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Impact of Energy Sector Growth on Perceived Transportation Safety in the 17-County Oil Region of Western North Dakota: A Three-Year Case Study

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Impact of Energy Sector Growth on Perceived Transportation Safety in the 17-County Oil Region of Western North Dakota: A Three-Year Case Study

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Andrew Kubas, Ph.D.
Kimberly Vachal, Ph.D.

Rural Transportation Safety and Security Center
Upper Great Plains Transportation Institute
North Dakota State University
Fargo, North Dakota

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ABSTRACT

The sharp increase in travel volumes, shift in traffic mix, and large increases in crashes have transformed the traffic environment in the oil region of western North Dakota. Roads once used for local access and agricultural purposes now regularly serve the energy sector. Oil companies, workers, commercial trucks, and industrial equipment associated with oil extraction use these roads to access drilling and production sites. This has led to a larger number of overweight and oversized vehicles sharing the roadway with other traffic. A survey questionnaire was sent to drivers to better understand perceptions and behaviors of road users in this region. County-level crash data were gathered to analyze changes in driving conditions during the latest oil boom – specifically between 2004 and 2014. This study addresses two goals for improving regional traffic safety: first, to examine public perceptions of traffic safety issues and priorities; and, second, to address crash trends and intervention strategies. Survey results indicate residents believe driving conditions in the region are dangerous, but ratings have improved as oil activity has decreased. Crash data reveal that crashes parallel oil production: as the number of active oil wells grew exponentially, so too did crashes – even when factoring for changes in vehicle miles traveled and population growth. Economic factors, such as the price of a barrel of oil, may be linked to the prevalence of crashes, especially those involving large trucks.

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1. INTRODUCTION

Road usage and condition in western North Dakota has changed. Interstate, highway, and low-volume unpaved roads have been used more regularly due largely to the growth in the energy sector. This evolution is prominent in a 17-county region where new extraction methods such as hydraulic fracturing, or "fracking," have improved production economics. Roads once used for local access and agricultural purposes now see high volumes of traffic to serve oil production. Oil companies, workers, commercial trucks, and heavy-duty industrial equipment associated with oil and gas development all rely on these roads to access drilling and production sites. This has led to both an increase in traffic volume and an increase in the number of overweight and oversized vehicles on the road. As such, a number of roads are now in poor condition and others are deteriorating rapidly.

The oil region of North Dakota consists of 17 counties in the western part of the state: Billings, Bottineau, Bowman, Burke, Divide, Dunn, Golden Valley, McHenry, McKenzie, McLean, Mercer, Mountrail, Renville, Slope, Stark, Ward, and Williams (Figure 1.1). Three of the largest cities in the state are located in this region: Minot (Ward County), Dickinson (Stark County), and Williston (Williams County). Because of the growing energy sector, the region has been transformed via various social, economic, and environmental changes – many of which stem from rapid population growth, an influx of labor and job-seekers, and improved economic development.

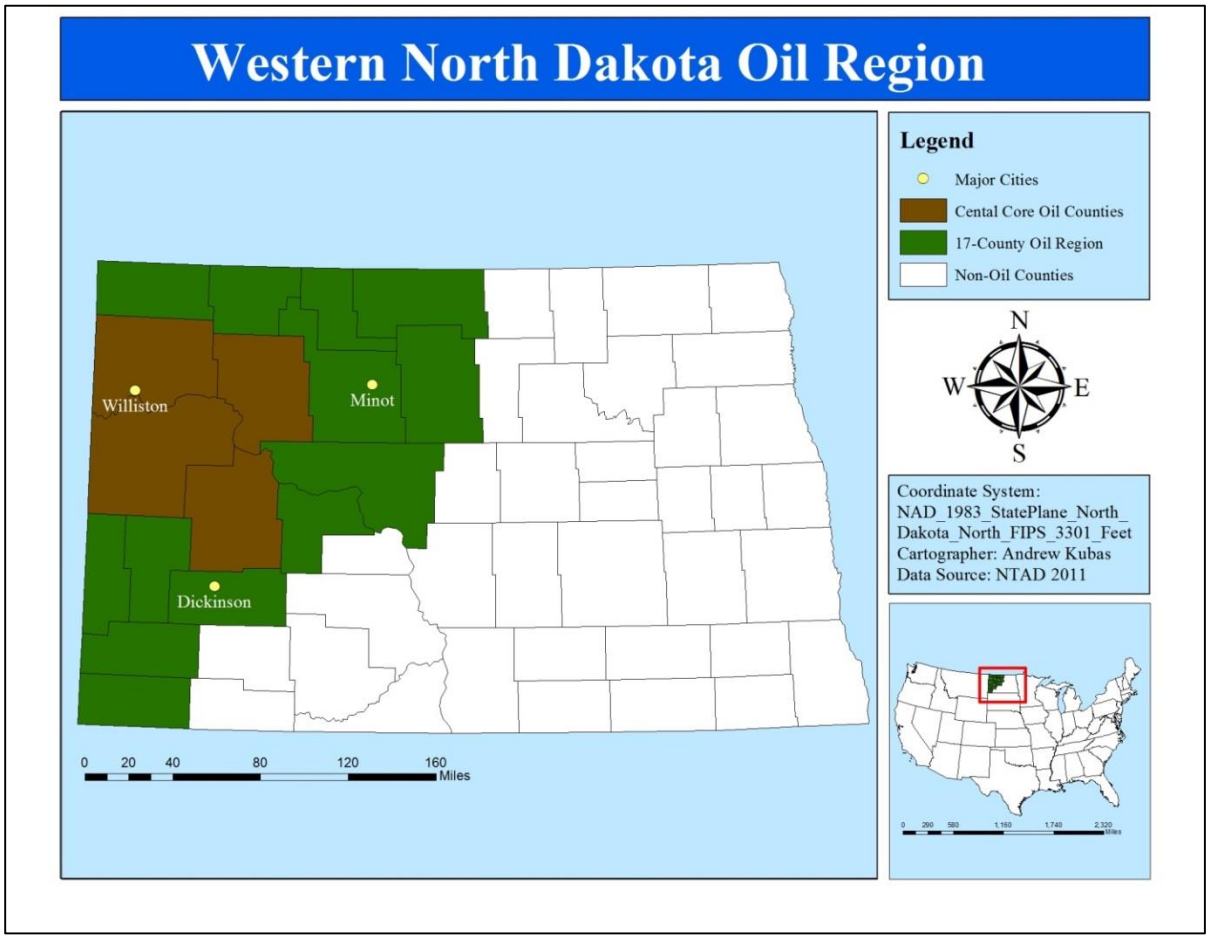

Figure 1.1 Western North Dakota Oil Region

It is undeniable that the expanding oil industry has resulted in numerous benefits. The state currently has the second-lowest unemployment rate in the nation, largely due to the success of the oil region (Bureau of Labor Statistics 2015). The oil boom also plays a direct role in North Dakota's budget surplus, although future budget forecasts are uncertain because of the declining price of oil (Bosman 2015). Despite these economic benefits, an increased public safety risk associated with greater traffic volume is evident when examining the number and severity of crashes in the area. Fatal crash incidence trends in the central core of the oil region show exponential growth (Figure 1.2). The central core consists of the four highest-producing counties as defined by the North Dakota Industrial Commission: McKenzie, Mountrail, Dunn, and Williams (Department of Mineral Resources 2015) (see Table 2.1). Vehicle miles traveled (VMT) in these counties is generally higher than in most other areas in the region. (However, in 2014, McLean, Stark, and Ward counties did have comparable VMT figures to the central core counties.) This implies that increased oil activity in these counties is amplifying the number of miles traveled. Consequently, when more miles are driven, there are more opportunities for drivers to have a crash. This may partially explain why crash rates in these four counties are considerably higher than in other parts of North Dakota.

When these four counties are compared to all other counties in North Dakota, it is apparent that driving conditions in the central core are more dangerous than in the rest of the state. Using 2004 as a baseline, the growth in fatal crashes in the central core outpaces fatal crashes elsewhere (Figure 1.2).

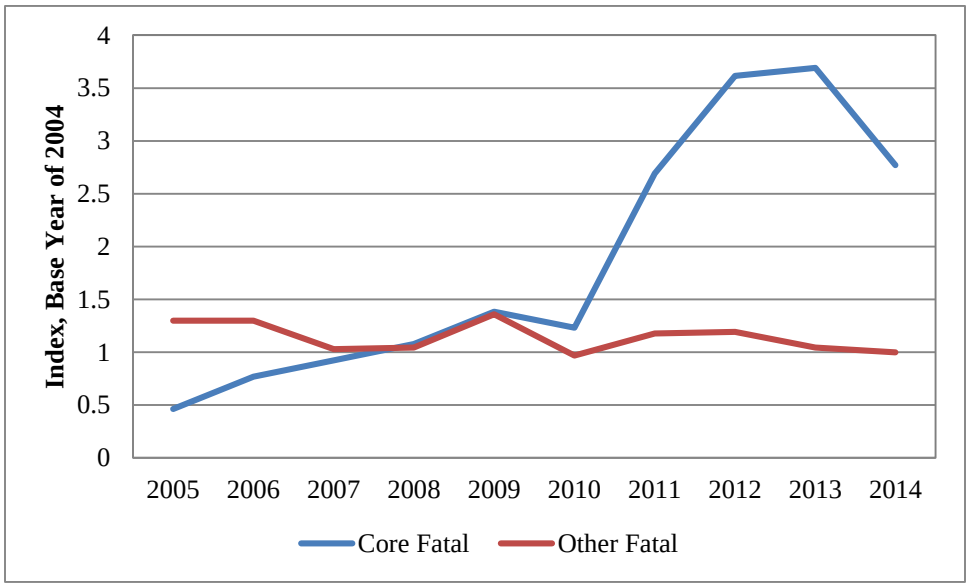

Figure 1.2 Fatal Crash Trends for Central Core Oil-Producing Counties and Other North Dakota Areas

Large truck crashes are another contributing factor that can be examined to compare and contrast counties. In all four counties the number of large trucks involved in crashes remained stable from 2004 through 2009. After 2009, however, the number of large truck crashes rose significantly (Figure 1.3). With the exception of McKenzie County, large truck crash rates have not grown as sharply since 2011, but the overall trend has clearly moved upward between 2004 and 2014.

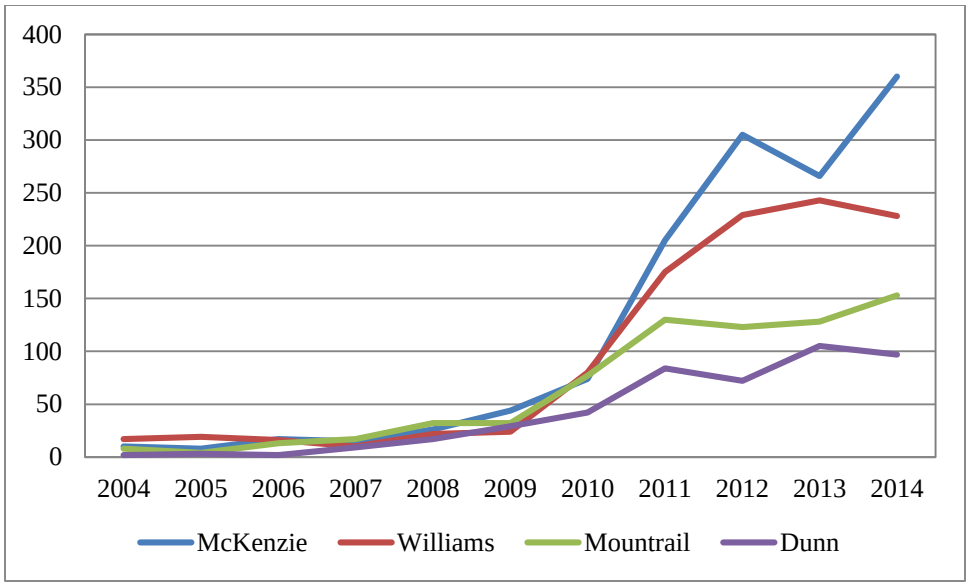

Figure 1.3 Large Truck Crash Involvement, by Central Core Counties

When factored together, the change in large truck crashes for the central core resembles an exponential growth curve (R^2=0.9535) (Figure 1.4). These counties increased from just 37 large truck crashes in 2004 to 838 in 2014, an increase of 2,164%. This increase is exaggerated due to the small number of truck crashes in the base year and a rise in VMT. Nonetheless, the rate at which truck crashes have increased outpaces the rate at which VMT has grown in these counties and is probably a contributing factor to perceptions of danger in the region. The prevalence of large truck crashes may be a factor in negative perceptions of traffic safety as heavy-duty trucks are more likely to be involved in serious crashes (Braver et al. 1992), especially when speeding (Neeley and Richardson 2009; Islam and Hernandez 2013; Vadlamani et a. 2011). Note that heavy-duty trucks are not necessarily the root cause of danger; drivers of passenger vehicles can be at-fault in a crash for unsafely attempting to pass a large truck.

Driving factors such as these have prompted stakeholders such as the North Dakota Department of Transportation (NDDOT), the North Dakota Petroleum Council (NDPC), and the North Dakota Highway Patrol (NDHP) to take action to encourage safety on the roadway. One awareness campaign – *ProgressZone: Moving Forward Safely* – was created in 2012 as an intervention strategy to improve driver safety. In 2014, the *Code for the Road* campaign was rolled out as a safety initiative. Various messages have been promoted on billboards, newspapers, radio advertisements, television broadcasts, and online advertisements to alert drivers about safe practices. Education and outreach have also been utilized, and funding has been allocated for additional safety personnel and law enforcement to patrol the oil region (Grand Forks Herald 2013).

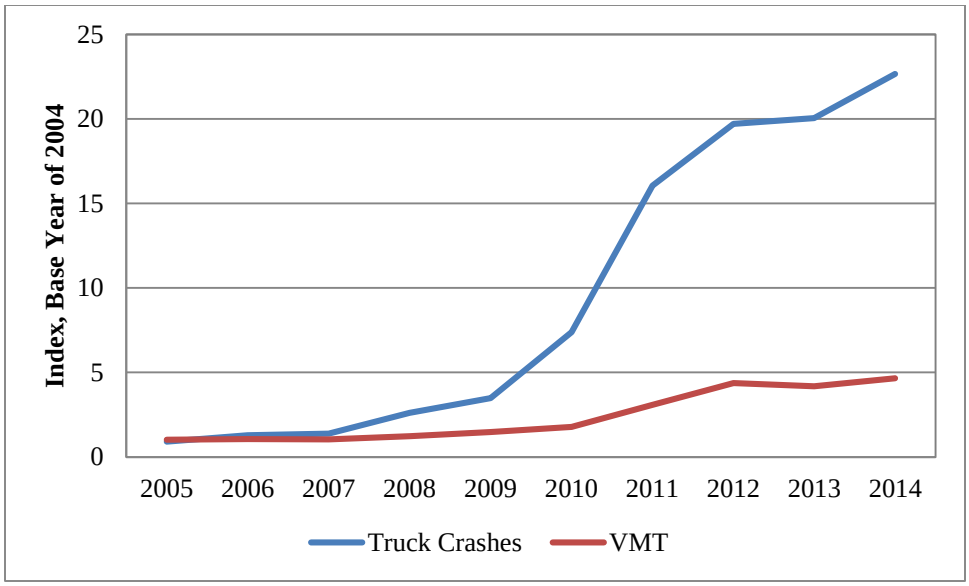

Figure 1.4 Large Truck Crash Growth Trends in Central Core Counties

This research report aims to address a few key goals related to improving traffic safety in the region: (1) to longitudinally examine public perceptions of traffic safety issues and priorities in the state's oil producing region; (2) to discover trends in large truck/passenger vehicle interaction among oil county drivers; and (3) to understand the efficacy of public education, specifically *ProgressZone: Moving Forward Safely* in 2012 and *Code for the Road* in 2014 and 2015 as safety intervention strategies focusing on large truck/passenger vehicle interaction. The following section provides context for the survey discussion presented in section five. Sections three and four highlight information on the methodology and survey response. Some crash facts related to the survey focus are given in section six. Section seven discusses the correlative relationships between economic factors of oil extraction and different crash metrics. The final sections include the conclusion and discussion for the survey.

2. BACKGROUND

2.1 Western North Dakota Oil Region Geography

The 17-county oil region is defined by its proximity to economically viable oil formations (Figure 2.1). Currently, two formations define the oil region: the Bakken and the Three Forks. The recently discovered Birdbear Formation is expected to augment oil activity further. All have different levels of drilling and production. The Bakken covers a significant portion of North Dakota, South Dakota, and Montana, and extends northward into Saskatchewan and Manitoba. It is estimated that the Bakken has a mean undiscovered volume of 3.65 billion barrels of oil (Pollastro et al. 2008). The Three Forks is directly below the Bakken, and is roughly two miles below the surface of the ground (Beitsch 2010). It has been estimated that it has two billion barrels of recoverable oil (Sonnenberg, Gantyno, and Sarg 2011). Presently, North Dakota produces just under 1.2 million barrels per day from these formations (Helms 2015), a number which was predicted by geological experts just a few years ago (St. Anthony 2011).

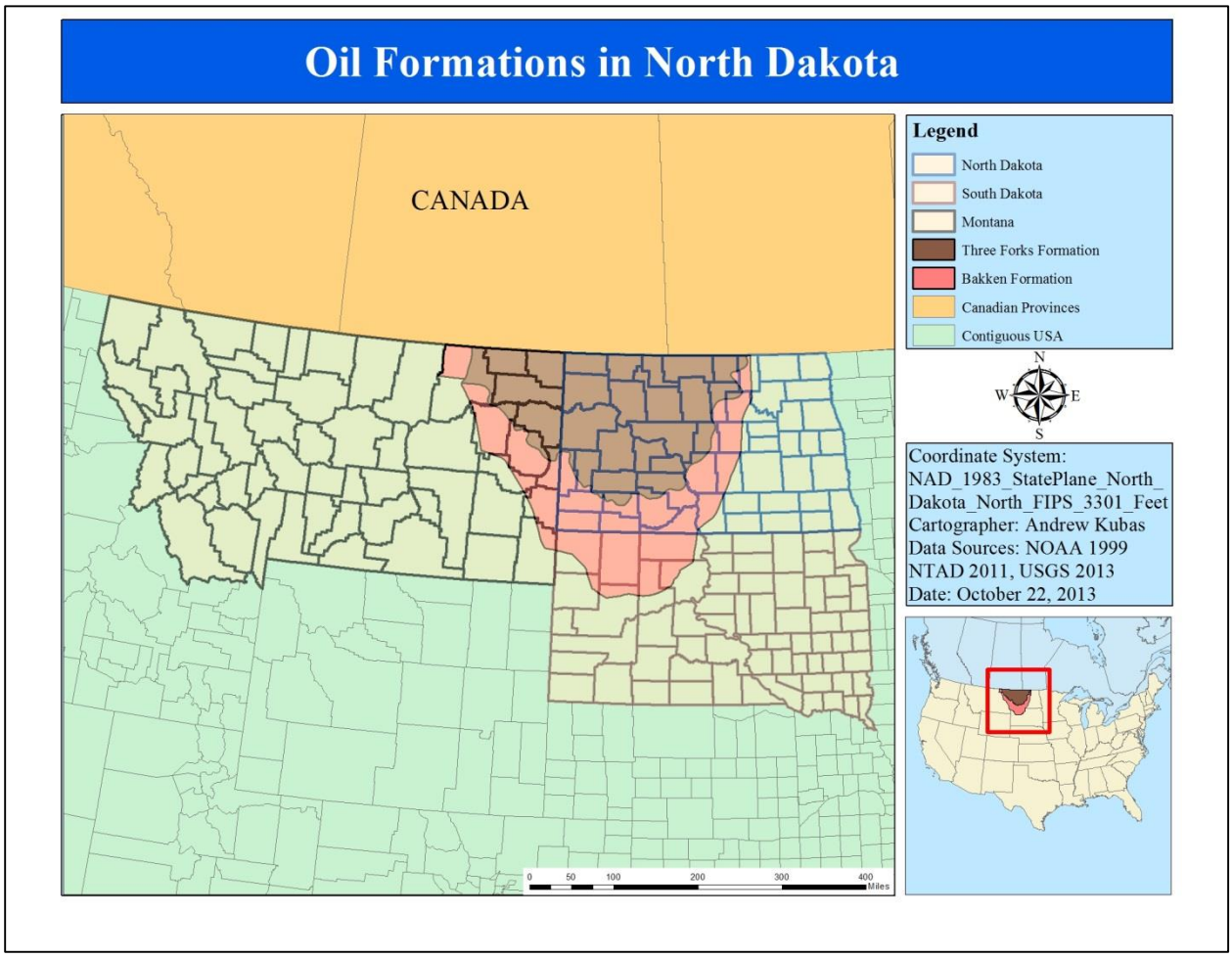

Figure 2.1 Oil Formations in North Dakota Oil Region

The Birdbear Formation lies further underground beneath the Three Forks Formation (LeFever 2009). Drilling and oil production is newer, with only 37 active wells producing as of 2010 (Yang and Kent 2010). Although the three formations share similar geographic and geologic properties, the drilling and production activity that takes place varies from formation to formation.

2.2 Growth and Development of the Oil Industry

Oil development in North Dakota has expanded rapidly, particularly since the latest "boom" in activity began in 2004 (NDIC 2015) (Figure 2.2). The North Dakota Industrial Commission's Department of Mineral Resources, Oil and Gas Division, reports that there are 12,543 actively producing oil and gas wells, a considerable spike from the 3,339 that were producing in 2004.

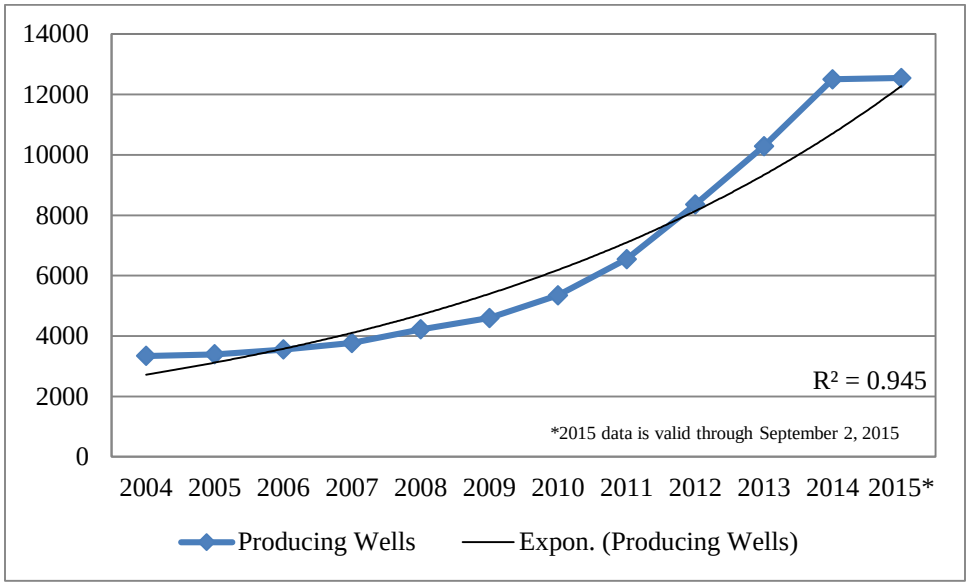

Figure 2.2 Active Oil Wells in North Dakota

The 17 western oil-producing counties vary considerably in terms of oil production (Table 2.1). McKenzie County has the highest volume of barrels of oil produced in June of 2015 (12,214,385), the greatest number of actively producing oil and gas wells (3,184), and the highest average production per well (3,836 barrels). These numbers represent a stark contrast from Mercer County, which did not have any wells producing in June of 2015. It was producing oil as recently as December of 2013.

These counties face unique impacts with regard to state and local roads because of oil development (Table 2.2, Table 2.3). As demand for oil has increased, so too has the use of local low-volume and high-volume roads. Many of these roadways were not designed for heavy truck traffic. The most common reason that infrastructure problems arise is because of the sheer volume of vehicles and weight that these vehicles place on each axle. The stressors are especially prominent in oil development (Rosendahl 2011). The NDDOT estimates that for each vertical oil well drilled, 400 truck loads are needed throughout implementation and maintenance (NDDOT 2008). Additionally, for each horizontal well drilled, anywhere from 600 to 1,000 truck loads are required (NDDOT 2008).

Based on extensive analysis of surface and base layer thickness, the materials of those layers, the amount of cracking and deterioration of the surface layer, underlying soil conditions, and the graded width of the road, a study from the Upper Great Plains Transportation Institute concluded that approximately 958 miles of paved roads and 12,718 miles of unpaved roads are impacted by oil development (UGPTI 2010). These impacts include additional maintenance costs, unforeseen maintenance costs, surface cracking, road deterioration, damages to grading, damages to drainage, and overhead expenditures (UGPTI 2010).

Table 2.1 Western North Dakota Oil Production, June 2015

County	Ranking	Barrels	Wells	Average Production per Well
McKenzie	1	**12,214,385**	**3,184**	**3,836**
Mountrail	2	7,378,427	2,362	3,124
Dunn	3	5,636,689	1,685	3,345
Williams	4	5,589,626	2,031	2,752
Divide	5	1,208,426	702	1,721
Bowman	6	602,727	373	1,616
Stark	7	464,045	251	1,849
Burke	8	443,016	522	849
Billings	9	421,379	494	853
Bottineau	10	189,403	537	353
McLean	11	83,331	42	1,984
Golden Valley	12	69,247	88	787
Renville	13	66,523	236	282
Slope	14	31,064	15	2,071
McHenry	15	5,961	13	458
Ward	16	3,039	8	380
Mercer	17	0	0	0
TOTAL		34,407,288	12,543	2,743

Bold: Leading county in category
Source: North Dakota State Industrial Commission 2015

Table 2.2 Conditions of Paved Roads Affected by Oil Development

Road Condition	Miles	Percent Miles	Cumulative Miles	Cumulative Percent
Very Good	60.8	6.3%	60.8	6.3%
Good	496.1	51.8%	556.9	58.1%
Fair	333.6	34.8%	890.5	92.9%
Poor	38.2	4.0%	928.7	96.9%
Very Poor	29.7	3.1%	958.4	100%

Source: Upper Great Plains Transportation Institute 2010

Table 2.3 Conditions of Unpaved Roads Affected by Oil Development

Road Condition	Miles	Percent Miles	Cumulative Miles	Cumulative Percent
Very Good	118.2	0.9%	118.2	0.9%
Good	4,601.9	36.18%	4,720.1	37.1%
Fair	7,374.2	57.98%	12,094.3	95.1%
Poor	574.3	4.52%	12,668.6	99.6%
Very Poor	49.3	0.4%	12,717.9	100%

Source: Upper Great Plains Transportation Institute 2010

In general, truck loads consist of heavy-duty vehicles and objects that are significantly over the size and weight limits of low-volume rural roads (NDDOT 2008) (Table 2.4). The main impacts of the overweight loads and heavy-duty vehicles on rural road networks are damages to the crown and rutting (Skorseth and Selim 2000). The weight of the vehicles gradually diminishes the crown. As the crown decreases, water accumulation and traffic can soften the crust, create a rut, develop potholes, and, eventually result in washboard conditions that make the road dangerous year round.

Table 2.4 Overweight Loads During Oil Development and Maintenance

Load Type (and number needed)	Weight (lbs.)
Generator House (3)	111,180
Shaker Tank/Pit	122,000
Suction Tank	131,000
Mud Pump (2)	164,000
Shaker Skid	111,760
Draw Works	130,880
Hydraulic Unit	127,640
Tool Room Junk Box	124,140
BOP Skip	138,680
Top Dog House	117,000
Crown Section	140,000
Derrick	159,000
VFD House	130,100
Mud Boat	114,380
Substructure	136,000
Centerpiece	139,440
Choke Manifold	126,000
MCC House	145,160
BOP Setting Machine	145,160

Source: North Dakota Department of Transportation 2008

A study by Mitra, Tolliver, and Dybing (2012) analyzed three main data sources – oil production forecasts, traffic data, and county road surveys – to assess the current situation in the state. Presently, there is greater traffic volume, an increased number of overweight vehicles, and an increased number of oversized trucks on the road because of energy sector growth. All of these variables contribute to deteriorating road conditions. The authors estimate an investment of $900 million will be needed during the next 20 years to maintain roads for transporting oil and allowing travelers to have acceptable roadway use in western North Dakota.

2.3 Community-Level Changes due to Oil Extraction and Development

Early research regarding the impacts that oil extraction has on a region shows a similar situation to that currently being experienced in North Dakota. Affolter (1976) studied the implications oil development had in Scotland factoring for ecological, planning, and general environmental considerations. There was a link between human activity and growing pressures on the built and natural environments. Oil extraction in the North Sea created noise, safety hazards, increased traffic volumes, altered landscape, construction camps, and localized changes to infrastructure – all of which are presently occurring in western North Dakota.

Near Coastal Louisiana, environmental consequences from oil extraction in the Gulf of Mexico were augmented by hurricanes and tropical storms. Laska et al. (2005) performed a social impact assessment to gauge which human activities in the region would be impacted by various proposed projects aimed at restoring barrier islands. The authors noted that such projects could threaten transportation modes such as road networks, ports, and airports; issues that would not have arisen without demand for oil extraction.

Prowse et al. (2009) discuss the implications that oil development has had in northern Canada. The researchers found that the development has led to noticeable changes to infrastructure and transportation, particularly in terms of designing pipeline networks to deliver oil and gas to market. The study sheds light into the relationship between oil extraction and transportation safety, but focuses extensively on future responses due to predicted climate change instead of present issues stemming from oil development.

A recent study from Kubas and Vachal (2014) indicates that drivers in western North Dakota do not feel safe when traveling via automobile. Residents from the region generally are fearful during large truck-passenger vehicle interactions. About three-quarters of drivers were willing to drive out of the way during a typical commute to avoid roads with heavy truck traffic or to drive on roads with better signage and surface conditions. The study also tracked crash rates noting that conditions in the western oil-producing counties were actually more dangerous than in the rest of the state.

2.4 Studies Relating to Perceived Safety

Some studies have attempted to measure perceptions of safety in various situations. Naveh, Katz-Navon, and Stern (2005) gave a questionnaire to doctors and nurses at two separate hospitals to identify patient safety within the hospital building. A major finding from the study was that when employees perceived that the safety procedures were congruent with their daily work demands and were realistic given the available resources, the priority given to safety was high and overall safety subsequently improved. This was further augmented when information flow was clear and sufficient from all employees in the hospital. In western North Dakota, it can be argued that daily travel demands have exceeded capabilities of the roadway, and this may influence how road users perceive safety.

A survey of workers at British Rail aimed to understand perceptions of the importance of safety in the organization (Clarke 1999). Three types of workers – train drivers, supervisors, and senior managers – were asked to participate. All three groups rated safety as being important, but each group varied on how they perceived other groups would rate the importance of safety. This finding parallels some of the literature on risk taking: humans tend to perceive themselves as being safer than others (see section 2.7). In general, a sense of "otherness" emerges when one is asked to compare one's self to one's peers or colleagues. In this instance, a hierarchy of transportation management officials rated the importance of safety differently compared to others at the exact same institution.

2.5 Driver Behavior as a Determinant of Roadway Safety

Driver behavior directly impacts safety. Operating a vehicle while impaired, speeding, or choosing not to wear a seat belt contributes to danger. Drivers have different underlying mechanisms that determine emotional or reckless driving violations. For example, Martinussen et al. (2013) gave a survey questionnaire to 4,335 Danish drivers in an attempt to understand behaviors while operating a motor vehicle. The study found a differentiation between how drivers with emotional violations and those with reckless violations change their driving styles. The changes stem from different underlying mechanisms, such as errors or lapses while unfocused, emotional arousal, reckless behavior, and confusion. Given the large volume of vehicles on western North Dakota roads, a lapse in judgment, loss of focus, or confusion on the roadway could be fatal.

Strayer and Drews (2007) focused on cell phone use as it related to driver distraction. The authors tested drivers by using a simulated screen to see if hands-free cell phone use resulted in any lost information while driving. Drivers who use a hands-free cell phone failed to see some information in the driving scene. According to the researchers, drivers do not encode information adequately, even when using a

hands-free device. The authors indicate that the best driving scenario is one in which the driver is not distracted whatsoever.

Individuals behave differently after being in a crash (af Wahlberg 2012). A study of drivers at the bus company Gamla Uppsalabuss in Uppsala, Sweden, attempted to explain if drivers operate vehicles in a safe manner after having been in a crash. The study showed that there is no large effect on general driving behavior after a crash, but the researcher noted that drivers may change specific behaviors. For example, an individual who experienced a crash at a junction may use extra caution when at junctions in the future.

Drivers exhibit more stress, worry, and exhaustion after a crash. A survey of 124 drivers from the Atlanta area found that 42 had been in at least one crash in the previous five years. When studying differences between those that did and did not crash, Lucas (2003) showed that drivers reporting having been in at least one crash had greater personal safety concerns, worries about driving, stress, exhaustion, and negative physical symptoms. These experiences may directly relate to overall perceptions of safety on the roadway.

Although drivers who have experienced a crash exhibit more fear and worry on the roadway, these motorists nonetheless tend to have higher levels of risk-taking, even after the crash has occurred (Lin et al. 2004). A 20-month study was conducted in Taiwan in which the impact of motorcycle crash experiences was investigated. Students with prior crash involvement had higher risk-taking levels than those without a crash. However, involvement in a previous crash did not change one's reported levels of risk-taking. This indicates that risk-taking among drivers varies individually – danger on the roadway can stem from individual behavior.

2.6 Large Truck-Passenger Vehicle Interaction

Nationally, fatalities from large truck crashes decreased from 1975 to 1999, likely due to safety improvements to trucks and passenger cars (Lyman and Braver 2005). After querying FARS data for U.S. truck crash rates and truck crash fatality rates over that time frame, the researchers found that fatalities in large truck crashes per 100 million truck miles traveled decreased. Similarly, truck driver deaths per 10,000 truck registrations also decreased over the same period. The number of fatalities in large truck crashes, however, has not changed per 100,000 population. It is hypothesized by the authors that across-the-board safety advances to truck and passenger cars may explain the overall crash rate improvement.

A study by Jermakian (2012) posits that further safety improvements such as side view assist, forward collision warning, lane departure warning, and vehicle stability control would be relevant to approximately one-fourth of all large truck crashes in the United States. The author extracted data from two sources – the National Automotive Sampling System General Estimates System (NASS GES) and FARS – to identify which safety features were relevant to different types of crashes. This was accomplished by factoring for the crash type and manner of collision and then separating individual crash events as they related to each of the four crash avoidance technologies. It was found that such technology could be applicable to tens of thousands of large truck crashes annually.

Aghabayk et al. (2011) showed that large trucks execute lane changes more smoothly on arterial roads and freeways than shorter vehicles. The researchers applied different models to lane-changing techniques by large and heavy trucks. They attributed the smoothness of large truck movements to the fact that heavy vehicles apply lower acceleration or deceleration when executing a lane change maneuver. Although the authors have a limited sample size, they also present preliminary findings suggesting that large truck driver behaviors are typically safer than drivers of passenger vehicles.

The Upper Great Plains Transportation Institute analyzed the impacts that oil and gas development have had on western North Dakota's roads (UGPTI 2010). Trucks make up a significant portion of traffic in oil-producing counties (Table 2.5). Of the 15 western North Dakota oil-producing counties studied, the mean number of trucks on the road each day is 61 (UGPTI 2010). Beyond volume, the number of trucks on the road in western North Dakota is also a significant proportion of the traffic (Table 2.6). As a whole, in the 15 counties that were studied, trucks comprised 42% of the average daily traffic (UGPTI 2010).

Table 2.5 Average Trucks per Day on Major County Roads

County	Road Segments Observed	Minimum	Mean	Maximum
Billings	9	4	31	80
Bottineau	3	48	68	86
Bowman	6	30	125	233
Burke	6	4	22	66
Divide	3	28	96	172
Dunn	10	12	61	198
Golden Valley	5	23	38	50
McHenry	4	7	21	40
McKenzie	12	14	97	253
Mercer	3	1	3	6
Mountrail	12	12	65	252
Slope	4	7	17	34
Stark	5	9	26	62
Ward	6	24	105	217
Williams	11	10	68	312
All	99	1	61	312

Source: Upper Great Plains Transportation Institute 2010

The same study from the Upper Great Plains Transportation Institute discussed a survey which analyzed 2007 truck traffic data to establish a baseline of average ADT and percent truck traffic on roads in North Dakota's oil region. The survey found that between 2008 and 2010 the percentage of trucks on collector roads – those designed to move traffic from local roads to arterial roads – increased from 18% in 2008 to 39% in the same counties by 2010 (UGPTI 2010). This is a considerable increase in a relatively short span of time, especially when considering that a majority of western North Dakota residents do not feel safe passing or being passed by heavy-duty trucks (Kubas and Vachal 2012).

Table 2.6 Percent Trucks and Multi-Unit Trucks on Major County Roads

County	Trucks as a percent of ADT	Multi-Units as a Percent of Trucks
Billings	49	23
Bottineau	24	38
Bowman	62	24
Burke	43	72
Divide	54	63
Dunn	46	46
Golden Valley	42	31
McHenry	51	52
Mercer	14	8
Mountrail	49	49
Slope	37	28
Stark	24	42
Ward	26	35
Williams	51	56
All	42	44

Source: Upper Great Plains Transportation Institute 2010

2.7 Perceived Risk on the Roadway

Drivers often perceive themselves as being safer than others. Out-of-state oil workers perpetuate the "self-versus-other" dynamic in western North Dakota. A study by DeJoy (1989) asked 106 college students to compare their risk of being involved in 10 different crash scenarios compared to other drivers at their school. Subjects consistently viewed their chances of being involved in a crash as significantly less than their counterparts. Delhomme, Verlhiac, and Martha (2009) had similar results in a study of 3,002 young French drivers. These individuals were asked to rate perceptions of one's self compared to other drivers with regard to tendencies and expectations when operating a vehicle. Like the study by DeJoy, drivers rated themselves as safer than other drivers. Additionally, this study factored for various emotional states. Drivers who exhibited comparative optimism tended to take less risk on the roadway and were safer drivers than those categorized as exhibiting comparative pessimism.

Certain demographics are more prone to taking risks on the roadway than others. In North Dakota, young male drivers are a particularly dangerous group. They are more likely to engage in dangerous driving activity, less likely to partake in safe driving behaviors, and are less likely to be positively influenced by traffic safety messages (Vachal, Benson, and Kubas 2010-2015). A study utilizing the U.S. National Household Travel Survey estimated the individual driver risk for crash involvement (Ouimet et al. 2010). Just as is in North Dakota, on a national scale the study indicated that young male drivers have the highest risk of any driver group. Additionally, young drivers with passengers in the vehicle were found to engage in high-risk activity on the roadway.

2.8 Safety Strategies/Campaigns as Intervention and Prevention Tools

Traffic safety interventions are generally formed under four approaches: policy (Shults et al. 2004), enforcement (Houston and Richardson 2006), education (Hedlund et al. 2008), and media (Nichols and Ledingham 2008). All intervention approaches have been used with varying degrees of success in addressing issues such as seat belt use, impaired driving, and speeding. These strategies are primarily associated with public education and perceptions, and have been proven in past applications.

For example, the *ProgressZone: Moving Forward Safely* campaign launched by the North Dakota Department of Transportation in 2012 utilized a combination of education and media strategies to alert drivers in western North Dakota oil-producing counties about safe behaviors (North Dakota Petroleum Council 2011a, North Dakota Petroleum Council 2011b). The campaign had four main messages displayed on large yellow billboards: "Pass With Caution," "Be Patient. Slow Down," "Buckle Up. Every Time," and "Roads Shared. Lives Spared" (Wehrman 2011). The campaign proved successful: roughly 42% of all drivers that viewed the safety messages positively changed their driving habits (Kubas and Vachal 2012). Understanding the safety impacts of this campaign is important in future traffic safety resource decisions (Donovan 2011).

The *Code for the Road* campaign is another example of education and media strategies focused on traffic safety. The safety messages target driver behavior and focus on buckling up, driving sober, and slowing down. It is a statewide initiative with commercials displayed on television, radio, and internet advertisements (Heidle, Horton, and Lerman 2014). Messages began appearing in 2014, and have been rolled out consistently in 2015.

Local, state, regional, and federal safety campaigns have been waged in an attempt to promote safer driving habits and discourage dangerous driving activity. Safety tools such as *What's the Hurry?* in northeastern Tennessee (Whittam et al. 2006), the *Hawaii Opportunity Probation with Enforcement* (Hawken 2011), the *South Dakota 24/7 Sobriety Project* (Loudenburg, Drube, and Leonardson 2010), the *Checkpoint Strikeforce* program in NHTSA's Region 3 (Lacey et al. 2008), the annual nationwide *Drunk Driving: Over the Limit, Under Arrest* Labor Day crackdown (Solomon et al. 2008), the *Target Zero Team Project* in Washington State (Cicchino 2012), the *Saving Lives* program in Massachusetts (Hingson et al. 1996), the *Strategic Evaluation States* initiative in Alaska, Georgia, and West Virginia (Syner et al. 2008), the *Better Driver Campaign* in Florida (Lee et al. 2010), and the national *Click It Or Ticket* campaign (Kim and Yamashita 2003) are geared toward improving safety on the roadway and have been studied extensively. Many of these programs emphasize preventing impaired driving, and some do so specifically targeting young males (Murry, Stam, and Lastovicka 1993).

2.9 Traffic Safety and Economic Factors

Studies have revealed a relationship between overall traffic safety and economic factors. Most link the price of petroleum and/or oil to crash patterns. In Minnesota, the price of gasoline was found to have an inverse relationship to traffic safety: as gas prices declined, the total number of crashes, property-damage-only crashes, and injury crashes rose, likely because of increased travel at more affordable prices (Chi et al. 2013a). The study found more noticeable differences in rural counties than in urban counties; rural communities generally had worse traffic safety conditions with lower gas prices. Considering the rurality of North Dakota and the recent decline in oil and gas prices, it may be expected that some traffic safety metrics will worsen.

A study in Mississippi had comparable findings: an increase in gas prices had a noticeably reduced less severe crashes (Chi et al. 2013b). However, there was a negligible effect on fatal crashes. A separate study in Mississippi linked higher gas prices with a decline in impaired driving crashes (Chi et al. 2011).

At the national level, trends mirrored those in individual states. Lower gas prices tend to result in more traffic fatalities (Grabowski and Morrisey 2014). Once again, this was not because of changes in driver behavior, but because of additional travel activity resulting in more opportunities for a crash to occur.

Hyatt et al. (2009) analyzed the effect of gas price as it specifically related to motorcyclists. The findings contrasted other studies in the literature in that higher gas prices appeared to result in more deaths to motorcycle drivers. The relationship between the price of gas and motorcyclist safety was somewhat inconclusive: higher gas prices resulted in more deaths to motorcycle drivers by volume, but when the authors factored for the rate at which vehicles were registered there was no substantive association between gas prices and motorcyclist fatalities.

Although these studies will guide the present research, none focus on areas with historically high oil extraction activity but declining petroleum prices. It is clear that economic factors such as the price one pays to enjoy vehicular travel are linked to actual traffic safety, but does a similar relationship exist when the volume of traffic declines because a substantial amount of said traffic is related to the price of oil and gas being high? It is plausible that there may be a correlative relationship between the price of oil, gas, and crash patterns, but it is uncertain if this relationship will also follow inverse patterns. For instance, as oil prices have dropped overall extraction activity has subsequently declined. As a result, drivers are able to travel more often – which increases crash likelihood – yet these same drivers may perceive travel to be safer as a product of fewer oil trucks and oil-related traffic sharing the roadway. This paper will examine possible correlative links between oil prices, crash trends, and perceptions of traffic safety.

2.10 Gaps in the Literature

These topics have been studied widely by academics and transportation safety personnel, but none have focused solely on North Dakota oil development. Moreover, none have given priority to rural road segments. The goal of this project is to measure driver behaviors, perceptions, priorities, and risk given rapidly changing road networks in western North Dakota and worsening crash trends. This will be achieved by (1) measuring public perceptions of traffic safety issues and priorities in the state's oil producing region; (2) determining perceived driver risk and its relation to danger on the roadway; and, (3) querying rural crash data to parallel it with on-road driving experiences as reported by drivers. This crash data will be compared to the non-oil-producing part of the state in an attempt to quantify if the perceptions of dangerous driving conditions are simply perceived or occurring in reality.

3. METHOD

A mail survey was used to obtain data from western North Dakota residents. A draft survey was designed by blending questions related to traffic safety, *ProgressZone: Moving Forward Safely* goals (in 2012), *Code for the Road* goals (in 2014 and 2015), and issues directly related to oil traffic and oil development. Industry partners provided input regarding questions to include in the final survey. The mailing to drivers included a cover letter which invited participation and explained the goals of the survey. The survey was first mailed to drivers on April 6, 2012, and was open to response until May 1, 2012. In 2014, the second mailing for a follow-up study was mailed to drivers on April 1, 2014, and was open to response until May 5, 2014. The 2015 mailing occurred on April 9, 2015, and was open to response until May 23, 2015.

The state driver licensing division used the 17-county oil region driver population for the sampling. Initially, the 2012 mailing list provided by the North Dakota Department of Transportation consisted of 2,700 driver addresses. Prior to mailing, 41 addresses were removed because they were in counties outside of the 17-county focus area. Thus, 2,659 addresses were verified for final mailing. Of these, 10 were flagged as addresses of individuals who had moved and had not provided a new forwarding address, 2 were flagged as "unmailable," and 22 were flagged as "problem" addresses that were not mailed. Ultimately, 2,623 surveys were mailed. Three of the 2,623 initial surveys that were mailed were unable to be forwarded to a current address and were returned by the post office. Of the 2,620 successfully mailed, 781 responses were obtained. From these, two responses had zip codes that were either out-of-state or unverifiable. Of the useable survey responses received, 779 were verified as North Dakota responses and form the valid driver response sample used as the baseline year in the analysis.

In 2014, a slightly larger mailing list of 2,720 driver addresses was provided by the state driver licensing division. Before mailing the survey, 54 addresses were removed because they were either addressed to out-of-state drivers or North Dakotans living in counties outside of the target area. None of the remaining addresses were flagged as "unmailable," "problem addresses," or sent to individuals who had changed residency. A total of 2,666 surveys were mailed. Two of these were returned as undeliverable. Of the 2,664 successfully mailed, 710 responses were acquired. Of these, 14 responses had zip codes that were either out-of-state addresses, unverifiable, or from counties outside of the 17-county target region. Thus, 696 surveys comprise the final sample for the 2014 follow-up study.

The 2015 mailing consisted of 2,720 driver addresses provided by the state licensing division. Prior to mailing the survey, 64 addresses were eliminated due to being addressed to areas that were outside of the target region. None of the 2,656 remaining addresses were tagged as "unmailable," or "problem addresses" by the post office. Of these, two were returned as undeliverable. From the 2,654 successfully mailed, 599 were returned. Three surveys did not include a zip code, one survey had an unknown zip code, and six had zip codes that were from North Dakota counties outside of the study area. A total of 589 surveys were valid and comprise the final sample for the third year of the study.

The sample sizes were based on a 95% confidence interval, with a 5% confidence level. The expected response rate was estimated at 20%. Although mail survey response is generally low – 10% is not uncommon – a slightly better response rate was expected due to the parameters used in the survey design and administration. These parameters included keeping the survey to a single page, including "Upper Great Plains Transportation Institute, North Dakota State University" letterhead, and using mail envelopes with official insignia. Given the timeliness of the topic at hand, it was expected that an above-average response would be obtained.

A proportionate stratified random sample was used to select drivers. The North Dakota driver population was stratified by county. Individuals living in the 17 oil-producing counties had no greater than a 3.5%

chance of receiving a survey. The greatest number of surveys was sent to Williams, Stark, and Ward counties, respectively. This aligns with the fact that these three counties are home to the three largest cities in the oil region: Williston, Dickinson, and Minot.

Although a random sample was obtained for the survey mailing, the sample was not representative of the population (Table 3.1). Males were overrepresented in the 2012 mailing and underrepresented in the 2014 follow-up study. Whereas the adult (18+) population in the 17 western North Dakota oil-producing counties is 51 percent male and 49 percent female, the sample used in 2012 had rates that were 62 percent male and 38 percent female and the 2014 follow-up study had rates that were 42 percent male and 58 percent female. In 2015, proportions more accurately represented the balance of the North Dakota population: 48% of responses were from males and 52% were from females.

The proportion of drivers in each age cohort did not always mirror the real-life proportion of drivers in the oil-producing counties. In 2012, the sample was underrepresented in terms of drivers 44 years of age and younger. In contrast, drivers between ages 55 and 74 were overrepresented in the sample when compared to their actual proportion of the population in the counties. In 2014, a comparable situation occurred: drivers under the age of 34 were underrepresented and drivers between the ages of 55 and 74 were once again overrepresented. The same trend occurred in 2015. Some age cohorts – such as the 45-54 age group and the 75+ age cohort – were accurately represented in the mailing sample.

Table 3.1 Mailing Samples and State Driver Population by Age

Survey Information	Age Cohort						
	18-24	25-34	35-44	45-54	55-64	65-74	75+
Surveys Mailed, 2012	86	285	212	584	637	488	366
Surveys Mailed, 2014	150	249	375	609	652	358	273
Surveys Mailed, 2015	157	270	425	530	634	354	286
Percent of Sample Mailed, 2012	3.2	10.7	8.0	22.0	24.0	18.4	13.8
Percent of Sample Mailed, 2014	5.6	9.3	14.1	22.8	24.5	13.4	10.2
Percent of Sample Mailed, 2015	5.9	10.2	16.0	20.0	23.9	13.3	10.8
Oil County Population[1]	17,486	21,976	18,087	24,914	21,292	12,730	13,637
Percent of 18+ Oil County Population	13.4	16.9	13.9	19.1	16.4	9.8	10.5

[1]Source: US Census Bureau 2010 Census

Survey responses were entered into a database using SPSS Statistics 22 software (see Table 5.1 and Table 5.2 for quantitative scale definitions). Initially, a factor analysis was performed to identify possible components linked to constructs developed by the researchers. After the factor analysis was conducted, different statistical analyses – such as measures of association, Chi-Square tests, and 1-way ANOVAs – were performed to identify differences in response distributions and differences across target groups. Most of the questions on the survey were posed at ordinal levels of measurement, though some were presented and subsequently coded as dichotomous "dummy" variables. Some variables, such as length of residency, were recoded to ordinal scales based on prior studies from the literature. Key driver groups – gender, age, newcomers/long-term residents, high-risk young drivers, and those exposed to the *Code for the Road* safety campaign – were treated as independent variables in the analysis. Driver knowledge, attitudes, behaviors, and beliefs were most often treated as dependent variables in the statistical analyses.

4. RESPONSE

Survey response rate was 29.7% in 2012, with 779 valid responses from the sample mailing to 2,620 drivers. The response rate was 26.1% in 2014, with 696 valid surveys obtained from a mailing to 2,666 drivers. A smaller response rate of 22.2% was obtained in 2015, with 589 valid surveys returned from a mailing to 2,654 North Dakota drivers. As expected, the proportion of responses by age cohort increased with age: there were more responses from older (45+) drivers than there were responses from drivers under the age of 45 (Table 4.1). This was likely because a smaller proportion of younger drivers received the survey compared to the higher proportion of older drivers who received it. Note that the valid responses obtained from this study are not representative of the 17 western North Dakota oil-producing counties: a much lower proportion of drivers under the age of 45 are in the sample than are in the population. Similarly, the portion of drivers between ages 45 and 74 is much higher than the actual proportion of individuals in this age group in the 17-county oil region. The 75+ age cohort comprised 10.3% of responses in 2012, 10.6% of responses in 2014, and 12.6% of responses in 2015 – numbers that accurately reflect their proportion (10.5%) of the oil region population. Also consider that the total number of responses from the 18-24 age cohort is not large enough to be extrapolated to fit the 17 western North Dakota oil county population. In general, at least 30 valid responses are required for data to be considered representative of a particular demographic. Thus, any conclusions made for the 18-24 age cohort cannot be considered indicative of the entire 18-24 year-old population in this portion of the state.

Table 4.1 Valid Survey Responses and State Driver Population, by Age

Survey Information	Age Cohort						
	18-24	25-34	35-44	45-54	55-64	65-74	75+
Valid Surveys, 2012	12	49	55	193	220	168	80
Valid Surveys, 2014	17	40	55	186	198	124	74
Valid Surveys, 2015	8	44	59	121	192	89	74
Percent of Sample Received, 2012	1.5	6.3	7.1	24.8	28.2	21.6	10.3
Percent of Sample Received, 2014	2.4	5.7	7.9	26.7	28.4	17.8	10.6
Percent of Sample Received, 2015	1.4	7.5	10.1	20.6	32.7	15.2	12.6
Oil County Population[1]	17,486	21,976	18,087	24,914	21,292	12,730	13,637
Percent of 18+ Oil County Population	13.4	16.9	13.9	19.1	16.4	9.8	10.5

[1]Source: US Census Bureau 2010 Census
Frequency Missing 2012=2; Frequency Missing 2014=2; Frequency Missing 2015=2

When factoring for both gender and age, multiple demographic groups have less than 30 responses for their respective cohorts. Responses obtained in 2012 cannot be extrapolated to fit the entire population of 18-24 year-old males, 18-24 year-old females, 25-34 year-old females, and 35-44 year-old males (Table 4.2). A similar pattern emerges for 2014 responses. Yet again, both males and females in the 18-24 age cohort did not have at least 30 responses; thus information obtained for these groups will not be considered representative. Males in the 25-34 and 35-44 year-old age cohorts also did not have 30 responses. There were only 27 responses from females over the age of 75; this represents another group for which responses must be interpreted critically. In 2015, responses for males under the age of 44, females under the age of 34, and females over age 75 cannot be extrapolated to fit the entire North Dakota driver population. In the forthcoming statistical analyses, independent variables are not examined in such detail; therefore considerations of only age and only gender can be considered an accurate reflection of attitudes in the target region (see sections 5.5.1 and 5.5.2 for further detail).

Table 4.2 Survey Response by Age and Gender

	2012		2014		2015	
Age	Male	Female	Male	Female	Male	Female
18-24	6 (50.0%)	6 (50.0%)	0 (0.0%)	17 (100.0%)	5 (62.5%)	3 (37.5)
25-34	30 (61.2%)	19 (38.8%)	5 (12.5%)	35 (87.5%)	20 (45.5%)	24 (54.5%)
35-44	24 (43.6%)	31 (56.4%)	24 (44.4%)	30 (55.6%)	23 (39.0%)	36 (61.0%)
45-54	113 (58.5%)	80 (41.5%)	69 (37.5%)	115 (62.5%)	41 (34.2%)	79 (65.8%)
55-64	137 (62.3%)	83 (37.7%)	86 (43.9%)	110 (56.1%)	97 (50.8%)	94 (49.2%)
65-74	104 (62.7%)	62 (37.3%)	55 (45.1%)	67 (54.9%)	49 (55.7%)	39 (44.3%)
75+	38 (47.5%)	42 (52.5%)	45 (62.5%)	27 (37.5%)	45 (61.6%)	28 (38.4%)
Total	452 (58.3%)	323 (41.7%)	284 (41.5%)	401 (58.5%)	280 (48.0%)	303 (52.0%)
	Frequency Missing=4		Frequency Missing=11		Frequency Missing=6	

5. RESULTS

Survey responses offer important insight into driver perceptions, attitudes, and behaviors regarding traffic conditions in the oil region. Simple frequency analysis of ordinal and dichotomous survey responses provides a baseline of driver views and behaviors. Quantifying responses allows for statistical testing of relationships, means, and tests of significance. Quantitative scale definitions are provided in Table 5.1 (for questions that were unchanged in survey iterations) and Table 5.2 (for unique questions on the individual annual surveys).

Table 5.1 Quantitative Scale Definitions: Identical Questions on All Three Surveys

Q#	Question	Scale	Conversion Values
1	Safety Now vs. 5 Years Ago	1-5	1=Much Less Safe to 5=Much Safer
3	Sudden Brake/Swerve	0-1	0=No, 1=Yes
4	Law Enforcement Presence	0-1	0=No, 1=Yes
5	Meet/Pass Large Trucks	1-5	1=Never to 5=Daily
6a	Safety Passing Large Trucks	1-5	1=Very Unsafe to 5=Very Safe
6b	Being Passed by Trucks	1-5	1=Very Unsafe to 5=Very Safe
7a	Extra Driving to Avoid Oil Trucks	1-4	1=No Change to 4=20+ Minutes Extra
7b	Extra Driving for Better Surface/Signs	1-4	1=No Change to 4=20+ Minutes Extra
8a	Seat Belt Use in Town	1-5	1=Never to 5=Always
8b	Seat Belt Use Over 30 MPH	1-5	1=Never to 5=Always
9	Speeding on 65 MPH Road (Over 70 MPH)	1-5	1=Never to 5=Always
13a	Signage of Traffic Rules	1-4	1=Least Important to 4=Most Important
13b	Law Enforcement Presence	1-4	1=Least Important to 4=Most Important
13c	Driver Awareness	1-4	1=Least Important to 4=Most Important
13d	Truck/Car Interaction	1-4	1=Least Important to 4=Most Important

Table 5.2 Quantitative Scale Definitions: Unique Questions

Q#	Year	Question	Scale	Conversion Values
2	2012	Message Alert System	0-1	0=No, 1=Yes
10	2014	Future Injury Crashes	0-5	0=None to 5=5 or more times
11a	2014	Safer Driver Than Others	1-5	1=Strongly Disagree to 5=Strongly Agree
10a	2015	Safer Driver Than Others	1-5	1=Strongly Disagree to 5=Strongly Agree
11b	2014	Out-of-State Dangerous	1-5	1=Strongly Disagree to 5=Strongly Agree
10b	2015	Out-of-State Dangerous	1-5	1=Strongly Disagree to 5=Strongly Agree
11c	2014	Risking My Life Driving	1-5	1=Strongly Disagree to 5=Strongly Agree
10c	2015	Risking My Life Driving	1-5	1=Strongly Disagree to 5=Strongly Agree
11d	2014	See Crash, Drive Less Often	1-5	1=Strongly Disagree to 5=Strongly Agree
10d	2015	See Crash, Drive Less Often	1-5	1=Strongly Disagree to 5=Strongly Agree
10e	2015	Fear Future Crash	1-5	1=Strongly Disagree to 5=Strongly Agree
10f	2015	Improve Road Conditions	1-5	1=Strongly Disagree to 5=Strongly Agree
12	2014	Multi-Vehicle Crash	1-3	1=No, 2=Else's Fault, 3=My Fault
11	2015	Multi-Vehicle Crash	1-3	1=No, 2=Else's Fault, 3=My Fault

The survey questionnaire was designed to measure certain constructs within transportation safety. The researchers wanted to learn about key latent variables which are not easily measured. When applied to residents living in western North Dakota, these factors include perceptions of danger, perceptions of risk, travel behavior, safety priorities, and attitudes toward large truck-passenger vehicle interaction. Factor

analysis was utilized to determine which variables had similar patterns of responses. Initially each variable (with the exception of demographic information) was correlated with one another to identify variables that may be unrelated to any underlying factor. A total of 17 variables were used in the factor analysis, and six components emerged as having an Eigenvalue greater than 1. A scree plot of the components, however, visually displays that the first four components explain a significant percentage of the total variance, and that the fifth and sixth components have an Eigenvalue slightly larger than 1, and are plausibly the "beginning point" of the scree plot's plateau (Figure 5.1).

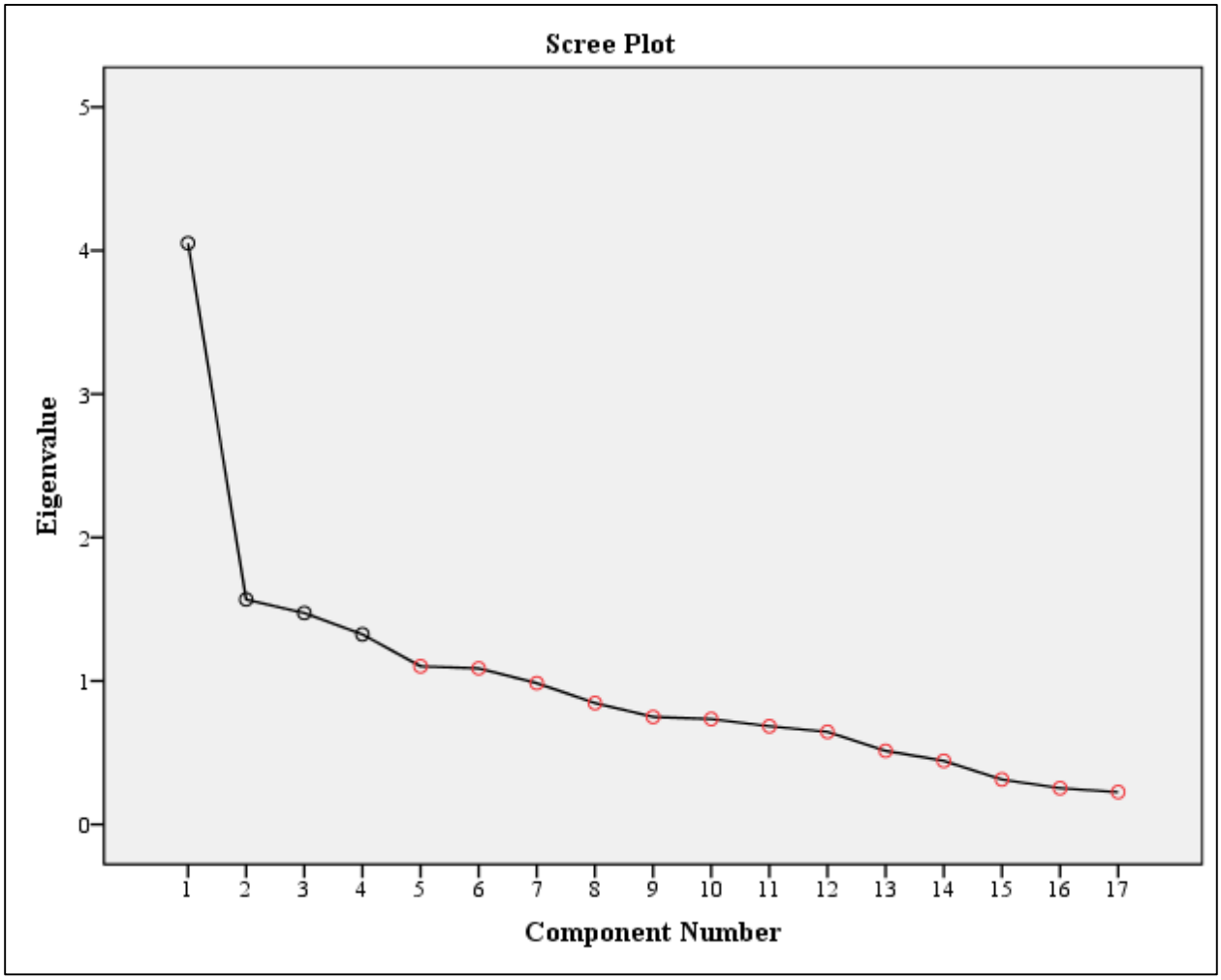

Figure 5.1 Scree Plot of Factor Analysis

These four components were subjected to a Varimax rotation with Kaiser Normalization, and factor loads were sorted by size. Only factor loads greater than 0.40 were considered. The four main components appear to be linked to the constructs identified by the researchers. The first factor relates to perceptions of danger. The second factor can be described as those choosing to avoid danger. The third factor encompasses safe driver behaviors. The fourth factor highlights large truck-passenger vehicle interaction. The relationships of driver responses to these themes will be the focal point of the following data analysis.

5.1 Perceptions of Danger

Multiple survey questions focused on safety conditions in the 17 western North Dakota oil-producing counties. Response frequencies for three of these general safety questions are provided in Table 5.3. Responses show that drivers most commonly do not feel safer driving now than they did five years ago. A majority of respondents chose the worst option on the Likert scale – "Much Less Safe" – in both 2012 and 2014. This declined to 42.4% of respondents in 2015. An independent samples t-test demonstrates that there was a statistically significant difference in how drivers rated safety in 2015. Compared to responses in 2014 ($t=-3.925$, $df=1,267$, $p<0.001$) and 2012 ($t=-4.475$, $df=1,352$, $p<0.001$) participants in 2015 believed that driving conditions were safer.

Just 1.1% of respondents in 2014 indicated that driving conditions had improved in the last five years by answering that they either feel "much safer" or "somewhat safer" when driving. This was a slight decline from the 1.4% of respondents that held this view in 2012. In 2015 the proportion of drivers holding this viewpoint more than tripled to 3.6%.

With regard to braking suddenly, treated here as a crash avoidance maneuver measure, the proportion of respondents revealing that they have had to brake or swerve suddenly to avoid a crash declined compared to the prior two iterations of the survey. This may be a contributing factor in why respondents rated driving conditions as more safe.

Table 5.3 Perceptions of Danger Responses

Question Number	Survey Question / Responses				
1	How safe do you feel driving in your area compared to five years ago?				
	Much Safer	Somewhat Safer	Same	Less Safe	Much Less Safe
2012	0.8%	0.6%	9.7%	33.2%	55.6%
2014	0.1%	1.0%	10.6%	36.2%	52.0%
2015	0.3%	3.3%	13.1%	40.9%	42.4%
3	Have you had to brake or swerve suddenly to avoid a crash in the past 3 months?				
	Yes	No			
2012	73.3%	26.7%			
2014	72.7%	27.3%			
2015	68.7%	31.3%			
11	Have you been in a multi-vehicle car crash in the past 12 months?				
	Yes, it was my fault	Yes, it was someone else's fault	No		
2014	0.0%	2.6%	97.4%		
2015	0.3%	3.2%	96.4%		

Only 17 respondents (2.6%) in 2014 and 21 respondents (3.5%) in 2015 reported that they had been in a multi-vehicle crash within the past year. Being in a multi-vehicle collision is a strong barometer of fear and danger on the roadway, and may contribute to some perceptions and behaviors. Unfortunately, these numbers are not large enough to extrapolate to fit the entire population of western North Dakota residents who have experienced a crash and will not be examined further in the analysis.

5.1.1 Danger: Perceptions of Self and Other

One common theme that emerged from the literature review was that of a "self-versus-other" complex. In general, humans perceive themselves as being safer and more responsible than others. This is also evident in situations related to transportation safety (see DeJoy 1989 and Delhomme, Verlhiac, and Martha 2009).

This theme prompted three questions on the final survey questionnaire to highlight self-versus-other perceptions as related to safety on the roadway (Table 5.4).

North Dakota drivers follow trends found in other studies: a majority rate themselves as safer than others with whom they are sharing the roadway. Similarly, a clear majority believe out-of-state drivers to be a source of danger when compared to fellow North Dakotans. This reveals that a sense of otherness exists when sharing the roadway. Despite this sense of otherness, North Dakotans in 2015 were not as critical when rating other drivers (t=3.034, df=1,277, p=0.002). The average rating for this prompt declined from a mean of 4.03 in 2014 to 3.90 in the most recent survey mailing, implying that North Dakota drivers in 2015 thought other drivers were safer than did their 2014 counterparts.

Table 5.4 Self-versus-Other Danger on the Roadway

Question	Year	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I am safer than others	2014**	0.1%	0.7%	24.5%	45.0%	29.6%
I am safer than others	2015**	0.0%	0.7%	29.7%	48.1%	21.5%
Out-of-state drivers are more dangerous	2014	0.9%	7.2%	20.4%	38.3%	33.2%
Out-of-state drivers are more dangerous	2015	0.7%	6.3%	22.7%	40.3%	29.9%
If I see a crash, I drive that route less often	2014*	4.9%	30.4%	42.4%	17.6%	4.7%
If I see a crash, I drive that route less often	2015*	5.6%	37.2%	38.4%	14.5%	4.3%

**Statistically significant difference at 1% level for independent samples t-test
*Statistically significant difference at 5% level for independent samples t-test

A similar trend happened when rating one's propensity to drive a route after seeing a crash (t=2.323, df=1,271, p=0.020). Although responses followed somewhat of a normal distribution, in 2015 drivers were more likely to continue driving a route even in the event they had witnessed a crash on that particular road segment. This may be due to limited route availability in some rural areas of western North Dakota.

5.1.2 Danger: Risk on the Roadway

A majority of drivers in 2014 and 2015 indicated that they feel as though they are risking their lives when driving in western North Dakota, based on those who answered that they "agree" or "strongly agree" with that prompt, respectively (Table 5.5). Less than one-in-ten (9.8%) either disagreed or strongly disagreed with the belief that they were risking their lives when driving in this part of the state in 2014 and approximately one-in-eight (12.3%) held this viewpoint in 2015. Between 2014 and 2015 a statistically significant shift in viewpoints occurred and respondents became more positive (t=2.196, df=1,268, p=0.028). On average, compared to responses from 2014, western North Dakota drivers in 2015 felt less likely to think that they were risking their lives when traveling in the target study region.

Table 5.5 Risk on the Roadway

Question	Year	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I feel like I'm risking my life when driving in western North Dakota	2014*	2.0%	7.8%	19.0%	40.8%	30.4%
	2015*	2.1%	10.2%	21.6%	40.6%	25.6%

*Statistically significant at the 5% level for independent samples t-test

5.2 Danger Avoidance

Some drivers actively attempt to avoid danger on the roadway. Other drivers may not have this chance considering the remote, rural areas prevalent in some North Dakota counties. Drivers in the target region were asked if – during a typical 20-minute commute – they would drive out of the way to avoid large oil trucks and/or travel on roads with better surface conditions. More than two-thirds indicated they would travel at least five additional minutes for these improved conditions (Figure 5.2 and Figure 5.3).

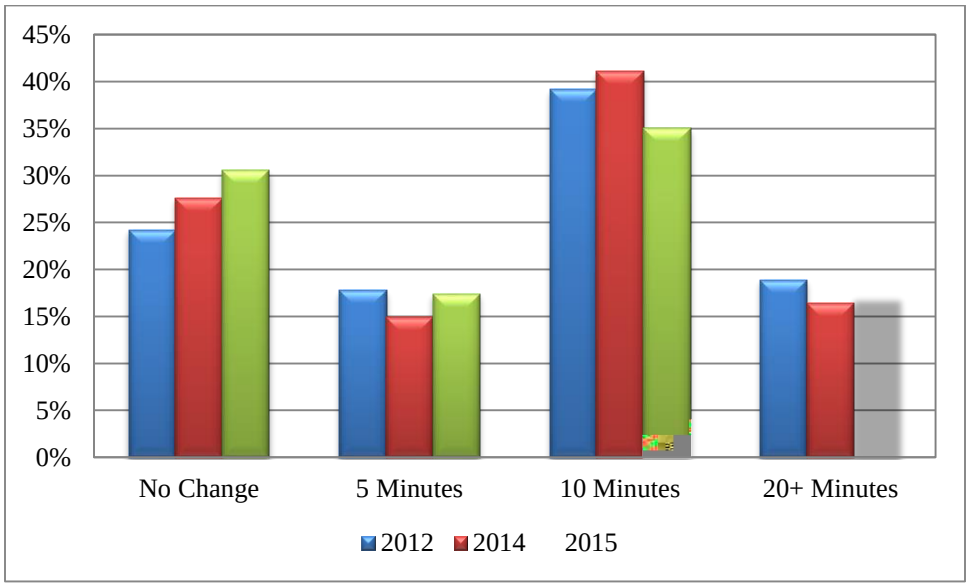

Figure 5.2 Willingness to Travel Out of the Way for Roads with Fewer Oil Trucks

In all three years of the survey, roughly one-fifth of drivers indicated that they would more than double their current commute time and add an additional 20 minutes to travel roads with better surface conditions. One's willingness to travel out of the way is linked to how safe one feels today compared to five years ago. In the 2015 iteration of the survey, those who feel less safe will drive further to avoid oil trucks ($F=9.418$, $df=4$, $p<0.001$) or for better surfaces ($F=4.841$, $df=4$, $p=0.001$).

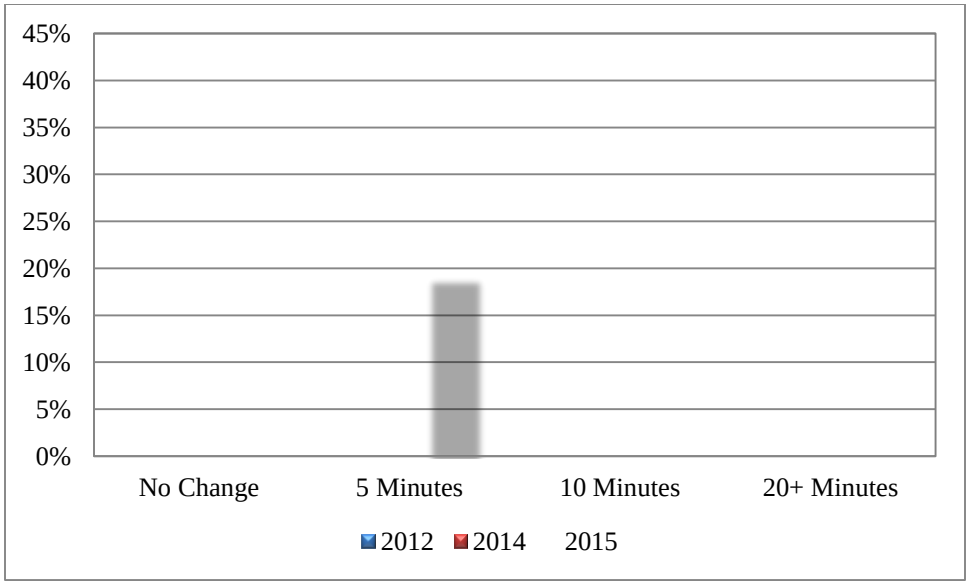

Figure 5.3 Willingness to Travel Out of the Way for Roads with Better Surface Conditions