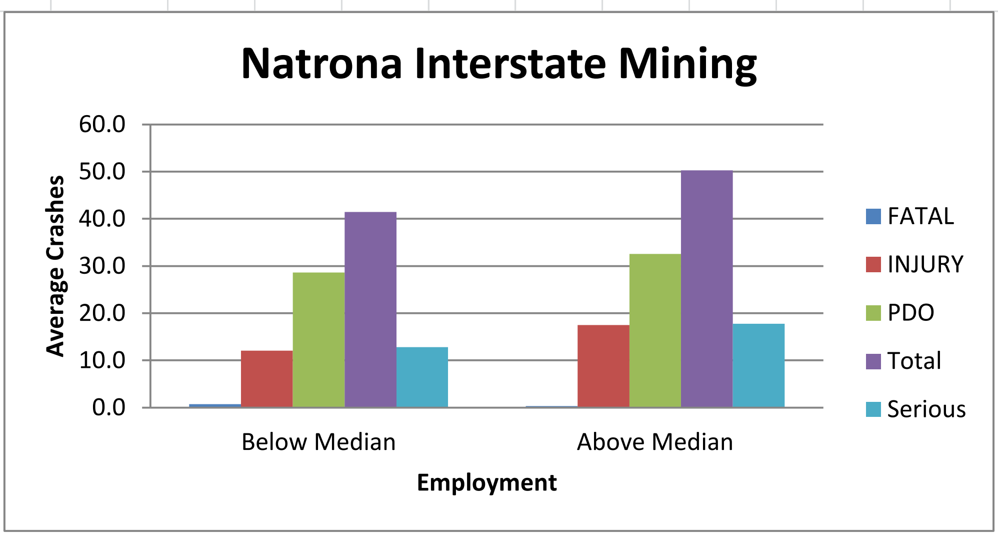


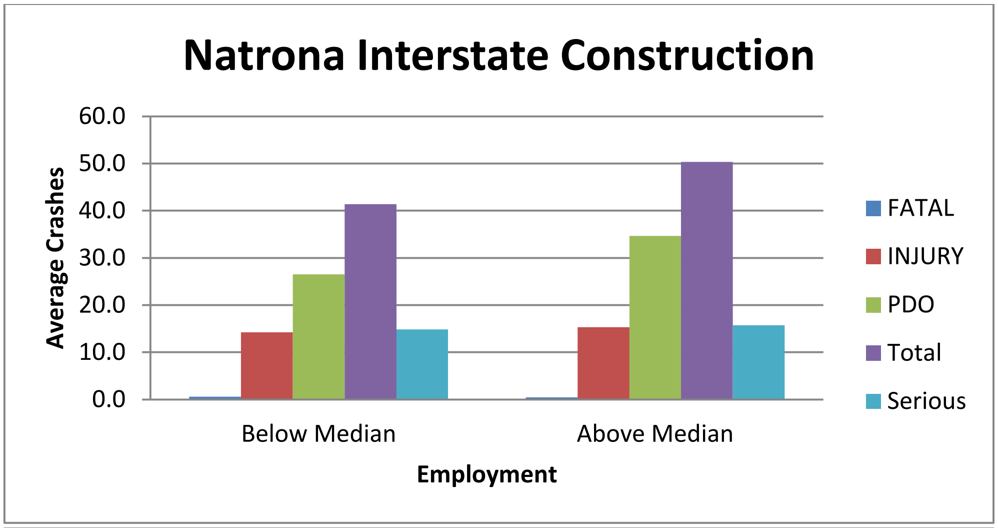
Laramie Interstate Construction
Average Crashes
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
Above Median
Below Median
Employment
FATAL
INJURY
PDO
Total
Serious



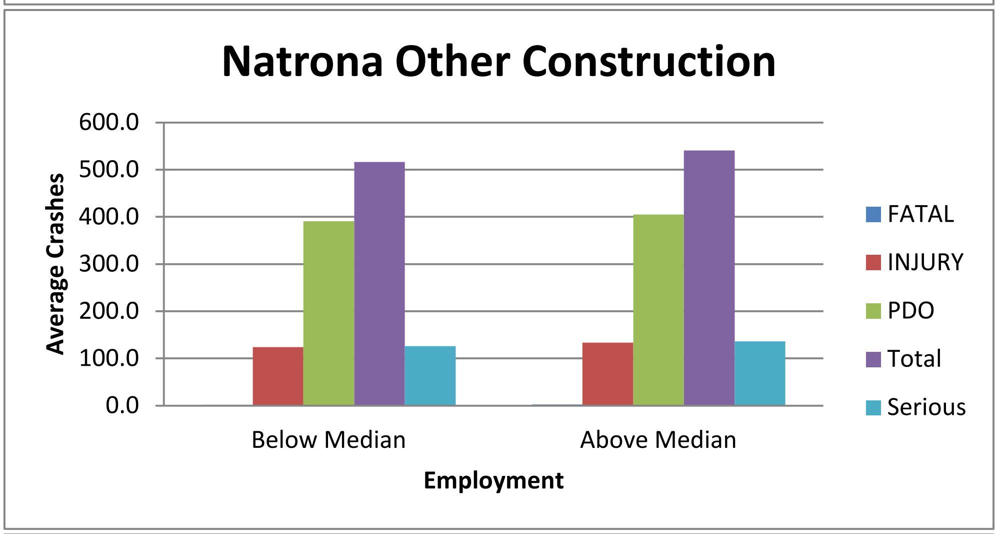
Laramie Other Construction
Average Crashes
450.0
350.0
250.0
150.0
50.0
-50.0
Above Median
Below Median
Employment
FATAL
INJURY
PDO
Total
Serious

Natrona County													
	Employment				INTERSTATE CRASHES				Other Crashes				Total
	Mining	Construction	M+C	Total	FATAL	INJURY	PDO	Total	FATAL	INJURY	PDO	Total	
2002	1890	1885	3775	31104	0	12	34	46	0	115	367	482	528
2002.25	1919	2257	4176	32954	0	5	19	24	3	128	335	466	490
2002.5	2053	2293	4346	33058	2	10	23	35	6	132	335	473	508
2002.75	2040	2147	4187	32987	1	8	43	52	1	116	393	510	562
2003	2081	2046	4127	32321	0	15	29	44	0	90	370	460	504
2003.25	2251	2367	4618	33816	2	9	17	28	2	133	322	457	485
2003.5	2562	2552	5114	34175	1	8	17	26	2	141	367	510	536
2003.75	2687	2359	5046	34119	0	21	49	70	0	131	497	628	698
2004	2706	2110	4816	33722	0	13	22	35	1	113	353	467	502
2004.25	2762	2431	5193	35199	1	12	26	39	3	110	356	469	508
2004.5	3199	2631	5830	35954	0	13	25	38	3	129	372	504	542
2004.75	3357	2417	5774	36186	0	20	36	56	2	138	441	581	637
2005	3310	2223	5533	35340	1	15	0	16	2	132	400	534	550
2005.25	3496	2501	5997	36517	0	14	0	14	3	135	356	494	508
2005.5	3652	2629	6281	36815	0	7	0	7	1	133	415	549	556
2005.75	3760	2480	6240	37299	1	18	0	19	3	153	541	697	716
2006	3996	2385	6381	37038	0	24	55	79	2	133	470	605	684
2006.25	4235	2733	6968	38599	0	13	31	44	0	139	372	511	555
2006.5	4260	2837	7097	38648	0	9	25	34	3	149	375	527	561
2006.75	4187	2695	6882	38905	1	25	34	60	4	144	424	572	632
2007	3755	2586	6341	38303	0	13	26	39	1	119	501	621	660
2007.25	3598	2921	6519	39361	0	15	28	43	1	132	336	469	512
2007.5	3572	3527	7099	39491	0	19	25	44	3	149	406	558	602
2007.75	3689	2958	6647	39726	1	25	71	97	4	153	526	683	780
2008	3574	2848	6422	39004	0	24	61	85	2	113	485	600	685
2008.25	3569	3105	6674	40162	1	12	38	51	1	146	365	512	563
2008.5	3790	3239	7029	40687	0	6	32	38	3	135	337	475	513
2008.75	3995	3078	7073	40837	0	26	44	70	6	131	551	688	758
2009	3631	2556	6187	39020	1	27	47	75	2	112	401	515	590
2009.25	2999	2741	5740	38671	1	13	36	50	3	128	300	431	481
2009.5	2737	2858	5595	37871	1	12	29	42	2	156	326	484	526
2009.75	2683	2651	5334	37262	1	19	54	74	0	107	506	613	687
2010	2841	2391	5232	36890	0	11	34	45	0	94	337	431	476
2010.25	2977	2654	5631	38088	1	9	30	40	2	107	291	400	440
Average	3171	2591	5762	36769	1	15	31	46	2	129	398	529	575
St. Deviat	711	354	974	2635	1	6	17	21	2	17	72	77	88
Median	3334	2571	5802	37150	0	13	30	44	2	132	372	511	553

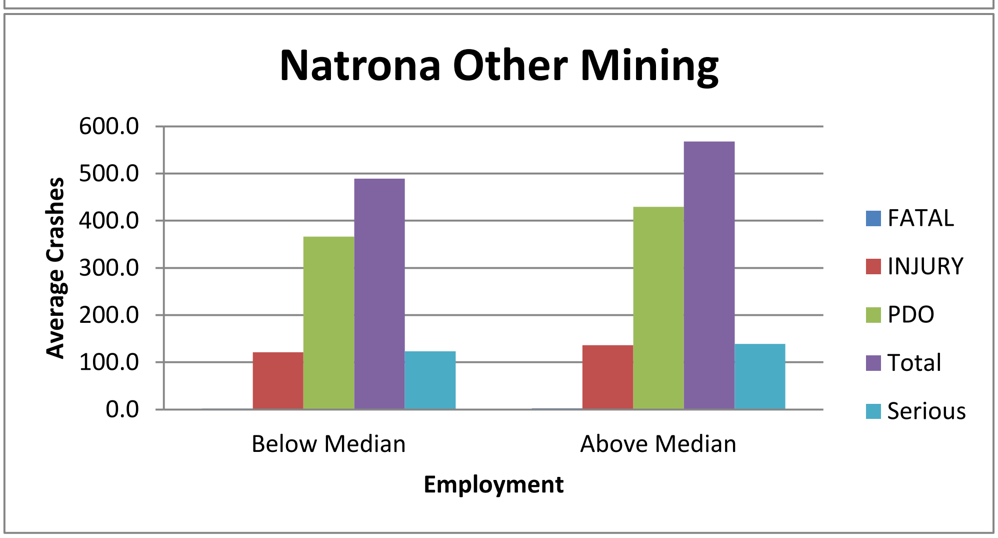




Natrona Interstate Construction
Average Crashes
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Below Median
Above Median
Employment
FATAL
INJURY
PDO
Total
Serious

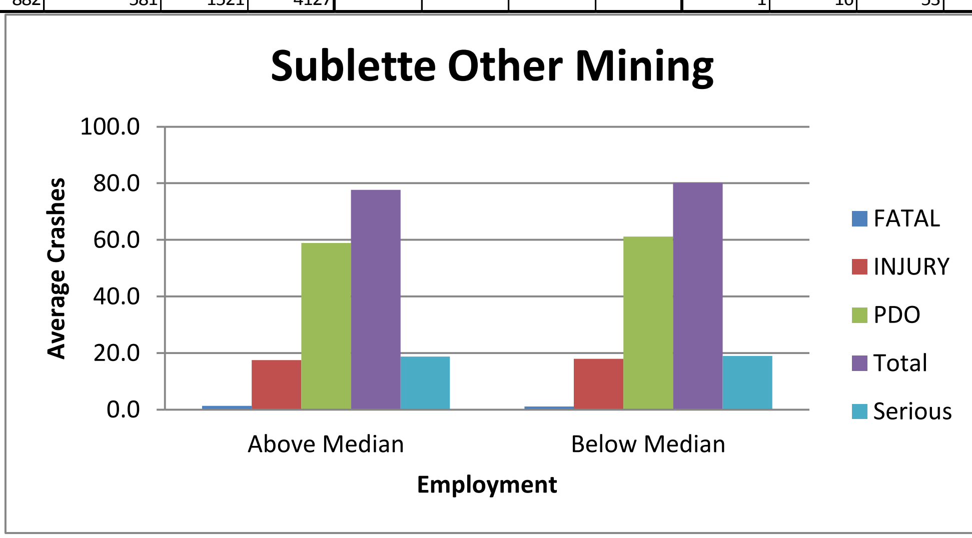


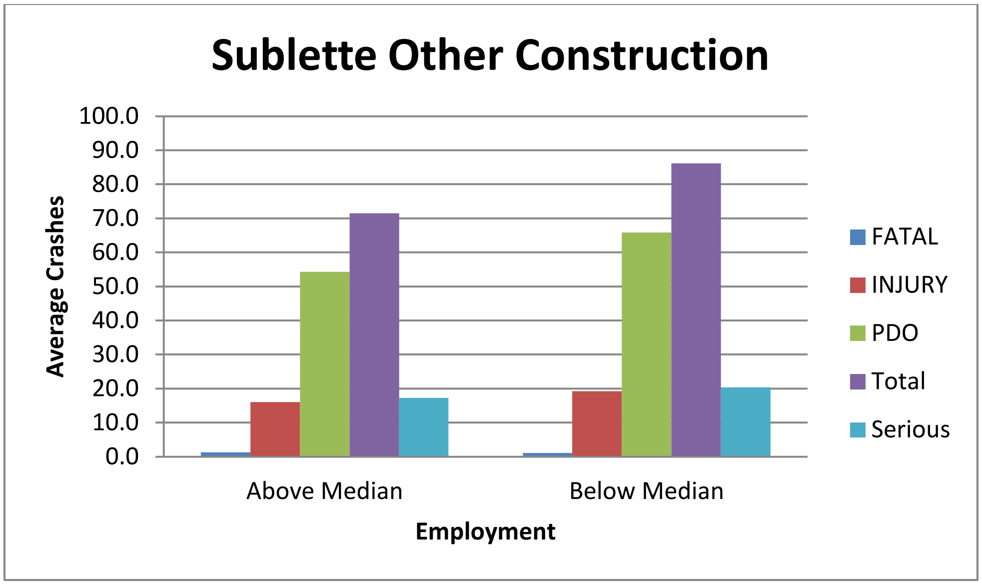
Natrona Other Construction
Average Crashes
600.0
500.0
400.0
300.0
200.0
100.0
0.0
Below Median
Above Median
Employment
FATAL
INJURY
PDO
Total
Serious



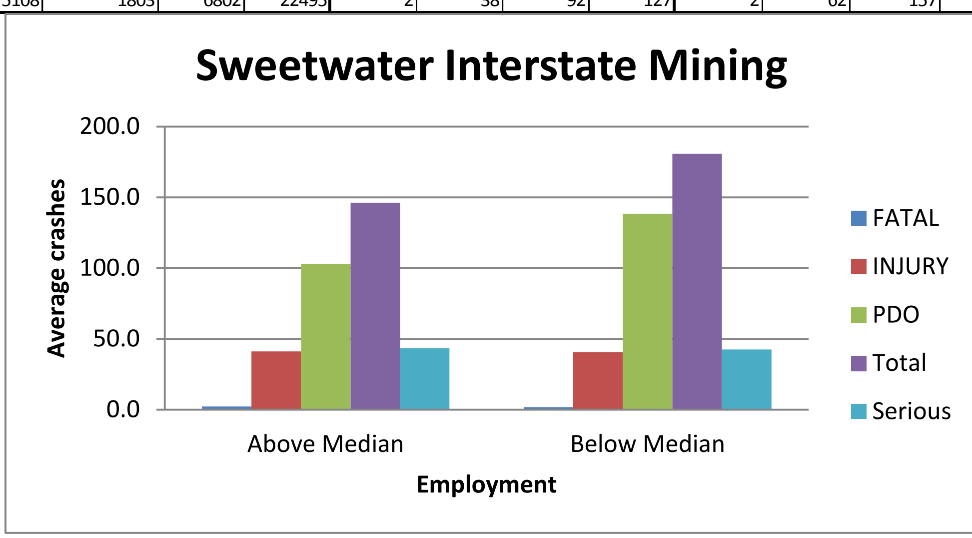
Natrona Other Mining
Average Crashes
600.0
500.0
400.0
300.0
200.0
100.0
0.0
Below Median
Above Median
Employment
FATAL
INJURY
PDO
Total
Serious

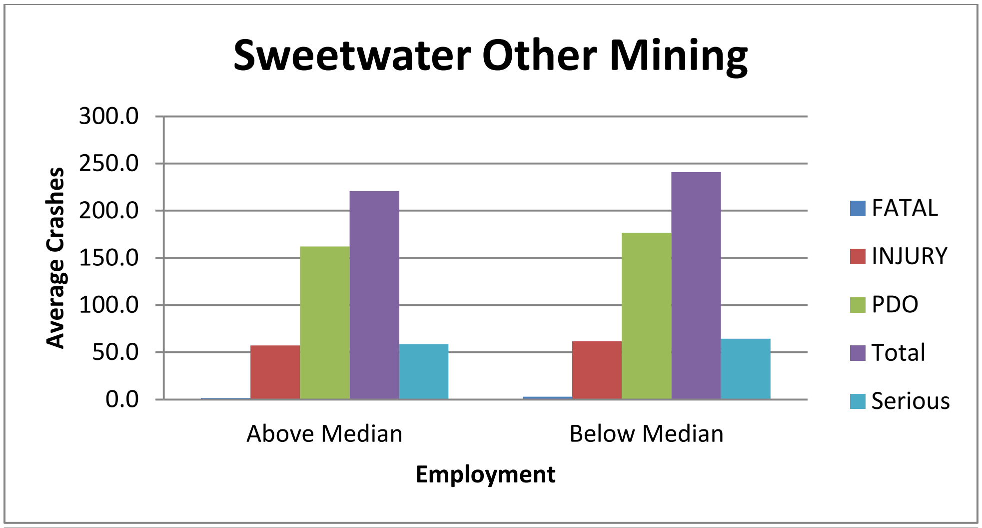
Sublette County													
	Employment				INTERSTATE CRASHES				Other Crashes				Total
	Mining	Construction	M+C	Total	FATAL	INJURY	PDO	Total	FATAL	INJURY	PDO	Total	
2002	253	214	467	2286					0	7	39	46	46
2002.25	346	284	630	2604					0	14	53	67	67
2002.5	341	314	655	2764					1	21	48	70	70
2002.75	333	260	593	2538					1	16	82	99	99
2003	393	199	592	2446					0	10	39	49	49
2003.25	452	271	723	2725					0	21	32	53	53
2003.5	558	338	896	3090					5	25	54	84	84
2003.75	510	288	798	2804					3	14	91	108	108
2004	536	313	849	2827					0	9	33	42	42
2004.25	547	365	912	3072					1	15	47	63	63
2004.5	626	414	1040	3347					3	19	65	87	87
2004.75	623	403	1026	3194					1	24	88	113	113
2005	602	364	966	3110					0	11	56	67	67
2005.25	659	442	1101	3497					0	7	54	61	61
2005.5	743	701	1444	4012					2	38	58	98	98
2005.75	718	707	1425	3781					4	20	96	120	120
2006	881	609	1490	3828					0	15	46	61	61
2006.25	883	669	1552	4242					3	28	61	92	92
2006.5	1001	648	1649	4580					0	27	100	127	127
2006.75	1020	605	1625	4413					2	15	52	69	69
2007	1569	578	2147	4868					2	23	50	75	75
2007.25	1626	682	2308	5244					2	26	43	71	71
2007.5	1559	776	2335	5466					1	29	111	141	141
2007.75	1526	685	2211	5181					0	12	67	79	79
2008	1583	654	2237	5157					1	10	58	69	69
2008.25	1681	619	2300	5494					0	23	48	71	71
2008.5	1864	655	2519	5854					0	21	96	117	117
2008.75	1948	583	2531	5773					1	16	53	70	70
2009	1951	546	2497	5689					1	8	42	51	51
2009.25	1677	521	2198	5489					2	22	34	58	58
2009.5	1556	637	2193	5491					1	11	67	79	79
2009.75	1627	629	2256	5424					0	6	52	58	58
2010	1506	618	2124	5119					1	10	45	56	56
2010.25	1553	848	2401	5586									
Average	1037	513	1550	4147					1	17	59	78	78
St. Deviat	563	180	708	1209					1	8	21	25	25
Median	882	581	1521	4127					1	16	53	70	70

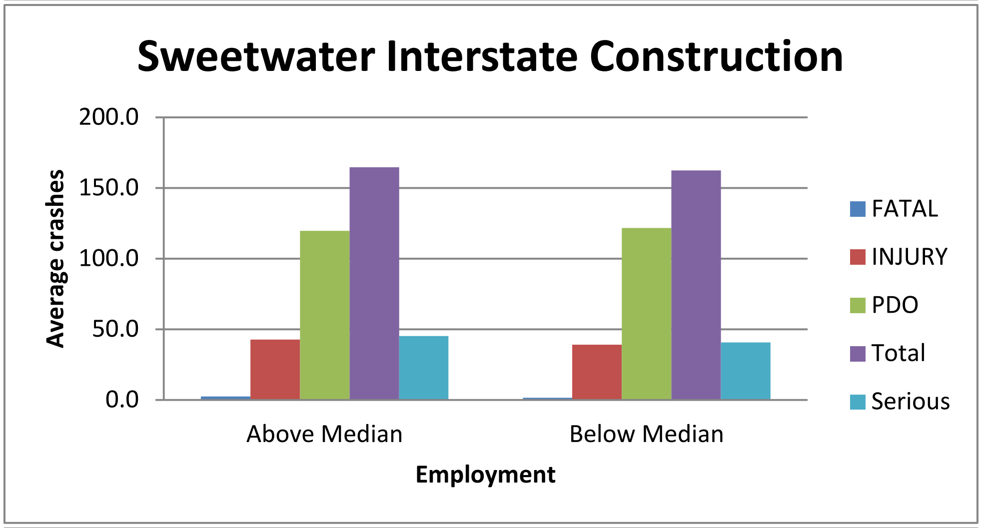


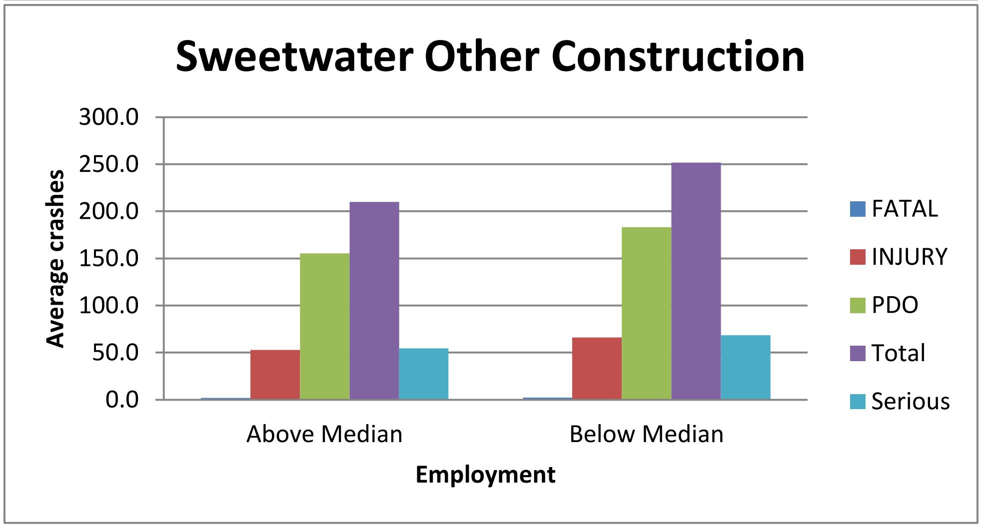

Sublette Other Construction
Average Crashes
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Above Median
Below Median
Employment
FATAL
INJURY
PDO
Total
Serious

Sweetwater County													
	Employment				INTERSTATE CRASHES				Other Crashes				Total
	Mining	Construction	M+C	Total	FATAL	INJURY	PDO	Total	FATAL	INJURY	PDO	Total	
2002	3227	1019	4246	17936	1	45	83	129	1	40	130	171	300
2002.25	3402	1157	4559	18531	3	31	63	97	1	59	115	175	272
2002.5	3412	1598	5010	18804	0	32	48	80	0	65	136	201	281
2002.75	3313	1395	4708	18718	4	57	126	187	0	59	149	208	395
2003	3477	1211	4688	18562	2	53	149	204	3	47	127	177	381
2003.25	3577	1572	5149	19499	2	22	68	92	1	64	128	193	285
2003.5	3667	1839	5506	19792	2	33	51	86	1	71	144	216	302
2003.75	3667	1766	5433	19907	4	73	222	299	3	50	223	276	575
2004	3937	1320	5257	19487	5	48	159	212	0	47	186	233	445
2004.25	4046	1679	5725	20441	5	24	76	105	1	54	144	199	304
2004.5	4261	1743	6004	20752	0	41	63	104	2	63	199	264	368
2004.75	4419	1671	6090	21078	1	59	96	156	3	61	186	250	406
2005	4586	1483	6069	20855	0	44	136	180	3	41	127	171	351
2005.25	4786	1880	6666	22045	2	42	72	116	1	74	148	223	339
2005.5	4853	1918	6771	22086	2	17	56	75	1	70	199	270	345
2005.75	4988	1950	6938	22442	0	33	137	170	0	68	212	280	450
2006	5214	1619	6833	22488	6	46	206	258	2	64	187	253	511
2006.25	5486	2323	7809	24185	1	28	68	97	3	54	165	222	319
2006.5	5664	2353	8017	24422	2	35	65	102	5	77	176	258	360
2006.75	5805	2109	7914	24503	5	81	226	312	2	69	251	322	634
2007	5587	1886	7473	24116	3	61	165	229	3	64	219	286	515
2007.25	5632	2222	7854	25076	2	28	57	87	5	88	143	236	323
2007.5	5556	2098	7654	24792	0	35	78	113	4	77	230	311	424
2007.75	5557	2354	7911	25044	0	58	234	292	0	55	227	282	574
2008	5851	2410	8261	25076	0	74	386	460	2	62	274	338	798
2008.25	5902	2345	8247	25411	0	22	76	98	0	62	135	197	295
2008.5	6095	2544	8639	25918	2	16	60	78	6	64	148	218	296
2008.75	6266	2162	8428	26036	3	47	154	204	2	67	213	282	486
2009	6115	1669	7784	24585	2	52	204	258	1	48	170	219	477
2009.25	5453	1855	7308	24338	1	25	89	115	2	62	117	181	296
2009.5	5117	1741	6858	23436	1	21	56	78	3	59	127	189	267
2009.75	5099	1475	6574	23049	4	44	144	192	3	41	201	245	437
2010	5145	1364	6509	22502	1	33	133	167	5	33	107	145	312
2010.25	5266	1908	7174	23982	1	29	95	125	2	40	113	155	280
Average	4836	1813	6649	22350	2	41	121	163	2	59	169	231	394
St. Deviat	951	389	1272	2497	2	17	74	88	2	12	44	49	122
Median	5108	1803	6802	22495	2	38	92	127	2	62	157	223	356

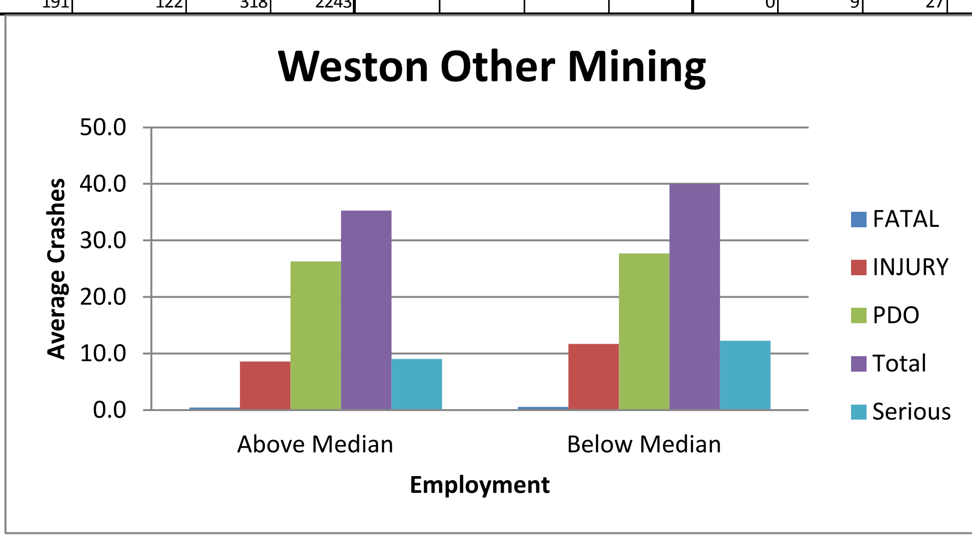


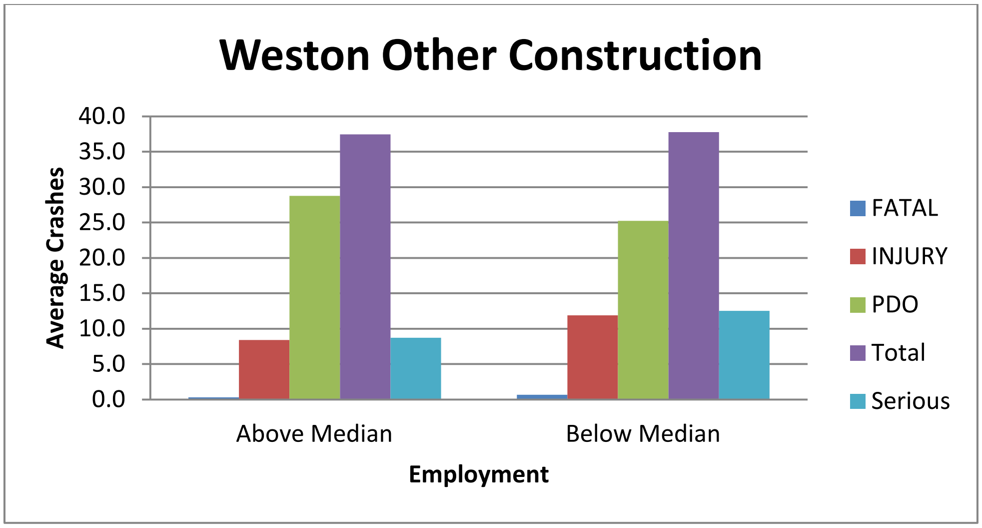

Sweetwater Other Mining
Average Crashes
300.0
250.0
200.0
150.0
100.0
50.0
0.0
Above Median
Below Median
Employment
FATAL
INJURY
PDO
Total
Serious


Sweetwater Interstate Construction
Average crashes
200.0
150.0
100.0
50.0
0.0
Above Median
Below Median
Employment
FATAL
INJURY
PDO
Total
Serious


Sweetwater Other Construction
Average crashes
300.0
250.0
200.0
150.0
100.0
50.0
0.0
Above Median
Below Median
Employment
FATAL
INJURY
PDO
Total
Serious

Weston County													
	Employment				INTERSTATE CRASHES				Other Crashes				Total
	Mining	Construction	M+C	Total	FATAL	INJURY	PDO	Total	FATAL	INJURY	PDO	Total	
2002.00	134	178	312	1785					0	10	19	29	29
2002.25	313	124	437	2290					0	12	21	33	33
2002.50	311	130	441	2270					1	18	31	50	50
2002.75	256	108	364	2238					0	6	31	37	37
2003.00	152	91	243	2090					0	9	29	38	38
2003.25	172	140	312	2201					1	7	12	20	20
2003.50	179	154	333	2139					0	15	22	37	37
2003.75	170	141	311	2179					1	9	34	44	44
2004.00	165	104	269	2096					0	6	18	24	24
2004.25	170	145	315	2189					0	6	28	34	34
2004.50	183	158	341	2178					0	16	35	51	51
2004.75	193	110	303	2194					1	11	42	54	54
2005.00	199	82	281	2154					0	5	25	30	30
2005.25	201	100	301	2224					1	5	22	28	28
2005.50	218	123	341	2212					1	19	31	51	51
2005.75	207	123	330	2267					0	10	27	37	37
2006.00	187	120	307	2155					0	13	15	28	28
2006.25	191	129	320	2192					1	9	26	36	36
2006.50	200	133	333	2130					1	28	23	52	52
2006.75	170	123	293	2182					3	7	41	51	51
2007.00	247	113	360	2247					0	10	25	35	35
2007.25	256	124	380	2335					1	12	18	31	31
2007.50	268	114	382	2260					1	20	31	52	52
2007.75	265	109	374	2338					1	8	37	46	46
2008.00	251	102	353	2302					0	10	33	43	43
2008.25	247	132	379	2380					0	3	18	21	21
2008.50	272	133	405	2336					0	13	30	43	43
2008.75	190	117	307	2347					0	8	49	57	57
2009.00	154	97	251	2268					1	8	34	43	43
2009.25	140	89	229	2277					0	8	23	31	31
2009.50	146	92	238	2259					0	7	23	30	30
2009.75	145	92	237	2271					0	4	28	32	32
2010.00	144	112	256	2267					0	5	24	29	29
2010.25	135	197	332	2352					1	8	13	22	22
Average	201	122	323	2224					0	10	27	38	38
St. Deviation	51	25	54	108					1	5	8	10	10
Median	191	122	318	2243					0	9	27	37	37




Weston Other Construction
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Average Crashes
Above Median
Below Median
Employment
FATAL
INJURY
PDO
Total
Serious

Adams County														
Year	Employment			Interstate Crashes					Other Crashes					Total
	Mining	Const	M + C	Fatal	Injury	PDO	Total	Serious	Fatal	Injury	PDO	Total	Serious	
2002	0	14	14						0	2	21	23	2	23
2003	0	12	12						0	10	26	36	10	36
2004	0	11	11						2	4	36	42	6	42
2005	0	13	13						0	3	30	33	3	33
2006	0	18	18						0	2	34	36	2	36
2007	0	17	17						0	5	25	30	5	30
2008	0	15	15						0	7	22	29	7	29
2009	0	20	20						1	7	44	52	8	52
Average	0.00	15.00	15.00						0.38	5.00	29.75	35.13	5.38	35.13
St. Deviat	0.00	3.12	3.12						0.74	2.83	7.87	8.85	2.92	8.85
Median	0.00	14.50	14.50						0.00	4.50	28.00	34.50	5.50	34.50

Burleigh County														
Year	Employment			Interstate Crashes					Other Crashes					Total
	Mining	Const	M + C	Fatal	Injury	PDO	Total	Serious	Fatal	Injury	PDO	Total	Serious	
2002	71	2776	2847	0	9	35	44	9	1	310	959	1270	311	1314
2003	51	2754	2805	1	8	67	76	9	2	424	1551	1977	426	2053
2004	0	2865	2865	0	14	71	85	14	4	412	1521	1937	416	2022
2005	0	2995	2995	1	16	73	90	17	6	440	1392	1838	446	1928
2006	0	3219	3219	0	17	96	113	17	1	420	1442	1863	421	1976
2007	57	3336	3393	0	19	102	121	19	6	468	1492	1966	474	2087
2008	60	3358	3418	0	8	89	97	8	4	529	1378	1911	533	2008
2009	42	3204	3246	0	19	92	111	19	2	506	2184	2692	508	2803
Average	35.13	3063.38	3098.50	0.25	13.75	78.13	92.13	14.00	3.25	438.63	1489.88	1931.75	441.88	2023.88
St. Deviat	30.20	247.11	250.63	0.46	4.77	21.58	24.73	4.69	2.05	66.96	336.52	384.17	67.83	401.34
Median	46.50	3099.50	3107.00	0.00	15.00	81.00	93.50	15.50	3.00	432.00	1467.00	1924.00	436.00	2015.00

Grand Forks County														
Year	Employment			Interstate Crashes					Other Crashes					Total
	Mining	Const	M + C	Fatal	Injury	PDO	Total	Serious	Fatal	Injury	PDO	Total	Serious	
2002	0	1978	1978	0	10	42	52	10	4	272	576	852	276	904
2003	0	2031	2031	0	15	68	83	15	3	350	1066	1419	353	1502
2004	0	2329	2329		26	79	105	26	12	385	1201	1598	397	1703
2005	0	2238	2238	0	10	82	92	10	6	342	1201	1549	348	1641
2006	0	2215	2215	1	19	80	100	20	4	308	1035	1347	312	1447
2007	0	2127	2127	0	13	74	87	13	4	301	1106	1411	305	1498
2008	0	2110	2110	2	20	105	127	22	5	290	1060	1355	295	1482
2009	103	2104	2207		24	64	88	24	2	334	1160	1496	336	1584
Average	12.88	2141.50	2154.38	0.50	17.13	74.25	91.75	17.50	5.00	322.75	1050.63	1378.38	327.75	1470.13
St. Deviat	36.42	114.28	115.25	0.84	6.10	17.91	21.31	6.32	3.07	36.75	202.16	230.68	38.60	244.76
Median	0.00	2118.50	2167.00	0.00	17.00	76.50	90.00	17.50	4.00	321.00	1086.00	1415.00	324.00	1500.00

LaMoure County														
Year	Employment			Interstate Crashes					Other Crashes					Total
	Mining	Const	M + C	Fatal	Injury	PDO	Total	Serious	Fatal	Injury	PDO	Total	Serious	
2002	0	12	12						1	9	90	100	10	100
2003	0	12	12						3	21	146	170	24	170
2004	0	19	19						1	14	148	163	15	163
2005	0	23	23						0	5	145	150	5	150
2006	0	19	19						1	19	129	149	20	149
2007	0	22	22						2	10	143	155	12	155
2008	0	27	27						0	26	135	161	26	161
2009	0	27	27						0	11	145	156	11	156
Average	0.00	20.13	20.13						1.00	14.38	135.13	150.50	15.38	150.50
St. Deviat	0.00	5.87	5.87						1.07	7.05	19.33	21.55	7.33	21.55
Median	0.00	20.50	20.50						1.00	12.50	144.00	155.50	13.50	155.50

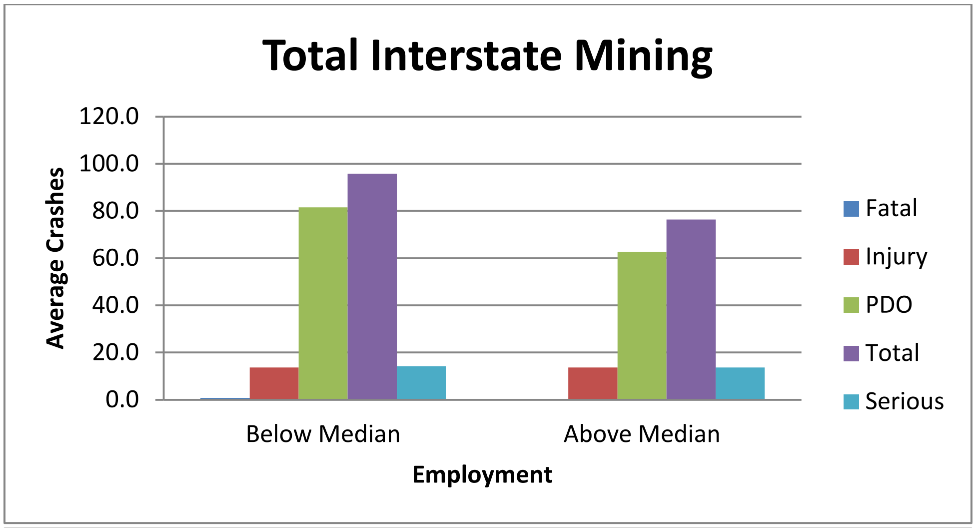
McKenzie County														
Year	Employment			Interstate Crashes					Other Crashes					Total
	Mining	Const	M + C	Fatal	Injury	PDO	Total	Serious	Fatal	Injury	PDO	Total	Serious	
2002	105	61	166						1	14	36	51	15	51
2003	130	64	194						4	17	102	123	21	123
2004	132	71	203						2	21	107	130	23	130
2005	126	76	202						2	21	95	118	23	118
2006	243	94	337						5	23	98	126	28	126
2007	281	144	425						3	23	119	145	26	145
2008	445	171	616						3	30	132	165	33	165
2009	254	237	491						5	30	128	163	35	163
Average	214.50	114.75	329.25						3.13	22.38	102.13	127.63	25.50	127.63
St. Deviat	115.69	63.56	166.77						1.46	5.60	30.03	35.74	6.50	35.74
Median	187.50	85.00	270.00						3.00	22.00	104.50	128.00	24.50	128.00

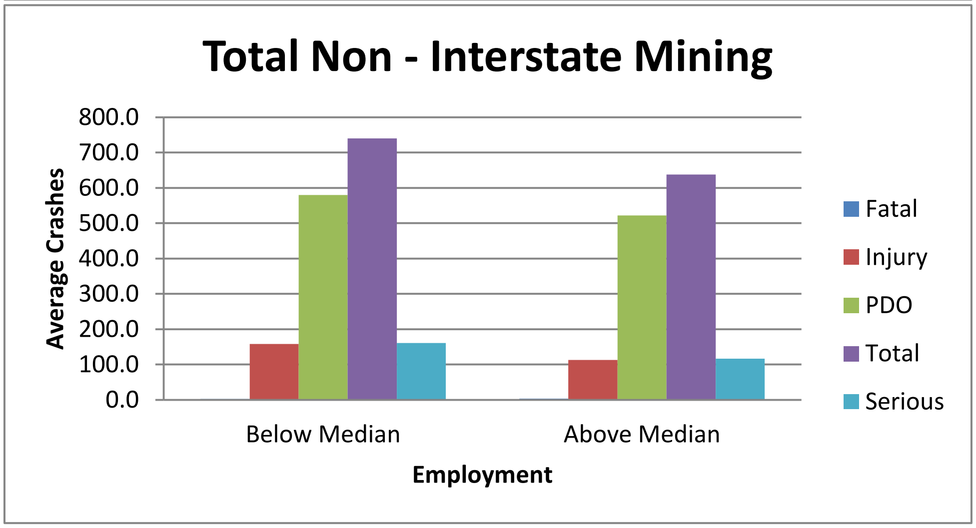
Mercer County														
Year	Employment			Interstate Crashes					Other Crashes					Total
	Mining	Const	M + C	Fatal	Injury	PDO	Total	Serious	Fatal	Injury	PDO	Total	Serious	
2002	592	286	878						0	25	87	112	25	112
2003	585	359	944						1	39	133	173	40	173
2004	579	426	1005						2	28	195	225	30	225
2005	586	353	939						1	24	169	194	25	194
2006	590	624	1214						2	22	166	190	24	190
2007	607	517	1124						1	28	165	194	29	194
2008	611	565	1176						2	20	123	145	22	145
2009	629	954	1583						1	36	199	236	37	236
Average	597.38	510.50	1107.88						1.25	27.75	154.63	183.63	29.00	183.63
St. Deviat	16.83	213.10	227.00						0.71	6.65	37.95	40.44	6.46	40.44
Median	591.00	471.50	1064.50						1.00	26.50	165.50	192.00	27.00	192.00

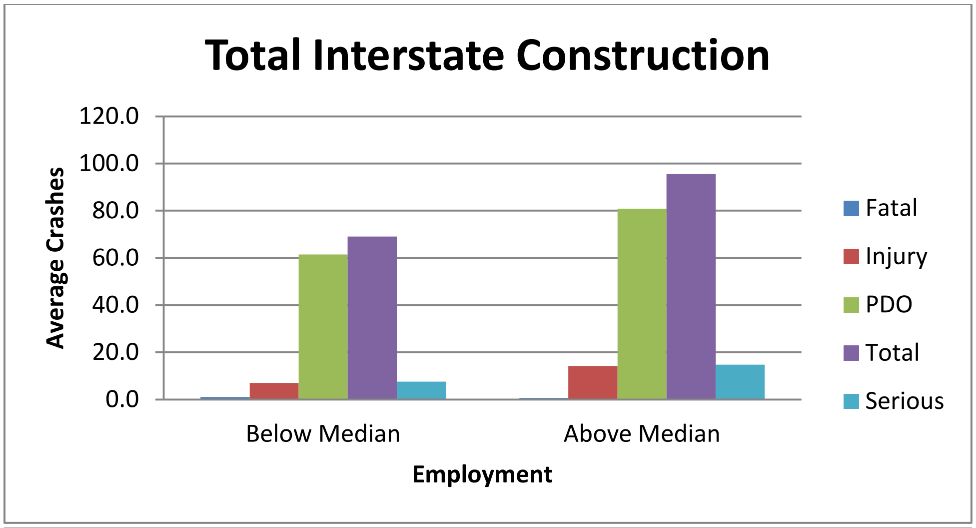
Stark County														
Year	Employment			Interstate Crashes					Other Crashes					Total
	Mining	Const	M + C	Fatal	Injury	PDO	Total	Serious	Fatal	Injury	PDO	Total	Serious	
2002	0	574	574	1	7	47	55	8	0	69	220	289	69	344
2003	0	672	672	3	12	82	97	15	2	119	391	512	121	609
2004	0	591	591		7	76	83	7	1	68	379	448	69	531
2005	0	698	698	1	13	85	99	14	3	81	321	405	84	504
2006	0	880	880	1	6	66	73	7	4	67	345	416	71	489
2007	0	781	781	1	13	111	125	14	1	81	380	462	82	587
2008	0	917	917	0	9	100	109	9	3	75	320	398	78	507
2009	0	816	816		13	115	128	13	2	59	382	443	61	571
Average	0.00	741.13	741.13	1.17	10.00	85.25	96.13	10.88	2.00	77.38	342.25	421.63	79.38	517.75
St. Deviat	0.00	127.91	127.91	0.98	3.07	22.98	25.14	3.44	1.31	18.39	56.86	64.81	18.46	82.34
Median	0.00	739.50	739.50	1.00	10.50	83.50	98.00	11.00	2.00	72.00	362.00	429.50	74.50	519.00

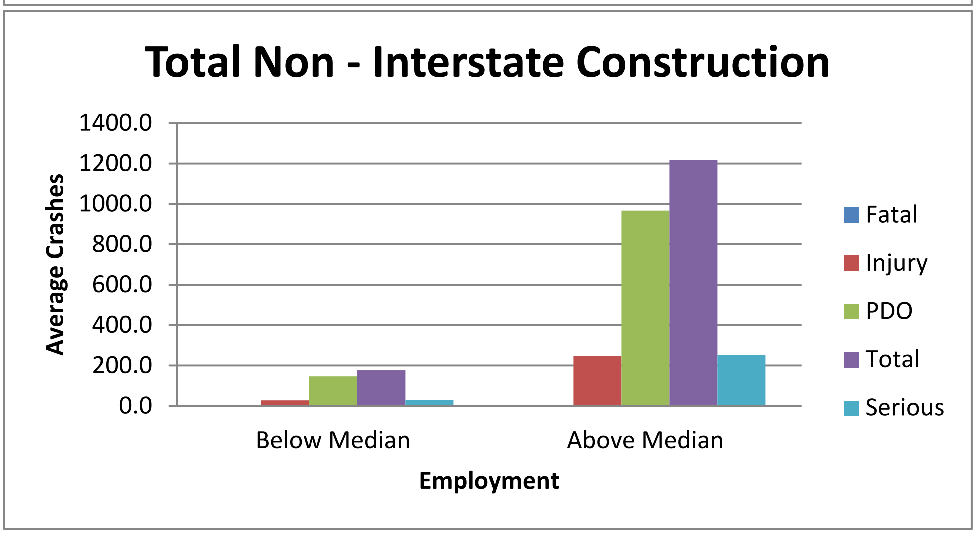
Ward County														
Year	Employment			Interstate Crashes					Other Crashes					Total
	Mining	Const	M + C	Fatal	Injury	PDO	Total	Serious	Fatal	Injury	PDO	Total	Serious	
2002	240	1228	1468						6	201	741	948	207	948
2003	270	1248	1518						3	287	1292	1582	290	1582
2004	331	1392	1723						8	249	1511	1768	257	1768
2005	420	1467	1887						6	28	1353	1387	34	1387
2006	370	1547	1917						6	191	1111	1308	197	1308
2007	372	1638	2010						6	211	1242	1459	217	1459
2008	379	1729	2108						8	232	1255	1495	240	1495
2009	391	1972	2363						10	289	1505	1804	299	1804
Average	346.63	1527.63	1874.25						6.63	211.00	1251.25	1468.88	217.63	1468.88
St. Deviat	62.19	250.89	299.71						2.07	82.58	246.11	272.36	82.95	272.36
Median	371.00	1507.00	1902.00						6.00	221.50	1273.50	1477.00	228.50	1477.00

Williams County														
Year	Employment			Interstate Crashes					Other Crashes					Total
	Mining	Const	M + C	Fatal	Injury	PDO	Total	Serious	Fatal	Injury	PDO	Total	Serious	
2002	765	428	1193						2	68	225	295	70	295
2003	889	454	1343						3	98	362	463	101	463
2004	1012	447	1459						3	86	367	456	89	456
2005	1401	458	1859						3	64	369	436	67	436
2006	1832	524	2356						0	74	370	444	74	444
2007	2045	592	2637						4	76	386	466	80	466
2008	3091	680	3771						2	102	414	518	104	518
2009	3069	722	3791						3	120	467	590	123	590
Average	1763.00	538.13	2301.13						2.50	86.00	370.00	458.50	88.50	458.50
St. Deviat	926.47	114.00	1038.31						1.20	19.30	68.35	83.12	19.54	83.12
Median	1616.50	491.00	2107.50						3.00	81.00	369.50	459.50	84.50	459.50






Total Interstate Construction
120.0
100.0
80.0
60.0
40.0
20.0
0.0
Average Crashes
Below Median
Above Median
Employment
Fatal
Injury
PDO
Total
Serious


Total Non - Interstate Construction
1400.0
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
Average Crashes
Below Median
Above Median
Employment
Fatal
Injury
PDO
Total
Serious