THE IMPACT OF NORTH DAKOTA'S OIL BOOM ON TRANSIT LIVABILITY

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The Impact of North Dakota's Oil Boom on Transit Livability

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ABSTRACT

Population growth in western North Dakota from those seeking employment in the oil industry has led to substantial increases in personal income and transit ridership. Local survey findings noted that population growth has impacted the quality of life by increasing pressure on infrastructure and increasing feelings of insecurity that stem from demographic shifts and not knowing who is living in local communities. The housing market has also struggled to keep pace. For example, the housing market in the Minot-Williston region is severely tight owing to net in-migration and a dearth in housing for sale.

Transit livability index measures showed an increase in recent years. The combinations of increased ridership and household income have been the two main catalysts for this change. More workers utilizing transit has also led to fewer workers commuting alone to work. However, an increasing mobility needs index and a lack of transit vehicles to meet demand are becoming evident as many of the transit livability indexes are showing smaller increases during the past one to three years compared to earlier gains.

A major finding of this research shows that if the oil boom continues similar to its current pace during the next five years, transit agencies, along with policy makers, should consider expanding services to provide more hours of service along with a larger coverage area to meet new demand. Another major finding is the need for more transit vehicles in the region as well as updating vehicles in current fleets that are beyond their useful life. Increased funding is needed so that transit agencies can improve service levels and meet increasing demand.

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1. INTRODUCTION

The western half of North Dakota has experienced tremendous economic growth in recent years due to increased oil exploration and drilling. Along with this growth have come transportation and housing issues that affect everyone involved. Western North Dakota has seen a dramatic increase in traffic volumes while local transit agencies have seen a substantial increase in ridership leading to greater demand for additional services. Also, increases in housing and apartment rental costs have forced some to relocate to other communities. These issues highlight a number of livability-related topics such as affordable housing, transportation mode choice, and the sustainability of existing communities, among others.

1.1 Objectives

This study was conducted in western North Dakota (Figure 1.1) to analyze topics focusing on transit livability and housing affordability. Transit livability, as it pertains to this research, is defined as the contributing role transit plays to community livability. Objectives included determining the impact of increased travel and housing costs on individuals living in the community as well as how increased household incomes resulting from the western North Dakota oil boom have affected livability. The effect on public transit was also studied to gain a better understanding as to how the oil boom has impacted local transit services. Analysis explored changes to various travel patterns throughout western North Dakota and the impact that population increases have had on available transit services. Forecasting techniques were also used to determine the effect on transit livability related to possible outcomes of three hypothetical oil boom scenarios.

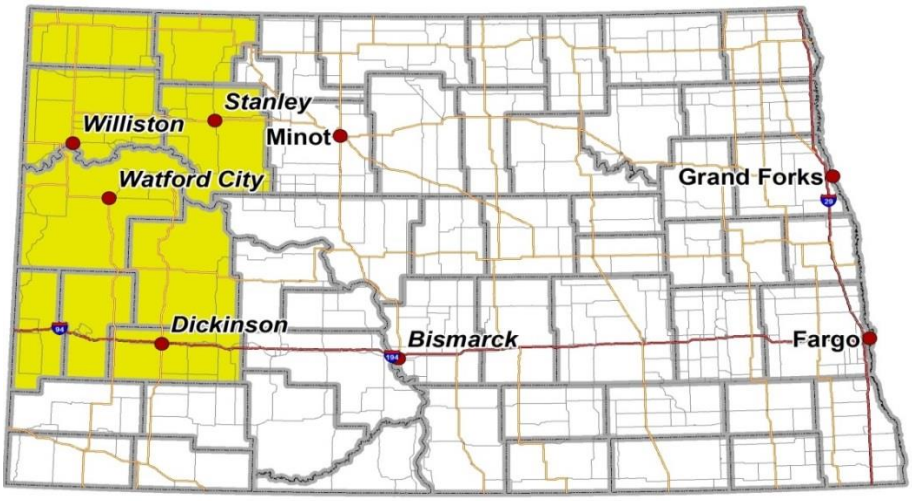

Figure 1.1 Nine County Study Region

1.2 Organization of Content

The study begins with a literature review including research papers and other applicable materials addressing livability issues from multiple perspectives. Following the literature review is a discussion based on the impact of oil exploration and extraction in western North Dakota. Drilling techniques, locations, and resulting demographic changes are all highlighted in this section. Following is an overview of transit livability index calculations and results for the nine-county study region. The livability index is designed based on livability principles developed by the Partnership for Sustainable Communities (2014). Finally, an overall summary concludes the study with recommendations based on research findings.

2. LITERATURE REVIEW

2.1 North Dakota Livability Overview

In the past few years, regionally and within local communities in western North Dakota, changes in population growth, environment, housing, land and water use, and mobility are imposing challenges on local societies and the environment. For example, the growth in population seeking employment in the oil industry has led to substantial increases in housing and other related costs. Additionally, oil exploration related incidents (e.g. spills) have increased residents' environmental concerns. These observed changes have potential impact on residents' and visitors' subjective perceptions and expectations about the environmental and social quality of their community, often described as livability. These impacts are likely to be higher for residents who have resided in the area before the surge in activity (e.g. traffic and noise pollution). Livability is potentially affected by transportation alternatives, affordable housing, job access, quality of schools, and other related amenities.

Although much of the literature has focused on urban areas, many similar livability issues are important within rural areas as well. A general description of a livable urban environment often portrays a community characterized as safe and secure, having good infrastructure, high levels of service provision, and economically viable and environmentally-friendly amenities (Hamilton and Atkins, 2008). Xingjian et al. (2011) combined information on four different indicators, including livability, to evaluate the social, economic and environmental characteristics of cities worldwide. They describe a city's livability measures as those based on social issues such as safety, education, and health. Kaal (2011) indicates that livability is not a new concept and provides historic context because it was used in the past. For example U.S. Vice President Spiro Agnew used the term during remarks to close an international conference on cities held in Indianapolis, IN, in 1971. He praised European cities for "their charm, their human scale, their livability" relative to U.S cities which "sprang up as transitory settlement-places on the way to someplace else**"** (The Times, 30 May 1971).

Anderson and Van Kempen (2003) indicate that the concept of livability has been used extensively by different groups in various settings to address societal issues. Local governments point to the concept in an effort to mitigate minor crime and enhance active citizen participation in social wellbeing. Housing corporations use livability as a rationale for redevelopment projects; whereas social movements make use of it in calling for environmental improvements and citizen participation in policy enactment. Livability has also served as a catalyst for a range of studies in urban planning and geography centered on identifying new ways to enhance and measure it (Hankins and Powers, 2009; McCann, 2007). The issues identified are encompassed in the livability principles put forth by the Interagency Partnership for Sustainable Communities (involving the U.S. Departments of Housing and Urban Development, Transportation, and Environmental Protection Agency) including:

- Provide more transportation choices
- Promote equitable, affordable housing
- Enhance economic competitiveness
- Support existing communities
- Coordinate and leverage federal policies and investment
- Value communities and neighborhoods

Observed socio-economic and environmental changes stemming from oil exploration in Western North Dakota have increased local residents' and policy makers' concerns and likely altered their perception about the quality of life for their community. These concerns and perceptions have led to a plethora of studies aimed at evaluating the likely impacts of oil exploration on the communities.

2.2 Local Survey Findings

Bohnenkamp et al. (2011) surveyed local extension agents and community leaders to evaluate western ND residents' concerns directly and indirectly linked to oil development. Their results grouped residents' concerns under the following categories: population change, labor and jobs, housing and cost of living, infrastructure, education, services (both public and private), crime, and other related concerns. Their report noted that the scale of issues facing Bakken communities is diverse and complex. Concerns by extension agents are explained in the following discussion.

Agents noted that those who lived in the communities prior to the oil boom miss the familiarity of what used to be a farm community characterized by quiet rural towns. Population growth has impacted the quality of life by increasing pressure on infrastructure, clashes of values, and the number of displaced individuals and families. They also note that a major change stemming from demographic shifts is the insecurity of not knowing who is living nearby. These likely concerns about increased insecurity resulting from rapid growth in population size can be corroborated by research. Bruinsma (2007) evaluated urbanization and crime in the Netherlands and noted that distance from the city center had an inverse relationship with crime. He found parallels in his findings to the Chicago School's Geographical perspective on Criminology. This school of thought indicates that the lower prevalence of crime in rural areas can be attributed to higher levels of social interrelationships and informal control leading to lower offender rates in an organized physical environment. Extension agents note that former residents have a general mistrust of oil workers. Parents who previously let their kids walk around by themselves can no longer do so because of perceived insecurity. Residents who planned to retire in the local communities because of the small "town feeling" now indicate their willingness to leave because of the chaos attributed to the oil boom.

Population growth has exacerbated the already-limited housing condition of communities in the region. Significant price changes have been observed. Agents noted that prices for a basic home in their cities have increased significantly to approximately $263,000 (a price only oil field workers can afford). Additionally, due to the lack of rent controls, rents have tripled from $300 before the boom to a current $900 on average a month for some residents. Extension agents note that there have been instances where rents as high as $1,500 a month have been observed. Campers, on the other hand, pay $800 a month on average to park their campers. Rising food prices is another reflection of the cost of living within communities. A gallon of milk sells for $6.28 (Bohnenkamp et al. 2011).

The oil boom in western North Dakota has attracted a diverse workforce of skilled and unskilled workers. Despite this fact, labor shortages have been observed for non-oil related business sectors. In fact, some businesses, both private and public, have shut down due to a dearth in labor related to their inability to compete with wages offered by the oil industry. In addition to higher wages, small businesses are unable to attract a workforce because potential employees are unable to find housing or childcare. Childcare has been identified as a major issue for families.

The oil boom has meant increased movement of trucks and other related equipment on area highways. Small rural communities that were already faced with aging infrastructure before the boom have seen roads deteriorate even further. Consequently, the region's two principal highways (U.S. Highways 85 and 2) that bear most of the traffic are in constant repair leading to seemingly perpetual road closures. These closures and the resulting detours prevent people and visitors from directly accessing campgrounds and other businesses.

Extension agents involved in providing parenting and family education services raised concerns about the link between the growing child population and the quality and availability of education within their communities. They note that immigrant children are often unprepared for school and lack knowledge of the severity of North Dakota winters, factors that can hamper their educational success. Children or students who live in tents lack basic amenities like lighting to complete their homework. In some cases, parents have to send their children to school to get a shower because their living quarters lack this amenity. Like businesses, schools are unable to find staff to handle the surge in enrollment because they are unable to pay comparative wages to the oil industry to reflect an increased standard of living).

Potential community service needs brought about by population growth necessitate the creation of new programs. However, budgets cuts have added stress on existing programs. Some programs have been reduced in quality while others have been eliminated. Even in cases were funding is available, extension agents note that it is difficult to attract new employees because of the lack of affordable housing. Inadequate budgets make it even more challenging. Agents noted that social services and child protection services have witnessed dramatic increases in demand. They add that social services organizations in communities across the area are overloaded. The environmental impact of oil drilling is a related issue. Farmers and ranchers are concerned with foreign invasive species of weeds likely to grow on open patches left behind from oil exploration and those bought in by the increasing number of out-of-state vehicles. Agricultural producers are also concerned about road dust generated by increased traffic which reduces crop yields and impacts the health of livestock.

In the past, the "Help Wanted" section of the local newspaper had between two and three help-wanted ads a week. Presently, a full page is dedicated to jobs. Certainly, there are jobs to be filled, but the perennial issue of housing is hindering potential employees from filling these positions. On the other hand, issues related to oil production also arise with employees already working in non-oil related area business. The availability of alternative well-paying jobs in the oil field makes employee management complicated. The least dissatisfaction can cause existing employees to quit, leaving behind a vacuum difficult to fill because potential employees are hesitant to relocate. Increasing rents as mentioned, is an issue for local business as well. Long-time businesses may face eviction if they can't afford the increasing rent.

Deteriorating road infrastructure because of heavy trucks is a common theme. In addition, increases in the number of road accidents have been observed. These have been attributed to inexperienced truck drivers, unfamiliarity of the area by out of-state drivers, and traffic infringements (non-respect of stop signs). Some smaller communities are unable to keep up with infrastructure needs due to limited resources.

2.3 Housing Concerns

Following housing market disruptions in predominantly rural areas that have witnessed a surge in oil drilling and gas exploration, the Economic and Market Analysis Division (EMAD) within the Office of Policy Development and Research of the U.S Department of Housing and Urban Development (HUD) (2012) formed the Gas and Oil Task Force (GOTF). This included a group of field economists to evaluate

the effect of gas and oil exploration and development activity on housing markets in eight affected rural communities including 19 counties in western North Dakota.

In their findings, the economists acknowledged energy development activities have led to significant disruptions in local housing markets within and in the vicinity of these areas. In an initial survey of apartment complexes in Williston, ND, conducted in late 2011, GOTF noted that most apartment complexes within the region were built during the previous oil boom in the 1980s.

The influx of population seeking employment can represent a sizeable proportion of local rural populations. Between April 2010 and July 2011, the population of Williams County, North Dakota, increased by 8% while employment grew by 41%. Specifically, resident employment in the 19 oil and gas producing counties for the 12-month period ending in March 2012 grew by 12,350 jobs, representing a 12.4% increase. The population within these counties rose by 6,225 to 179,800 as of July 1, 2012, representing a 3.6% increase since 2010. The surge in population has increased pressure on local housing markets, infrastructure, and resources. This influx of people and resources (money) into the oil and gas counties has meant the demand for affordable housing has surpassed the supply. This has led to price hikes in housing comparable to those of large cities in metropolitan areas of the United States. For example, housing complexes that were built between 2008 and 2010 had rents ranging from $950 to $1,060 for a one-bedroom-bathroom unit; rents for two-bedroom-bathroom units were between $1,145 and $1,310; and those for three-bedroom-two bathroom units were asking between $1,270 and $1,430 a month. Specifically, in Tioga, situated fifty miles from Williston, newer two-bedroom units were renting for $1,200 monthly in 2011. This volatility in housing prices can be seen in the changes from 2010 to 2012. Recently (in 2012), rents for two-bedroom units were between $2,100 and $2,800 while three-bedroom/two-bathroom duplexes were available for $3,150. Meanwhile, a four-bedroom unit in the basement of a house rents for $3,000 (U.S. Department of Housing and Urban Development 2012).

Housing affordability and other related concerns are hindering efforts by county and city officials to meet the needs of the growing population. In response to the dearth in housing, Williston was converting an old junior high school into a 44-unit housing complex for low-income seniors funded by $8.5 million in federal housing assistance. North Dakota public housing authorities (PHAs) have difficulties utilizing the number of vouchers allowed with available funding because of the increasing per unit cost of renting. For example in 2011, the seven main PHAs near the oil producing region were only able to lease approximately 56% percent of their Housing Choice Vouchers Unit Months Available (UMA) compared to other ND PHAs that leased 84% of Their UMAs. This difference is linked to funding and a lack of housing.

This U.S. Department of Housing and Urban Development (2013) provided a summary of the housing market situation in the oil and gas producing region of North Dakota. It noted that the growth in gas and oil production has expanded net in-migration from 2,025 people in 2009 to 2,650 in 2012. In comparison, annual net out-migration averaged 430 people for the 6 years between 2000 and 2006. Beginning 2010, the population of the Housing Market Area (HMA) increased by an average of 3,775, or 3.9%, annually with net in-migration representing 80% of total population growth. Increased pressures from oil activities including population growth, increased transportation activity, and related issues led the North Dakota Legislature to approve $91.4 million in funding for state roads, emergency and police services, and other infrastructure needs for the energy-impacted communities of Dickinson, Minot, and Williston.

The housing market in the Minot-Williston HMA is severely tight owing to net in-migration and a dearth of housing for sale. During the one year period ending in April 2013 average existing single-family home prices rose 21% to $241,700. In comparison, average prices were $126,700 between 2005 and 2007. Similarly, the rental market in the area is as tight as the sales market. Hikes and tight rental market conditions in this HMA led the HUD to increase the estimated Fair Market Rents (FMRs) sharply

between 2012 and 2013. In 2012, the FMR for two-bedroom units in Mountrail, Ward, and Williams counties were $668, $686, and $605 respectively. However, in 2013, the FMRs significantly increased by 56%, 58%, and 70% to $1,041, $1,087, and $1,026 respectively. Despite noticeable increases in rental housing inventory (1,100) from 2010, the number of renter households (2,025) outpaced available space leading to decline in rental vacancy rate from 3.5% in 2010 to less than 1% recently. Housing options have been limited for some oil workers, especially in Williams County. At the end of 2012, following infrastructure and other concerns related to the growth in informal housing (e.g. man camps), Williams County issued a moratorium on new temporary housing.

Despite the present limitation 0n housing units, builders are responding to the increasing demand. In 2012, permits were granted for the construction of a total of 2,350 apartment units in the HMA, representing an increase of 750 units (47%) relative to 2011. One of the biggest developments underway in the area, Confluence at Harvest Hills, a 270-unit corporate rental project will have an expected rent rate of $2,700 for one-bedroom units, $3,500 for two-bedroom units, and $4,500 for three-bedroom units when completed.

3. THE OIL BOOM IMPACT ON WESTERN NORTH DAKOTA

There have been substantial impacts on western North Dakota related to oil exploration and extraction in recent years. Figure 3.1 shows the whereabouts of the Bakken Formation that underlies areas of North Dakota and Montana as well as the Canadian Provinces of Saskatchewan and Manitoba. As of 2007, the Bakken was considered an insignificant reserve because its resources were locked in rock formations with low permeability, leaving them hard to penetrate and recover with current technologies. However, drilling technologies such as hydrofracturing, or fracking, has transformed the Bakken into a major oil and gas producer, propelling North Dakota to become the second largest state in terms of crude oil production, behind only Texas (Geology.com 2013).

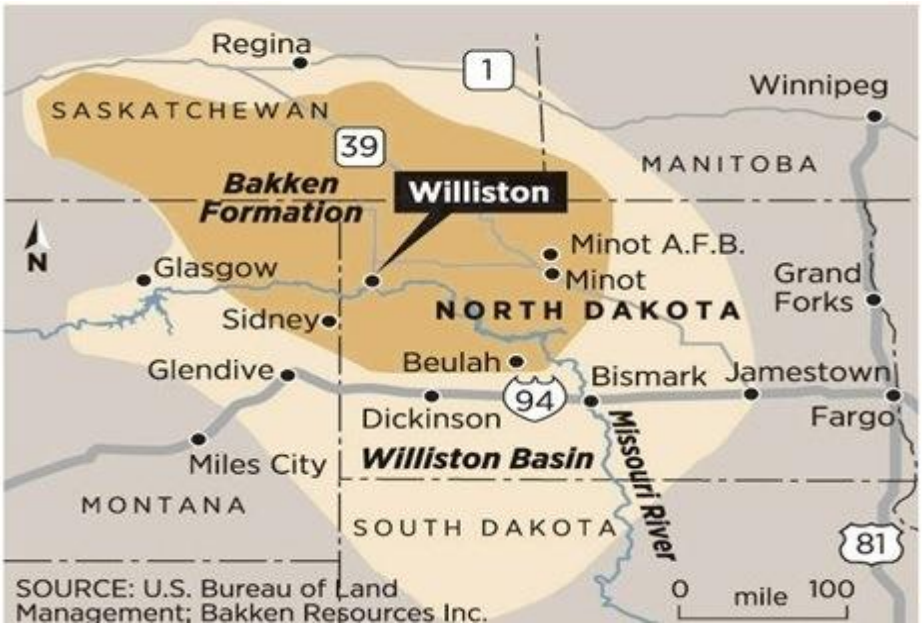

Figure 3.1 Bakken Formation

The future looks good for oil and gas extraction within the Bakken. The U.S. Geological Survey (2013) completed a geology assessment of oil and gas resources for the area, finding more than 7.3 billion barrels of oil and 6.7 billion cubic feet of gas that are yet to be recovered while, according to the ND Department of Mineral Resources (2014), current oil wells are producing a little more than 1 million barrels per day. So, if current oil prices hold relatively steady, there should be sustainable oil production in the area for years to come.

Although this is not a study on drilling techniques to extract oil and gas, without modern fracking technologies the oil boom in western North Dakota would not be possible and as a result, this research could not capture the related impacts. Therefore, a basic explanation of the technology is warranted as its effects have been felt both regionally and nationwide. Fracking, short for hydraulic fracturing, is a drilling technique which uses large volumes of water along with small amounts of chemical and sand pumped under high pressure through a gas well. The purpose is to create larger fractures in the rock formation. After the water is removed, the sand that was pumped in props open the fractures allowing oil and gas to flow into the well (Curtis 2011).

Figure 3.2 illustrates the fracking technique compared to the more conventional vertical drilling technique. Vertical drilling is done at a much shallower depth while fracking utilizes greater depth along with horizontal drilling to reach oil and gas resources. Because the horizontal section of the well is at a tremendous depth, often more than 10,000 feet in the Bakken, it must also include a vertical well, thus resembling the letter "L" in Figure 3.2.

Vertical wells are only able to access resources that directly surround the well, whereas horizontal wells can access resources near the entire section of the horizontally drilled portion. However, drilling horizontally is a much more complex process compared to drilling a conventional vertical well. First, the depth of the resource-rich layer must be found by drilling a vertical well. When the optimal depth is determined, a special bit assembly is used to keep track of the vertical and horizontal well location at all times. When the approximate location to turn the drill horizontally is located, the drill is progressively angled to bore a horizontal hole (Curtis 2011). Once the hole is complete, the fracking technique is used to fracture nearby rock formations. Records indicate that horizontal drilling was first used during the 1940s in Pennsylvania, and it became more popular with improved equipment along with other technological advancements during the 1980s (Geology.com 2013).

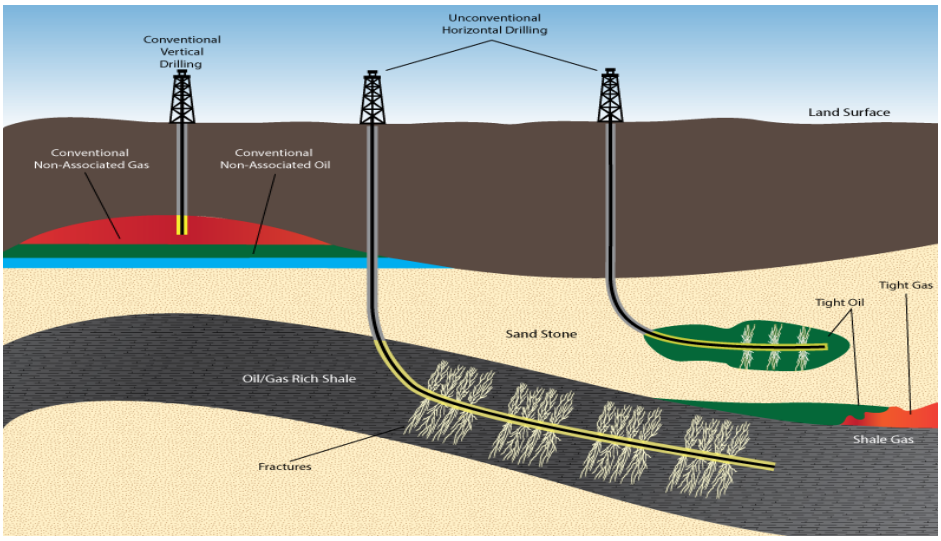

Figure 3.2 Vertical vs. Horizontal Drilling (Curtis 2011)

Active oil and gas wells in North Dakota are seen in Figure 3.3. As recently as 2007, there were roughly 300 oil wells producing just over 10,000 barrels of oil per day. This dramatically increased over the next seven years to the current total of 8,731 oil producing wells yielding more than 1 million barrels of oil per day. Figure 3.4 shows the average total oil production by year in barrels of output per day. The greatest concentration of oil-producing wells can be found in northwest North Dakota. The primary communities within the oil-producing region are Williston, New Town, Dickinson, and Watford City. Many of the producing wells are located in relatively remote areas with limited access to basic amenities.

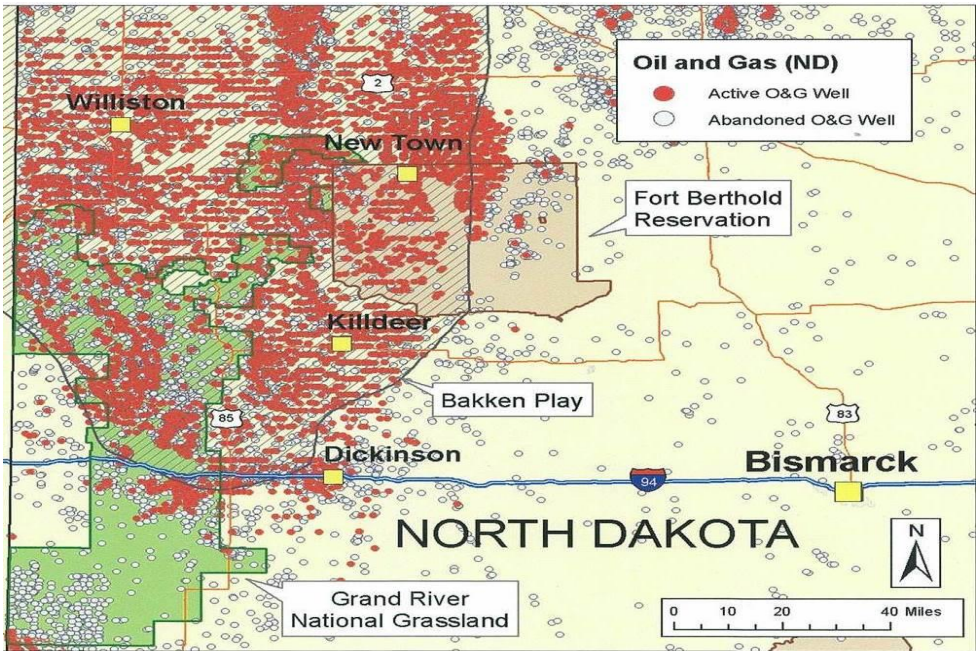

Figure 3.3 North Dakota Oil and Gas Wells NRDC (2013)

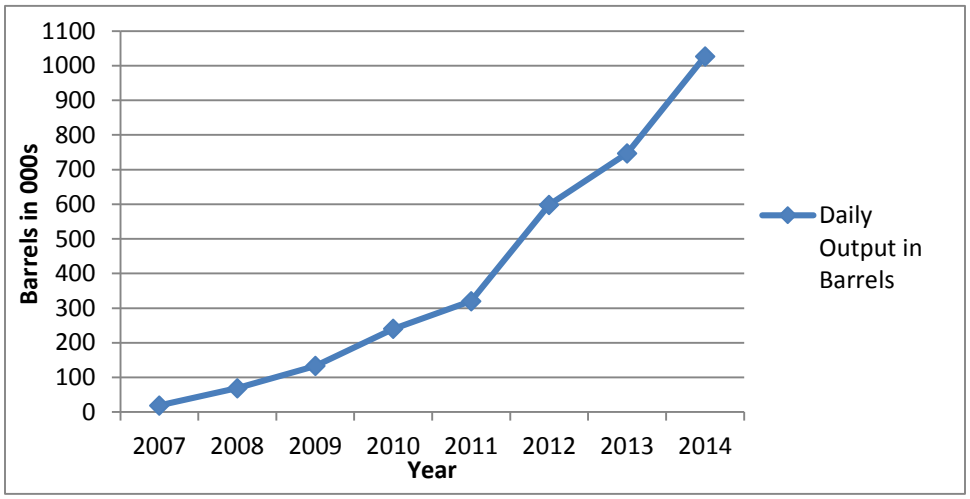

Figure 3.4 Average Annual Oil Output in Barrels per day

The oil boom has prompted a dramatic population increase. Figure 3.5 shows the annual North Dakota state population from 2000 to 2013 in thousands of residents. Statewide population decreased from 2000 to 2002 and then began to increase at a very modest rate until 2007. From 2007 to 2013 the total North Dakota state population increased by nearly 11%, from 653,000 residents in 2007 to 723,000 in 2013.

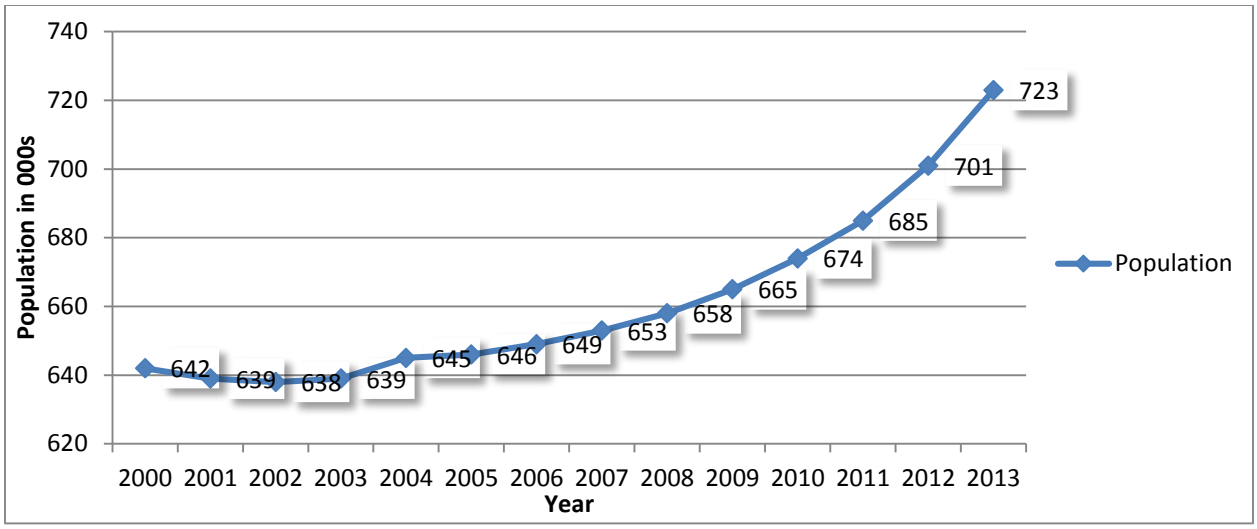

Figure 3.5 North Dakota Population 2000-2013, ND Census (2014)

Counties in the oil patch have seen population increases at a much greater rate than the state as a whole. Table 3.1 shows the population of the nine major oil-producing counties in North Dakota from 2000 to 2013. From 2000 to 2010, before oil exploration intensified, five of the counties saw an overall decrease in population while the entire nine-county area saw a total population increase of just 7.6%. Beginning in 2010, with the dramatic escalation of the oil boom, the populations of McKenzie, Williams, and Mountrail counties all increased more than 20% in just three years. The population of McKenzie County nearly doubled during that time period as it experienced a 46.4% increase. All but one county saw population growth greater than 10% and the nine-county region experienced a total population increase of 24.5%.

Table 3.1 Population Changes in ND Oil Producing Counties, ND Census (2014)

County	**Year**					**% Increase 00-10**	**% Increase 10-13**
	2000	**2010**	**2011**	**2012**	**2013**		
Divide County	2,283	2,071	2,135	2,234	2,314	-9.3%	11.7%
McKenzie County	5,737	6,360	7,020	7,994	9,314	10.9%	46.4%
Williams County	19,761	22,398	24,388	26,744	29,595	13.3%	32.1%
Billings County	888	783	830	904	874	-11.8%	11.6%
Golden Valley County	1,924	1,680	1,745	1,802	1,823	-12.7%	8.5%
Stark County	22,636	24,199	25,133	26,856	28,212	6.9%	16.6%
Mountrail County	6,631	7,673	8,107	8,755	9,376	15.7%	22.2%
Dunn County	3,600	3,536	3,743	3,972	4,162	-1.8%	17.7%
Burke County	2,242	1,968	2,060	2,178	2,306	-12.2%	17.2%
Totals	**65,702**	**70,668**	**75,161**	**81,439**	**87,976**	**7.6%**	**24.5%**

The most dramatic population growth in the region has taken place among those 20 to 34 years of age. Figure 3.6 illustrates the incredible population growth within this age range as five of the counties in the core oil producing region have witnessed a greater than 50% population increase among 20 to 34 year olds from 2000-2013 while McKenzie county alone has experienced an 84% increase. Even the four

counties in the region that have seen less growth compared to the top five counties have all seen an increase of more than 30% among this demographic with Divide County in northwest North Dakota experiencing an almost 50% increase among 20 to 34 year olds.

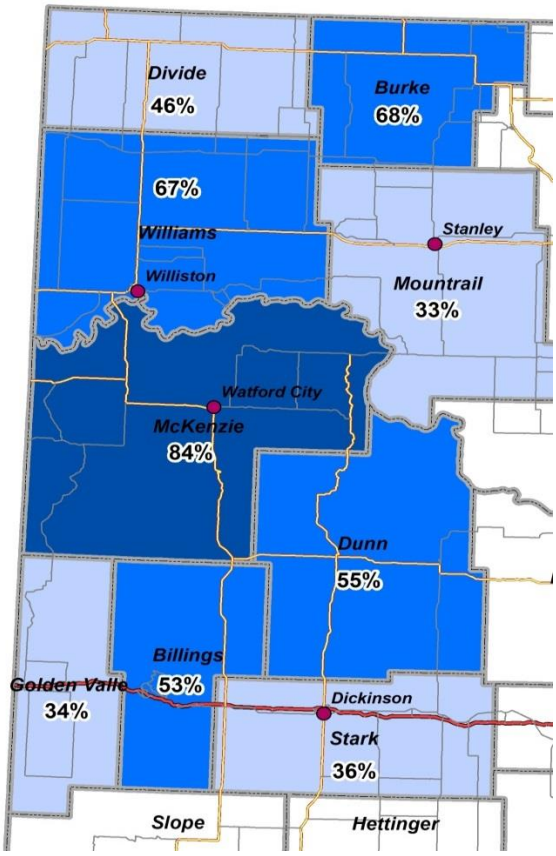

Figure 3.6 Increases in 20-34 Year Old Population, 2010-13, ND Census (2014)

The increasing number of young adults moving to western North Dakota seeking oil industry employment has caused the median age in the state to decrease dramatically in recent years (Figure 3.7). As recent as 2008, the median age of North Dakota residents was 37.3 years of age compared to the national average of 37. However, from 2008 to 2013 the median age of North Dakotans decreased by two years to 35.3 years old while the median age of American citizens nationwide increased to 37.6 years. As a result, North Dakota is now the fourth youngest state in the nation.

Population growth in western North Dakota has been a direct result of the relatively high-paying oil industry jobs available in the area. Figure 3.8 shows that from 2000 to 2007, North Dakota's per capita income ranged from roughly 85% to 90% of the national average. However, beginning in 2008, with the influx of high-paying oil industry jobs, North Dakota's per capita income rose to 100% of the national average and has continued to rise to a 2013 per capita income of more than 120% of the national average.

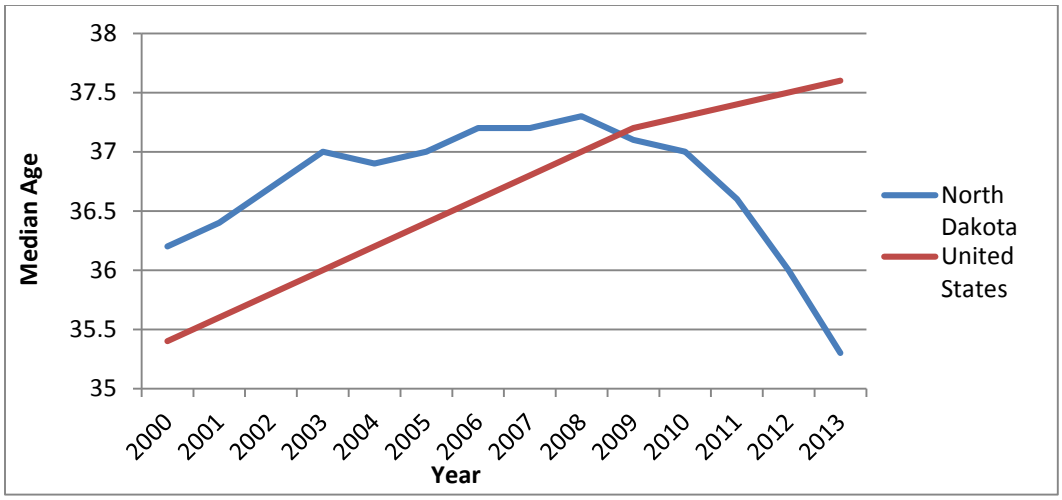

Figure 3.7 Change in Median Age, ND vs. US, ND Census (2014)

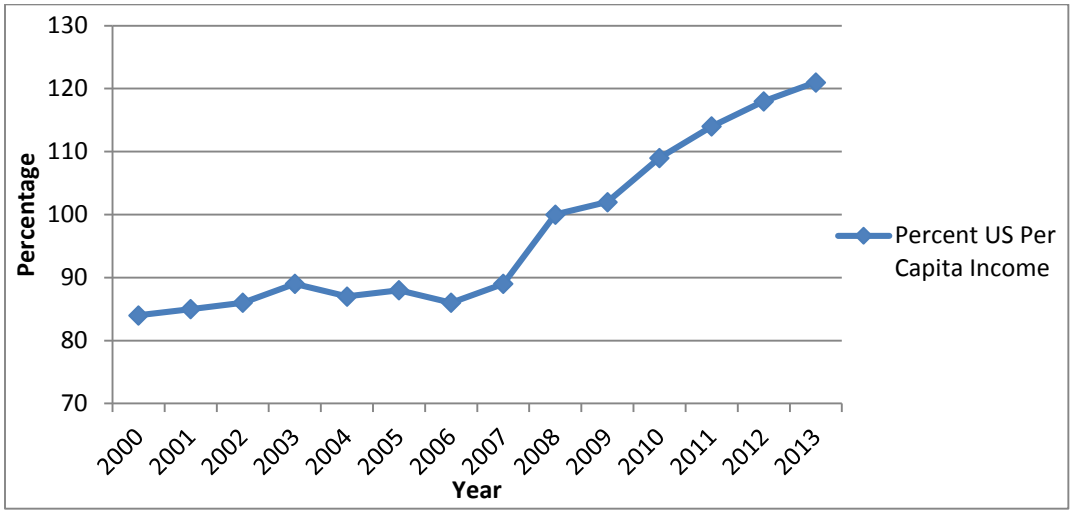

Figure 3.8 Changes in ND Income Per Capita vs. US, ND Census (2014)

4. TRANSIT LIVABILITY INDEX OVERVIEW AND RESULTS

Results from transit livability index calculations are the focus of this chapter. Calculations were conducted from a county perspective to determine the impact of the oil boom on transit activity in the most heavily impacted nine-county region of western North Dakota. The nine counties included in the index were Divide, Burke, Williams, Mountrail, McKenzie, Golden Valley, Billings, Dunn, and Stark (Figure 4.1). The index included historical data calculations as well as a forecast dependent on different scenarios pertaining to the oil boom region.

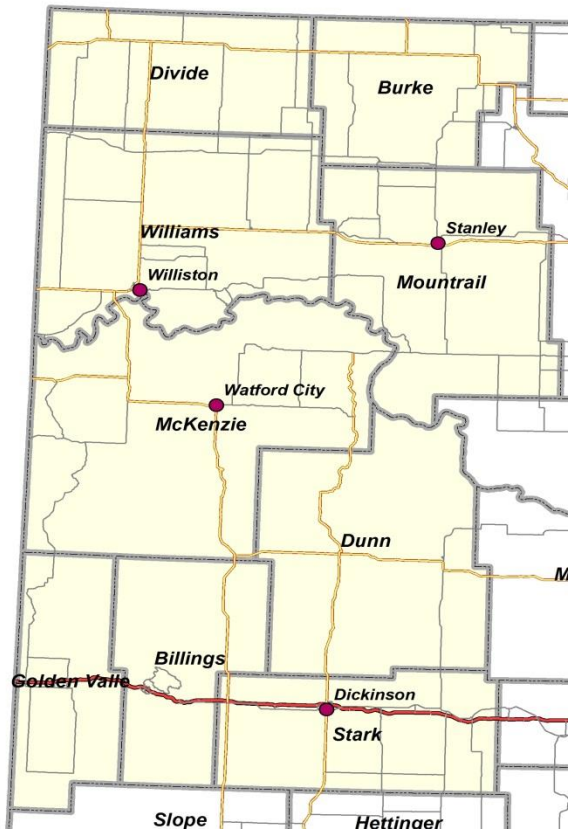

Figure 4.1 Nine-county region

4.1 Data and Methodology

Transit livability indexes were calculated by focusing on the six core livability principles developed by the Partnership for Sustainable Communities (2014) (Table 4.1). Data used to calculate index measures were collected from both the Rural National Transit Database (RNTD 2013) and the American Community Survey (US Census 2013).

Table 4.1 Livability Principles

Provide More Transportation Choices
Promote Equitable, Affordable, Housing
Enhance Economic Competitiveness
Support Existing Communities
Coordinate Policies and Leverage Investment
Value Communities Neighborhoods

Table 4.2 shows each livability principle along with its relationship to transit. Previous work by both Ripplinger et al. (2012) and Brooks et al. (2013) highlighted the relationship between transit and livability. These relationships are specified in this and the previously mentioned studies as well. The transit livability index measures used in this research are shown in the third column.

Table 4.2 Livability's Relationship to Transit and Measurements

Livability Principle	**Relationship to Transit**	**Index Measure**
Provide More Transportation Choices	Transit service provides an alternative transportation choice.	Percent of Workers that Do Not Drive Alone to Work
Promote Equitable, Affordable Housing	Transit provides a means to connect home owners to communities and can lower overall housing and transportation expenses.	Household Income after Transportation and Housing Expenses
Enhance Economic Competitiveness	Transit provides greater accessibility to workers for commuting and access to services, improving the economic competiveness of a community.	Revenue Vehicles/County Population
Support Existing Communities	Transit utilizes the existing built environment to serve and support an existing community.	Ridership/Developed Land Area
Coordinate Policies and Leverage Investment	Transit coordinates funding from federal, state, and local entities to provide quality service and operate cost-effectively.	State and Local Operating Investment/Operating Expenses
Value Communities Neighborhoods	Transit adds value to local communities by serving local residents who deserve safe, affordable transportation choices while often possessing mobility disadvantages.	Ridership/County Mobility Needs Index

All of the transit livability index measures were calculated at the county level from 2008 to 2013. Time series data was utilized to show the impact of the oil boom on transit during the given time frame. Equal weighting was given to each measure as individual index measures characterized a specific livability principle and therefore, none was determined to be more important compared to any other. Also, after the base calculations were performed, the index was classified in percentiles from 1 to 10 using a normal distribution. This provided consistency for analysis and comparison among the results.

The forecasting method looked at three hypothetical outcomes during a five-year period from 2014 to 2018. The first included average growth pertaining to the nine-county region while the second forecast assumed a continued oil boom scenario consistent with the 2008 to 2013 time frame. Finally, the third forecast considered a potential oil bust with a corresponding decrease in transit funding and demand. Different time series forecasting models were considered for the analysis and the 2nd order moving average model was found to have the best fit. The 2nd order moving average model, denoted as MA(2), has the following notation:

$$X_t = \mu + \varepsilon_t + \Theta_1\varepsilon_{t-1} + \Theta_2\varepsilon_{t-2}$$

where: μ = mean of the data set
$\Theta_1 + \Theta_2$ = parameters of the model, and
ε_t = error term.

4.2 Livability Index Results

Transit agencies in the nine-county region have seen tremendous growth in ridership from 2008 to 2013. Figure 4.2 highlights this growth, showing that as recently as 2008, transit ridership for the region was slightly more than 40,000 rides per year. Large increases in ridership occurred during the next three years with nearly 120,000 using the service in 2011. Ridership fell off slightly in 2012 and 2013, but has remained relatively constant overall at between 110,000 and 120,000 rides per year. In the Williston area, for example, the largest number of new riders are those either going to school within the local public school system, or those using the service to get to and from work on a regular basis. Note that the Williston Public School System does not operate traditional school bus transportation, so many new school-age residents rely on the public transit system to provide this service (Bogren 2013).

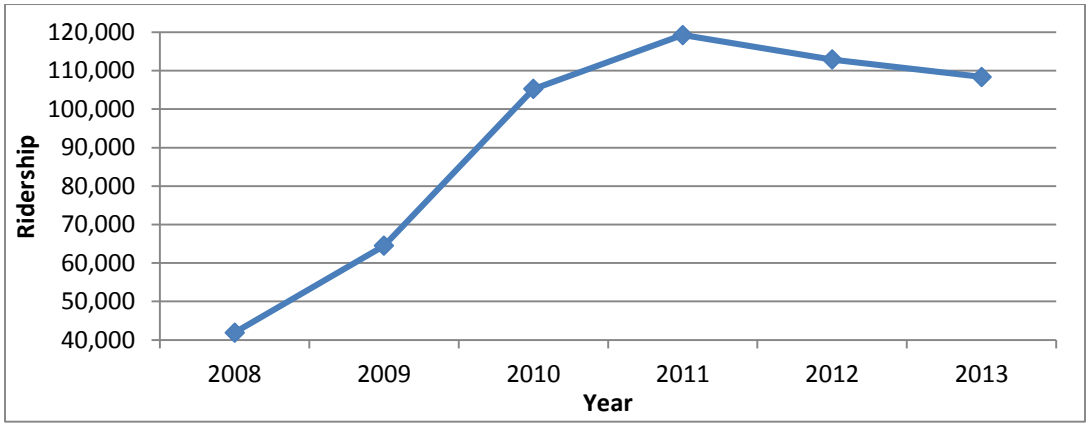

Figure 4.2 Western North Dakota Transit Ridership, 2008-2013

Average transit livability index results for the six-year time frame from 2008 to 2013 are shown in Figure 4.3. All of the county indexes were classified ranging from 1 to 10 with Mountrail County having the highest index value for the time period while Divide County had the lowest. Overall, all counties were within the 4.23 to 5.69 index range which was quite consistent when considering the differing demographics, geographies, and distance from the central oil patch for each county. All raw data calculations can be found in Appendix B.

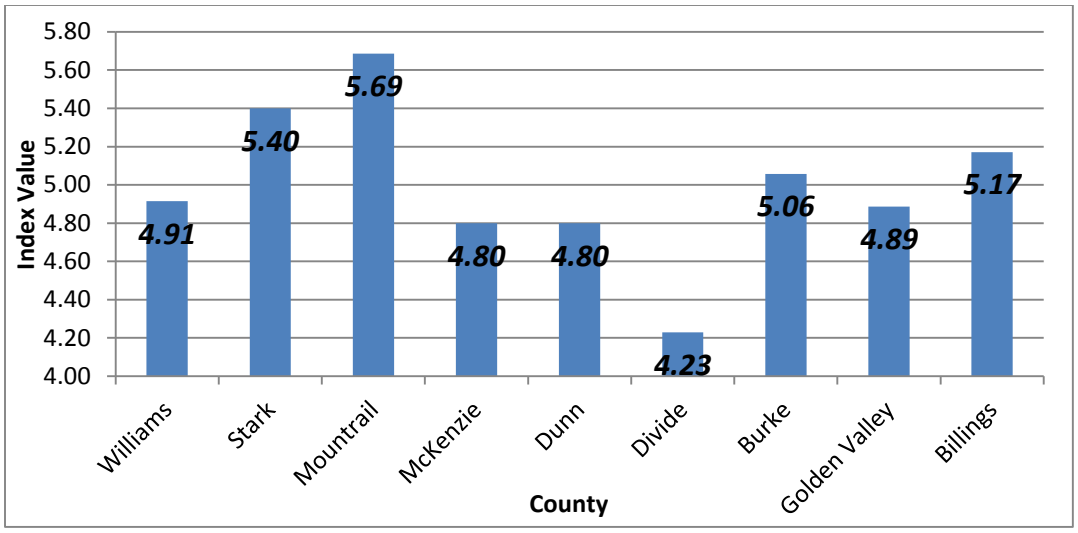

Figure 4.3 Overall Transit Livability Indexes, 2008-2013

The time series transit livability index results were partitioned by county population. Table 4.3 shows the nine counties considered and their respective populations. The third column shows the divisions that were made for the analysis. Comparing counties like Williams and Stark, with populations nearing 30,000, to those such as Golden Valley and Billings, with populations below 2,000, was not feasible. The smaller counties showed more variability throughout the six-year study time frame as a relatively small change in population, for example, had a much greater effect on index values compared to a similar change among the larger counties. For this main reason, and also because illustrating nine counties within one figure can be cumbersome and confusing, the counties were separated.

Table 4.3 County Population

County	Population	Size
Williams County	29,595	Large Counties
Stark County	28,212	
Mountrail County	9,376	Medium Counties
McKenzie County	9,314	
Dunn County	4,162	
Divide County	2,314	Small Counties
Burke County	2,306	
Golden Valley County	1,823	
Billings County	874	

Figure 4.4 shows the six-year transit livability indexes for Williams and Stark counties. Both counties showed an overall increase in transit livability during the time period, with Williams County being more dramatic and volatile. A substantial 32% increase in population that led to the near doubling of transit ridership during the time period accounted for the majority of the increase. Stark County's increase was less dramatic, but the county has seen a nearly 17% population increase in recent years while witnessing a notable increase in transit ridership as well.

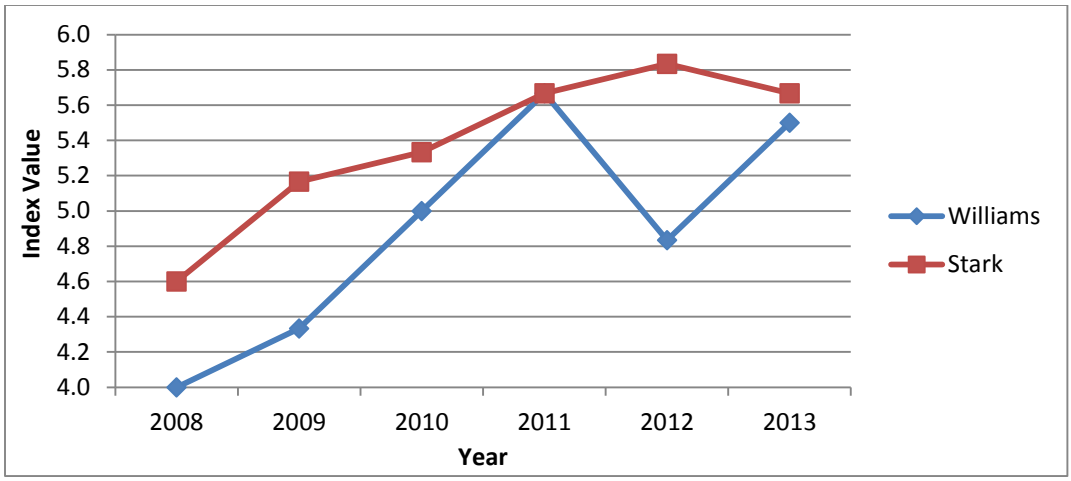

Figure 4.4 Livability Indexes for Williams and Stark counties

Figure 4.5 illustrates the transit livability indexes for Mountrail, McKenzie, and Dunn counties. All three counties saw an increase in their respective indexes during the six year period with Mountrail County showing the most dramatic change. This was because of a significant increase in state and local funding for Souris Basin Transit, which serves Mountrail County, as well as population growth and a large increase in household income. Mountrail County has seen a nearly 42% increase in household income after transportation and housing costs from 2008 to 2013, the largest in the entire region. The county is in the heart of the oil boom region (see Figure 3.3) and has seen the greatest benefit from financial gains. McKenzie and Dunn counties have had increases in related areas as well, but not to the extent of those in Mountrail County.

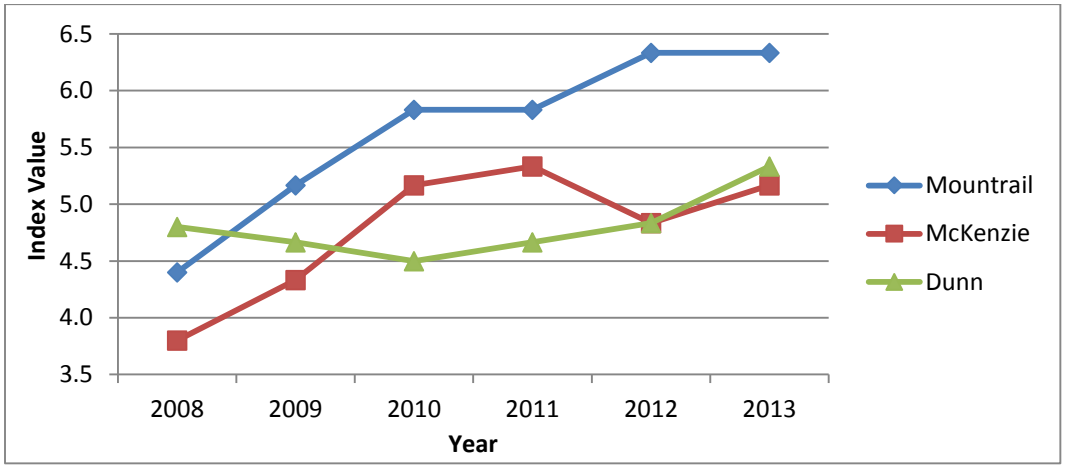

Figure 4.5 Livability Indexes for Mountrail, McKenzie, and Dunn counties

Figure 4.6 shows transit livability indexes for Divide, Burke, Golden Valley, and Billings counties. These indexes are not as straight forward as those from the larger counties. Both the Burke and Billings counties indexes remained relatively similar over the six-year time frame while both Golden Valley and Divide counties saw an increase. Golden Valley's increase was primarily due to an increase in state and local funding to the Golden Valley/Billings Council on Aging which provides transit service in the county, as well as an increase in household income after transportation and housing expenses. Divide County had the lowest overall transit livability index in 2008, but showed a noticeable increase resulting from increased

ridership as well as a substantial increase among residents who do not drive alone to work. Divide County receives the majority of its transit service from the Northwest Dakota Public Transit Agency headquartered in Williston, and its increased ridership is largely due to those using the service to get to and from work. This is believed to have an impact on work commuters in Divide County.

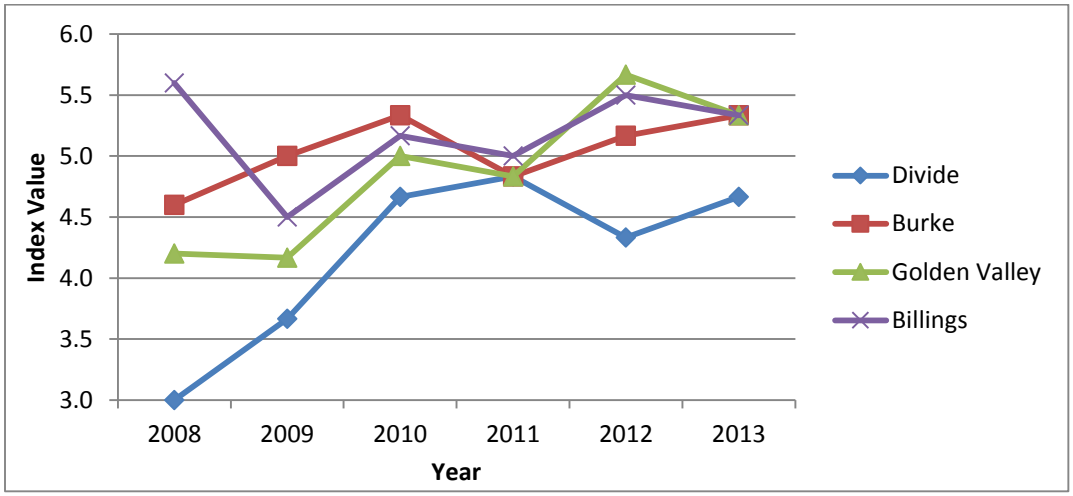

Figure 4.6 Livability Indexes for Divide, Burke, Golden Valley, and Billings counties

Although average transit livability indexes increased from 2008 to 2013 for nearly all counties in the study region, disaggregating the data to look more closely at individual livability measures indicated some concerns. The individual livability measures not mentioned below can be found in Appendix A. Figure 4.7, for example, shows the transit livability index measures for valuing communities and neighborhoods. This variable is calculated by dividing transit ridership by the mobility needs index of a given county. Notice that the values increase among the large and medium counties from 2008 to 2011 and then begin to plateau and decrease from 2011 to 2013. This corresponds to the similar ridership plateau seen in Figure 4.2 as well as increased mobility needs among residents in the larger counties. As populations increased in these larger counties, the mobility needs of residents have grown as well. The larger counties in the study area are beginning to see mobility needs comparable to those in some of North Dakota's largest counties such as Burleigh and Cass.

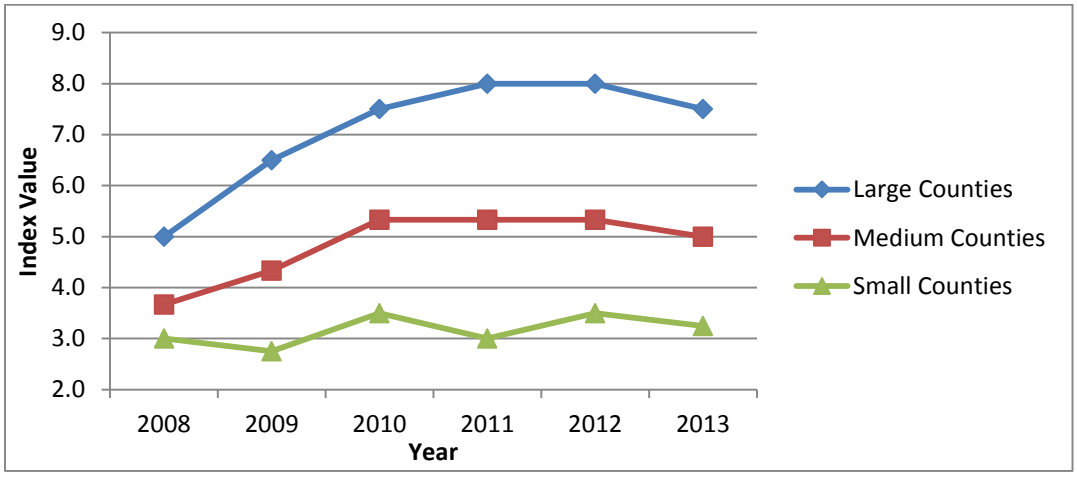

Figure 4.7 Value Communities and Neighborhoods

Findings from the livability variable enhancing economic competitiveness are a concern. Figure 4.8 illustrates that for all counties considered, this index measure has decreased significantly in recent years. Enhancing economic competitiveness is calculated by dividing the number of transit vehicles by the population they serve. Results indicat that as populations have swelled throughout all counties in the study region, the number of transit vehicles has not increased proportionally. This is particularly evident in the larger counties which have seen the greatest gains in raw population, but negligible increases in transit vehicles to serve their population base.

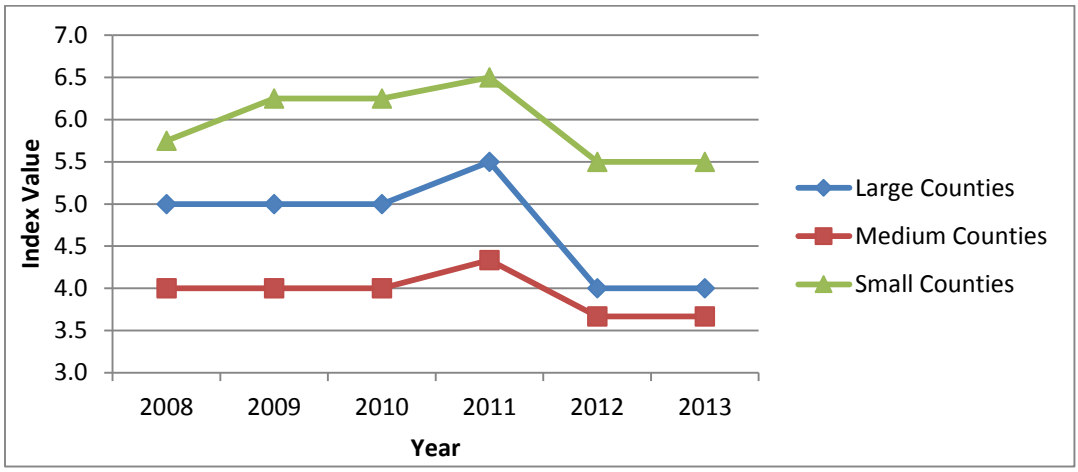

Figure 4.8 Enhance Economic Competitiveness

4.3 Forecasting Results

The forecasting method looked at a continuation of the previous five years into the future. Three scenarios were considered for future growth relative to transit in the nine-county region. The first assumed minimal to average growth in transit ridership to a level of 120,000 rides per year by 2018. Average growth was also assumed for operating investments, household income, and county population. The second scenario assumed a transit ridership growth rate similar to that of the past five years, defined as a boom scenario, with ridership reaching 160,000 by the year 2018. Investment, income, and population growth were correlated to ridership increases. Lastly, the third scenario assumed an oil bust with corresponding transit ridership falling to 80,000 rides by 2018, and accompanied by a corresponding decrease in operating investments, income levels, and county population. The levels of ridership were chosen to be consistent with current annual ridership that falls in the 110,000 to 120,000 range for the region. A 2nd order moving average forecast (MA(2)) was used to quantify the transit livability indexes relating to the forecast assumptions. More detail pertaining to this forecasting model was discussed earlier in methodology, section 4.1.

Figure 4.9 illustrates a MA(2) forecast using a set of assumptions and the six previous years of livability index data. Notice that 54 previous observations, representing one observation per year for each of the six years for all nine counties, were used to predict the next 24 forecasted livability index observations in this example. This figure helps one visualize how the model performs and predicts future values based on historical data.

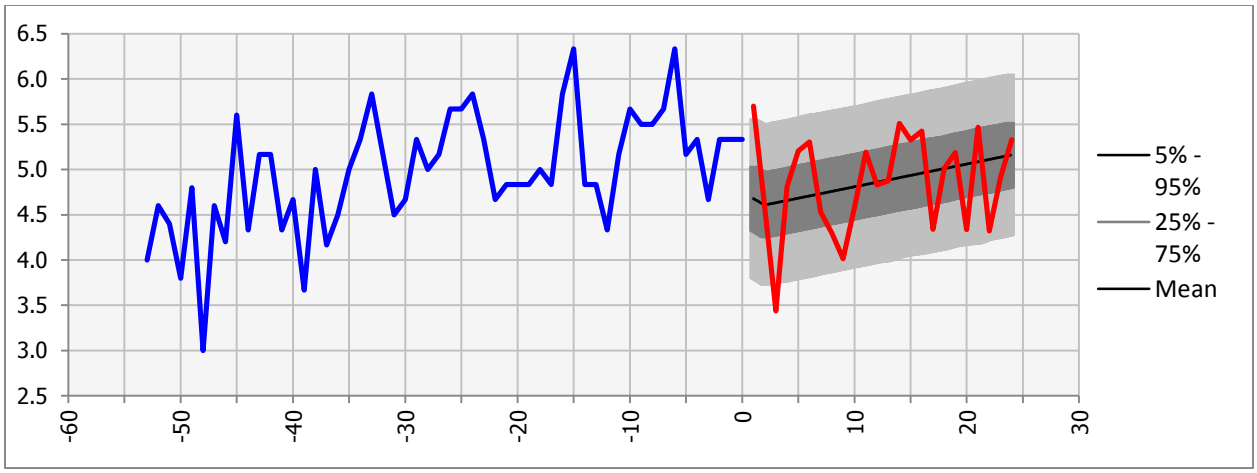

Figure 4.9 2nd Order Moving Average Forecast

Figure 4.10 shows the complete forecast for all counties given the previous assumptions using the MA(2) model. Actual transit livability index values are shown from 2008 to 2013 while the three different scenarios are forecast from 2014 to 2018. The average growth model yielded a transit livability index that remains relatively constant for three years and then begins to decline. The decline is due primarily to the aging of the transit fleet in the region resulting in a lower economic competitiveness index value. The rest of the index measures remained nearly constant.

The boom scenario, assuming ridership reaching 180,000 by 2019, resulted in an increase in the index for two years followed by a steady decrease from 2016 to 2018. The transit livability index decline occurred due primarily to the corresponding increase in operating costs due to increased ridership as well as the continuing increase in the mobility needs index of the region. Finally, the bust assumption, with ridership falling to 80,000 by 2018, had the largest negative impact on the transit livability index. Along with the lower ridership came other assumptions of the bust scenario including: lower state and local operating investment, lower household income levels, fewer workers utilizing transit, and decreasing county population. All of these factors led to lower overall transit livability index values from 2015 to 2018.

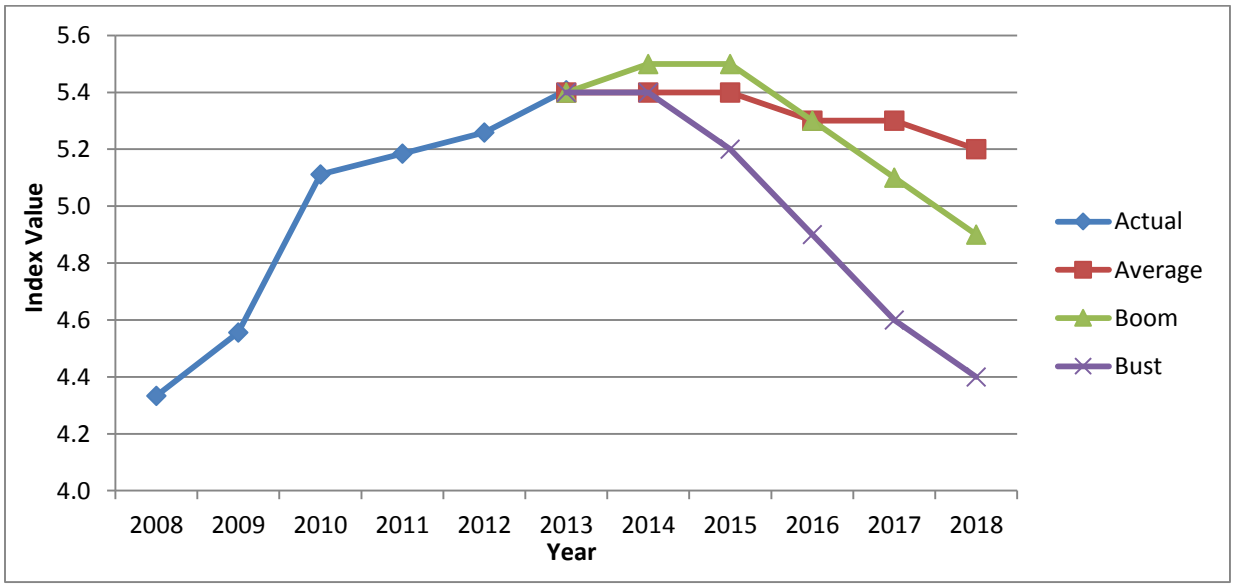

Figure 4.10 Transit Livability Index Forecasts

4.4 Summary

The main objective of the transit livability index measures in this chapter was to determine the effect of the western North Dakota oil boom on livability in the region. Overall, transit livability measures showed an increase in recent years. Combinations of increased ridership and household income in the region have been the two main catalysts for this change. More workers utilizing transit has also led to fewer workers commuting alone to work. However, an increasing mobility needs index and a lack of transit vehicles to meet demand are becoming evident as many of the transit livability indexes are showing smaller increases during the past one to three years compared to earlier gains. Although the livability index had been increasing, it began to plateau when growth in oil activity was accelerating. The larger counties of Stark and Williams are the first to show these shortcomings as indicated by Stark County's decreasing transit livability index.

Forecast findings also showed an increasing mobility needs index for the region within the boom scenario, and a need to update and increase the number of transit vehicles in service. Finally, an oil bust scenario would have the greatest negative effect on the transit livability index as this scenario would lead to cuts in investment levels, lower income levels, and a decreasing population in the western North Dakota oil producing region.

5. SUMMARY AND CONCLUSIONS

Population growth in western North Dakota from those seeking employment in the oil industry has also led to substantial increases in personal income and transit ridership. Local survey findings noted that those who lived in the communities prior to the oil boom miss the familiarity of what used to be a farm community characterized by quiet rural towns. Population growth has impacted the quality of life by increasing pressure on infrastructure and prompting insecurity stemming from demographic shifts and not knowing who is living nearby.

The housing market has also struggled to keep pace. For example, the housing market in the Minot-Williston region is severely tight owing to net in-migration and a shortage of housing for sale. During the one year period ending in April 2013, average existing single-family home prices rose 21% to $241,700. In comparison, average prices were $126,700 between 2005 and 2007. Despite the present limitation on certain types of housing units, builders have been responding to the increasing demand. In 2012, permits were granted for the construction of a total of 2,350 apartment units in the Minot-Williston region representing an increase of 750 units (47%) relative to 2011.

The substantial changes in western North Dakota related to oil exploration in recent years is solely due to large deposits of oil and natural gas in the Bakken Formation. As of 2007, the Bakken was considered an insignificant reserve because its resources were locked in rock formations with low permeability, leaving them hard to penetrate and recover with current technologies. However, drilling technologies such as hydrofracturing, or fracking, has transformed the Bakken into a major oil and gas producer resulting in North Dakota becoming a significant crude oil producer. Because of this, all but one county within the nine-county study region has seen a population growth of greater than 10% and the region as a whole has experienced a population increase of 24.5%.

Transit livability index measures showed an increase in recent years. The combinations of increased ridership and household income have been the two main catalysts for this change. More workers utilizing transit has also led to fewer workers commuting alone to work. However, an increasing mobility needs index and a lack of transit vehicles to meet demand are becoming evident as many of the transit livability indexes are showing smaller increases during the past one to three years compared to earlier gains. Forecast findings showed an increasing mobility needs index for the region within the boom scenario, and a need to update and increase the number of transit vehicles in service. Finally, an oil bust scenario would have the greatest negative effect on the transit livability index as this would lead to cuts in investment levels, lower income levels, and a decreasing population in the western North Dakota oil producing region.

A major finding of this research shows that if the oil boom continues similar to its current pace during the next five years, transit agencies and policy makers should consider expanding services to provide more hours of service along and a larger coverage area to meet demand. Fixed-route implementation in the Williston area should also be considered as this and previous research (Mattson and Hough 2015) has shown that, with further growth, demand response service alone will not be able to meet the rising demand for transit service in the community.

Another major finding is the need for more transit vehicles in the region as well as the need to update vehicles in current fleets that are beyond their useful life. Increased funding is needed for more vehicles so that transit agencies can improve service levels and meet increasing demand. A growing mobility needs index in the region, due to population growth and a large aging demographic, will require more coordination by transit agencies with their local human service organizations. Improved coordination will provide better overall quality of life services for local residents. Future study should be considered to focus on this coordination effort and its potential effects on local communities and key players involved.

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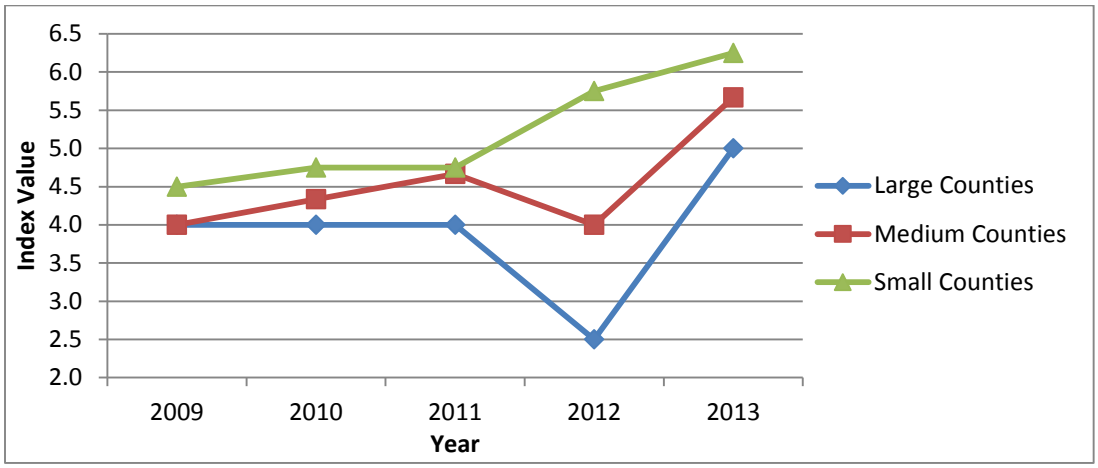
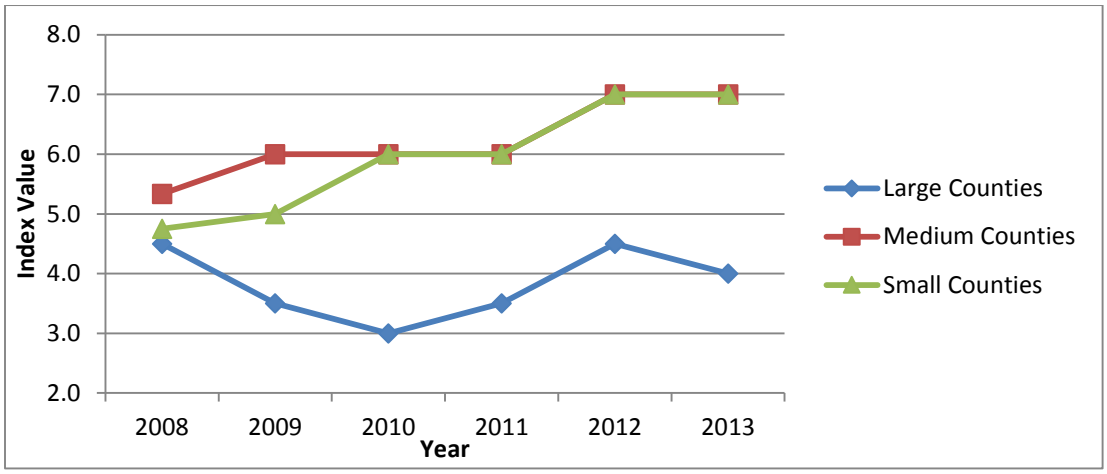
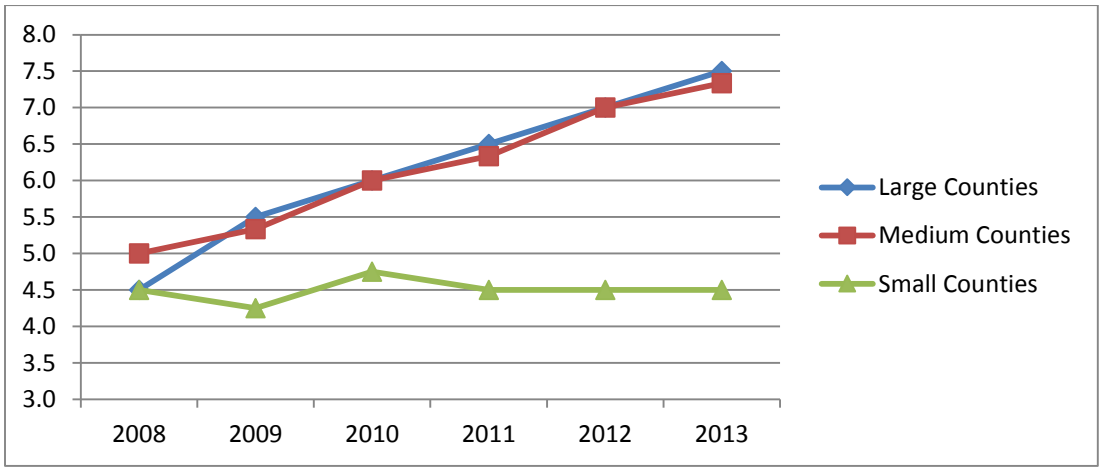
APPENDIX A: INDIVIDUAL LIVABILITY MEASURES



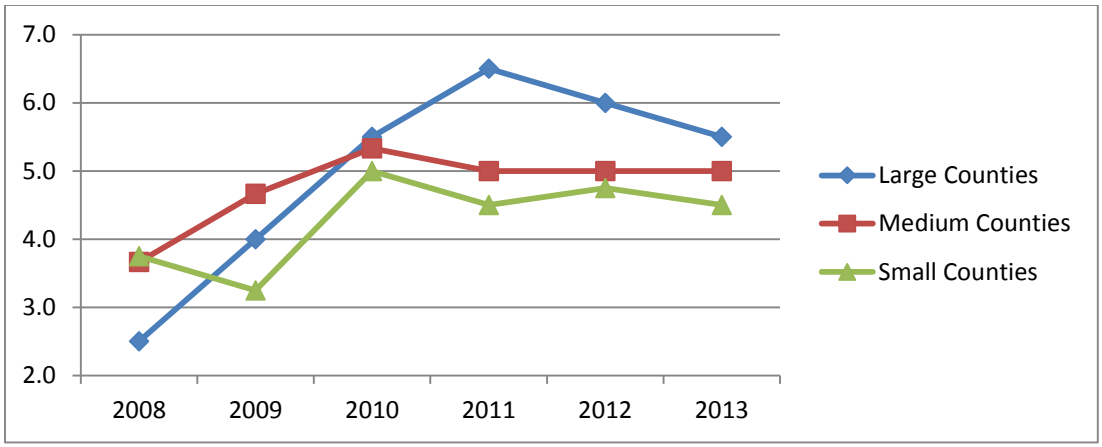
Coordinate Policies and Leverage Investments



Percent who do not Drive Alone to Work



Promote Equitable Affordable Housing



Support Existing Communities

APPENDIX B: LIVABILITY MEASURES, RAW DATA

	Williams	Stark	Moountrail	McKenzie	Dunn	Divide	Burke	Golden Valley	Billings
C&L Fed Investment									
2009	38.1%	35.2%	39.8%	38.1%	37.1%	38.1%	39.8%	42.3%	42.3%
2010	40.0%	21.3%	36.1%	40.0%	39.0%	40.0%	36.1%	41.2%	41.2%
2011	41.8%	20.2%	39.3%	41.8%	40.4%	41.8%	39.3%	40.4%	40.4%
2012	18.7%	21.4%	43.6%	18.7%	44.2%	18.7%	43.6%	67.0%	67.0%
2013	40.9%	42.8%	52.8%	40.9%	52.8%	40.9%	52.8%	63.6%	63.6%
Value Communities and Neighborhoods									
2008	2838	2770	1798	1787	2502	888	1061	2348	1126
2009	4026	5399	2289	2534	2535	1259	1801	1182	567
2010	6209	8982	3520	3517	2043	2185	2308	1973	946
2011	5930	11495	3492	3111	1908	2318	1718	1589	762
2012	5775	10078	3614	3029	1997	2258	1778	2318	1111
2013	6100	8881	3112	2742	2319	2385	1722	1961	940
Enhance Economic Competitiveness									
2008	0.00028	0.00051	0.00042	0.00028	0.00022	0.00028	0.00042	0.00148	0.00148
2009	0.00027	0.00050	0.00042	0.00027	0.00022	0.00027	0.00042	0.00185	0.00185
2010	0.00029	0.00053	0.00046	0.00029	0.00022	0.00029	0.00046	0.00185	0.00185
2011	0.00030	0.00052	0.00048	0.00030	0.00022	0.00030	0.00048	0.00185	0.00185
2012	0.00024	0.00048	0.00042	0.00024	0.00022	0.00024	0.00042	0.00111	0.00111
2013	0.00022	0.00043	0.00042	0.00022	0.00025	0.00022	0.00042	0.00111	0.00111
Percent who do not drive alone to work									
2008	14.7%	15.6%	15.0%	14.0%	20.9%	11.1%	24.8%	12.8%	19.0%
2009	12.3%	14.0%	17.1%	13.8%	23.6%	13.9%	25.0%	12.1%	15.3%

2010	11.7%	14.0%	17.6%	15.1%	20.9%	16.3%	24.3%	13.1%	20.6%
2011	14.7%	12.7%	17.6%	15.1%	20.9%	16.3%	24.3%	13.1%	20.6%
2012	14.1%	15.6%	18.1%	16.9%	22.7%	19.0%	27.2%	17.4%	24.4%
2013	14.4%	14.9%	18.1%	16.9%	22.7%	19.0%	27.0%	17.4%	24.4%
Promote Equitable Affordable Housing									
2008	40,626	33,242	36,854	35,731	36,481	35,878	39,396	18,484	44,030
2009	42,897	35,196	42,755	37,402	38,844	34,405	38,982	22,092	40,056
2010	48,666	39,077	44,305	41,914	42,385	32,893	41,658	23,294	40,694
2011	50,554	39,647	47,489	43,770	41,596	34,083	40,937	23,752	37,378
2012	53,677	41,536	50,985	46,720	41,542	35,680	38,993	23,041	34,469
2013	57,067	43,665	52,210	48,365	45,357	35,774	37,636	22,804	40,982
Support Existing Communities									
2008	473	602	899	510	834	386	663	1381	938
2009	671	1125	1526	724	845	547	1126	695	472
2010	1140	1761	2011	1256	681	950	1506	1161	788
2011	1140	2169	1863	1166	596	966	1432	935	586
2012	1031	1866	1701	1069	624	903	1482	1288	855
2013	1034	1586	1556	1010	725	883	1325	1032	723