Journal of Rural and Community Development

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Citation:
Rahm, D., Fields, B., & Farmer, J. L. (2015). Transportation impacts of fracking in the Eagle Ford Shale Development in rural south Texas: Perceptions of local government officials. *The Journal of Rural and Community Development*, *10*(2), 78-99.

Publisher: Rural Development Institute, Brandon University.

Editor: Dr. Doug Ramsey

ISSN: 1712-8277 © Journal of Rural and Community Development
www.jrcd.ca

Transportation Impacts of Fracking in the Eagle Ford Shale Development in Rural South Texas: Perceptions of Local Government Officials

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Abstract

This paper explores the impacts on transportation infrastructure and transportation-related issues associated with the gas and oil boom in the Eagle Ford Shale region in rural south Texas. It begins with a general explanation of fracking and its general impacts along with specifics of the Eagle Ford Shale region. Drawing on data gathered both from crash trends and two surveys administered to public officials in the Eagle Ford Shale region, we present a description of the impacts of fracking on cities and counties. Crash trends between 2009-2013 overall show a 26 percent increase. Fatalities and severe injuries also increased by 49 percent. The survey results show that counties and cities are experiencing significant challenges in meeting increased demands placed on their transportation system by fracking including increased traffic and congestion, deteriorating roads, and increased cost of maintenance.

Keywords: fracking, transportation policy, energy resources, rural traffic, oil

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1.0 Introduction

The use of hydraulic fracturing or "fracking" to access shale oil deposits has grown tremendously over the last decade. While the environmental consequences of fracking have received significant scholarly and media attention, the urban planning and transportation consequences of a booming energy resource-based economy on local communities has received comparatively less attention (Christopherson & Rightor, 2012). While the oil and gas boom brings an area potential economic advantage, the rapid expansion of drilling in many areas also brings some potentially negative side effects in terms of potential health impacts and overburdened community resources (Adgate, Goldstein, & McKenzie, 2014; Schafft, Borlu, & Glenna, 2013). A particular area of concern is the impact of the fracking boom on the transportation sector where heavy truck traffic, deterioration of road networks, and the number of crashes and road fatalities have grown in areas impacted by fracking (Johnson, 2010; Prozzi, Prozzi, Grebenschikov, & Banerjee, 2011; Quiroga, Fernando, & Oh, 2012; Muehlenbachs & Krupuick, 2013).

In some areas of the United States, the negative transportation impacts of fracking booms have been mitigated through regulatory measures that impose fees on heavy trucks to pay for roadway damage and the additional transportation strain imposed by the flow of industrial traffic. In the Marcellus Shale development region in Pennsylvania, for example, local communities have crafted regulations that require gas companies to enter into road maintenance agreements when vehicles over a certain weight are used. This has helped to significantly mitigate negative transportation impacts (Brasier et al., 2011). In other areas of the country, however, the local economic, regulatory, and political climate often limits local options for transportation mitigation. In Texas, for example, local efforts to control the limits of fracking have been limited by the state legislature (Malewitz, 2015).

This paper is focused on understanding how the diverse regulatory and political climates impact local transportation policy perceptions within fracking boom areas. It provides an analysis of the Eagle Ford Shale play in rural south Texas. The Eagle Ford play covers more than 3,000 square miles and accounts for more than 16 percent of all U.S. oil production. Even with the recent downturn in oil prices, the region holds vast resources of oil and gas that can still be profitably drilled using hydraulic fracking technology (Holeywell, 2014). Discovered in 2008, development of the oil and gas in the region began in 2009. In 2013 the region contributed more than $87 billion to the Texas economy and employed more than 155,000 full-time workers (Institute for Economic Development, 2014). At the same time, road conditions have deteriorated, and roadway crashes have increased. Traffic crashes associated with an increase in fracking activity have been a particularly large concern in Texas where fatalities associated with commercial vehicles increased 50 percent during the last several years (Schneider, 2014). This study of the Eagle Ford Shale region through an analysis of regional crash data and a survey of key transportation stakeholders provides insights into the potential and limits of "pathways for action within communities" to address fracking booms (Brasier et al., 2011, 38).

This study begins with a basic explanation of fracking and its general impacts. The following section provides some detail about the Eagle Ford Shale region. We provide a review of the literature pertaining specifically to transportation-related issues associated with fracking-boom areas. The methods used for our study follow along with a discussion of the data gathered and analysis of the data. We conclude with an assessment of the overall impacts the fracking-boom has on transportation in the Eagle Ford Shale and implications for other regions impacted by the fracking expansion.

2.0 Overview Of Fracking And Its Impacts

To better understand the impact of fracking on transportation, a basic understanding of the industry is necessary. Fracking is a technology that has existed for about 60 years (Malakoff, 2014) but until relatively recently it has been applied mainly to vertical wells in a far more limited way. Innovation in fracking methods about a decade ago, however, incorporated horizontal drilling and multistage fractures to get at what otherwise would be uneconomical sources of gas and oil that lie in unconventional reservoirs. In shale formations the reservoir rock does not permit the gas and oil to flow into a conventional vertical well at an economical rate. The goal of horizontal drilling and fracking is to enable such a flow (Rahm, 2011).

To get at shale gas and oil, a vertical well is first drilled and then, using directional drilling equipment that is transported to the site, the well is drilled horizontally. The vertical drilling typically goes down between 5,000 and 12,000 feet. At that point the horizontal drilling begins. The horizontal drilling extends the well several thousand more feet. During the drilling of the vertical portion of the well, a series of steel casings are cemented into place to protect fresh water aquifers, which typically lie above the shale formations, from potential contamination. Cracks in the shale are created by forcing fracking fluids down the well in great volume and at high pressure that exceeds the breaking point of the shale. The fracking fluid contains sand or other "propping" agents that hold the cracks open after pumping of the fracking fluid ceases. The fractures are made in the horizontal part of the well. Once the rock is fractured, the gas can flow through the horizontal part of the well, up the vertical part, for collection. Shale gas and oil wells are typically fractured in stages and multiple times (Vaughan & Pursell, 2010).

The volume of fracking fluids and the impact on the transportation system can be large. The Environmental Protection Agency (EPA) estimates that the water needed to drill a horizontal hydraulically fractured shale gas well is typically between 2 and 5 million gallons per well depending on the depth, horizontal distance, and number of times a well is fractured (Environmental Protection Agency, 2010). Some amount of the fracking fluid is returned to the surface after the fracking. This wastewater, called flowback, must be handled and transported appropriately as it contains contaminants that consist either of chemicals deliberately added to the fluid prior to drilling to assist with some aspect of the drilling operation or contaminants that have been absorbed from the rock itself. Recovered fracking fluids can range from 15 to 100 percent of the volume initially injected, depending on the site. This wastewater can be disposed of in several ways. It may be injected back underground in a disposal well, it may be discharged to a surface water body after treatment to remove contaminants, or it can be applied to land surfaces (Office of Research and Development, 2010). Most of these activities occur off of the fracking site and require transportation, usually by truck, to other locations.

As the use of fracking has increased and expanded it has become very controversial. A primary concern involves the chemicals used in the fracking fluids. Fracking fluids not only contain propping agents to hold the fractures open but often other substances as well. While the fracking fluid is typically more than 99 percent water, other components are used. While disclosure of the chemicals added to fracking fluid is often not legally required, it is widely believed that the substances such as potassium chloride, guar gum, ethylene glycol, sodium carbonate, potassium carbonate, sodium chloride, borate salts, citric acid, glutaraldehyde, acid, petroleum distillate, and isopropanol are added. These substances are added for a variety of reasons. For instance, acid helps dissolve minerals and assists with the fracturing process by creating fissures in the rock. Borate salts maintain fluid viscosity. Other substances are added to prevent pipe corrosion, minimize friction between the pipe and fluid, and to prevent scale deposits on the pipe (Vaughan & Pursell, 2010). Critics allege that some of the substances used are hazardous materials and carcinogens, toxic enough to contaminate groundwater resources and create toxic air emissions such as diesel fuel, kerosene, benzene, toluene, xylene, and formaldehyde. There are a number of cases in the U.S. where local communities claim that their air or drinking water has been polluted by hydraulic fracturing fluids, methane, or petroleum by-products such as benzene. Incidents have been reported in several states.

Health threats and fear of environmental contamination are critical issues in the debate over the fracking (Adgate et al., 2014), but land and water use issues, along with the transportation implications, are also important. The surface land used for fracking operations resemble large industrial -sized operations. A large cement pad is necessary. Use of the large quantities of water necessary, especially in arid locations, may be an issue for local water providers. The disposal of wastewater from the hydraulic fracturing process can be complicated and involve either deep-injection, surface water body disposal after decontamination, or disposal directly to the land. In any event, this wastewater must be dealt with, producing another large surface water body, land, or underground hydrological impact (Office of Research and Development, 2010). Injection of wastewater into disposal wells has been associated with increased earthquake activity (Frohlich & Brunt, 2013).

Another consideration is the pipeline infrastructure used to gather the gas and oil and then to move them from the collection point, through refining, to end-use locations. While oil may be also transported by rail or truck, the intricate transport network for natural gas consists of gathering systems, processing plants, pipelines, and storage fields (Energy Information Administration, 2010). Finally, a major concern revolves around the varied impacts of fracking on transportation. Trucks transport heavy loads of drill rigs, fracking water, wastewater, and other equipment. An increased number of private vehicles populate the roads to move oil and gas workers to and from work sites. Popular reports of increasing traffic, road wear, crashes, and fatalities are common in areas of the country being fracked.

2.1 The Eagle Ford Shale

One of the areas experiencing significant transportation-related impacts from fracking is the Eagle Ford Shale play which covers much of south Texas, as depicted in Figure 1. It lies just south of San Antonio and runs west to the U.S.-Mexico border, covering more than 21 counties. The 15 most drilled counties include Lavaca, DeWitt, Gonzales, Wilson, Karnes, Bee, Live Oak, Atascosa, McMullen, La Salle, Frio, Zavala, Dimmit, Maverick, and Webb.

In 2009, Petrohawk Energy drilled the first of the commercial oil and gas wells in the Eagle Ford Shale play. Since then, activity rapidly expanded and the Eagle Ford Shale play has become one of the top producing plays in North America, with potential for continued increasing production levels. In 2013 alone, more than 3,200 new wells were drilled. In 2013, the Eagle Ford produced over 600,000 barrels of oil per day along with 2,829 million cubic feet of natural gas (Texas Independent Producers and Royalty Owners Association, 2013). By 2014 production had increased to 1.5 million barrels of oil a day and over 6,000 million cubic feet of natural gas (U.S. Energy Information Administration, 2014).

Figure 1: The Eagle Ford Shale Play.

Source: Phillips Energy, 2013.

The Eagle Ford Shale is an unconventional oil, gas, and condensate play. While natural gas and crude oil are generally well understood, condensate is less well known. Condensate is a type of very light oil that is available in large quantities in shale plays. It typically is in gaseous form underground but condenses into a liquid when it is pumped to the surface, thus the name (Sider, 2014). Shale gas, oil, and condensate extraction using fracking has revolutionized gas production in the Eagle Ford Shale region. The fast increases in production in the Eagle Ford Shale in recent years are owed primarily to improvements in the fracking techniques being used and the fact that drilling is very profitable. For every million dollars a driller puts into sinking a well, they can expect to receive back about $1.5 million in oil, gas, and condensate revenue over the course of a year (PR Newswire, 2014). The incentives to expand drilling and increase production, therefore, are great. While the 2014-2015 drop in the price of oil may slow new drilling, already existing wells will continue to produce for some time. In addition, fracking activities are likely to continue if the negotiated lease has a clause for termination in the event of lack of activity on the part of the driller. These termination clauses are common and give drillers incentives to continue drilling new wells even if profits are small lest they lose the lease and forfeit potentially large profits when oil prices recover.

3.0 Literature Review

The scholarly literature associated with the issue of hydraulic fracturing and transportation impacts is still developing. While there have been numerous studies that reference transportation impacts of fracking (Brasier et al., 2011; Schafft et al., 2013; Food and Water Watch, 2013; Adgate et al., 2014), a smaller, but growing number of transportation–specific studies have been done to date (Johnson, 2010; Abramzon, Samaras, Curtright, Litovitz, & Burger, 2014; Hesse, Tinjum, & Warren, in press). Most of these studies have focused on the transportation impacts in a particular region.

In the Marcellus Shale play, for example, Muehlenbachs and Krupuick (2013) argue that fracking booms strain transportation infrastructure and create large traffic problems. They assert that more than 2,000 truck trips are required for each well drilled in the Marcellus Shale in Pennsylvania. These trips are required to transport drilling rigs, workers, fracking fluids, water, and for the removal of wastewater. Using data from the Crash Reporting System of the Pennsylvania Department of Transportation, they found a significant increase in the number of total crashes and crashes involving a heavy truck in counties with shale gas development. They found that one additional well drilled per month raised the frequency of crashes involving heavy trucks by more than 2 percent and that on average there are 9 crashes per county per month in the Marcellus Shale development area. Lampe (2012) also suggests that traffic in the Marcellus Shale will increase dramatically since in the Marcellus Shale injected and flowback water is mostly transported by truck. Lampe argues this will increase the crash rate. While pipeline networks might mitigate the crash rate by reducing truck transport, the pipeline networks will simultaneously increase land disturbance.

Gilmore, Hupp, and Glathar (2014) used GIS to quantify truck traffic associated with water and the fracking of the Marcellus Shale. They conclude that the truck travel distances are longer than necessary due to inefficient routing. Travel distances could be reduced by 40-80 percent if routing improvements were implemented. Rahm et al. (2013) also quantified wastewater truck traffic in the Marcellus Shale and concluded that between 2008 and 2011, wastewater traffic miles fell by over 30 percent. This was due, they suggest, to better wastewater tracking and reporting systems as well access to local and regional wastewater treatment facilities.

In terms of understanding the policy implications of these technical components, Abramzon et al. (2014) provide a strong framework for understanding policy responses in the Marcellus Shale region. Abramzon et al. (2014) argue that there are 3 broad types of policy responses which can be used to address these costs: cost recovery through taxes or fees focused on the drillers, policies designed to decrease damage to roadways such as truck weight limits, and altering infrastructure to make it more resilient to higher intensity activity. A "comprehensive" policy, according to Abramzon et al. (2014, 6), "would combine elements of these three approaches."

While a comprehensive policy may be optimal, Brasier et al. (2011) highlight the effectiveness of utilizing maintenance agreements in the Marcellus Shale play in Pennsylvania. Maintenance agreements require drilling companies to restore roadway quality to pre-drilling conditions. In Pennsylvania where a strong posting program of weight limits triggers a maintenance agreement with local communities, bonds are provided by drilling companies to restore roadways. The result, according to Brasier et al.'s study respondents (2011, 52), was that while companies were seen to have "damaged roads at a much faster pace than they have repaired them," the companies eventually "restored the roads to equal or better condition than before they were damaged." Brasier et al. (2011) note that understanding how differing state regulatory policy climates impact these local policies is an important area for future research.

In Texas, for example, state regulatory climate and underlying roadways conditions and policies differ from Marcellus play region. In Texas, a series of new studies has analyzed the impact of shale energy development on transportation over the last several years. Prozzi et al. (2011) analyze the impact of shale development on roadway surface quality. They point to three primary causes of increased truck traffic associated with shale oil development: transportation of the fracking rig, traffic focused on construction during the fracking phase, and traffic associated with wastewater removal during fracking processes. Each of these phases results in a different intensity of truck transportation. The impact of the increased truck traffic associated with these phases was calculated to decrease road service life by approximately 41 percent overall (Prozzi et al., 2011, p. 135). While the study examined truck traffic impacts, it did not consider broader impacts associated with individual construction workers traveling back and forth to job sites.

An additional issue impacting road surface quality is the impact of earthquakes. Frohlich and Brunt (2013) provided an extensive analysis of the earthquake activity in the Eagle Ford Shale related to the disposal of wastewater in injection wells. These earthquakes raise questions about the impacts on infrastructure including roads and bridges. Williamson (2014) reported that the large number of earthquakes in shale producing plays raises concerns about damage to aging infrastructure in Oklahoma. The Oklahoma Department of Transportation Director consulted experts from California to determine the possible impacts on roads and bridges.

Quiroga et al. (2012) analyze traffic increases connected to shale development and the potential roadway safety issues associated with the increase. They point out that fracking transportation is often uneven and occurs in "outbursts of intense activity… followed by periods of inactivity in which relatively little traffic occurs" (Quiroga et al., p. 39). For example, they reveal that the pad site preparation, rig mobilization and drilling operation phases for a single well in the Barnett Shale of North Texas can generate 187 truckloads per year. Meanwhile the maintenance phase for a single well in this shale can produce an additional 88 truckloads annually, with an additional 997 truckloads estimated every few years for refracking. (Quiroga et al., 2012). This closely matches Muehlenbachs and Krupuick (2013) estimate of truck traffic per well site in Marcellus Shale in Pennsylvania discussed previously.

In terms of roadway safety impacts, Quiroga et al. (2012) examined a broad set of energy-related industries together and found that there were increases in crash rates in areas associated with energy activity versus control areas. They note that there is "an indication that corridors where energy developments take place have higher crash rates," but these conclusions are "circumstantial" because "existing data do not include any data elements connecting energy developments with crashes" (Quiroga et al., 2012, p. 107).

The issues with energy-related transportation impacts in Texas also drew the attention of the Texas Transportation Commission. They established a Task Force on Texas' Energy Sector Roadway Needs. The Commission's report provides a more in depth analysis of crashes in impacted areas. They note that the majority of crashes occurred during the 5PM to 6PM timeframe with only 10 percent of the crashes overall involving commercial vehicles (Texas Department of Transportation, 2012, p. 7). The indication seems to be that energy-related employee traffic at rush hour may have an impact on roadway crashes in energy-impacted regions.

In terms of policy response, Texas has also sought to steer additional roadway resources towards impacted regions. In 2012, the Texas Legislature passed House Bill 1025 that provided $450 million to help rehabilitate roads impacted by energy sector development. The funding was designed to be split between the state and county for their respective road networks. To implement the county portion of the program, the Texas Department of Transportation (TXDOT) established a grant program to distribute funds. Counties were to submit a report outlining road conditions and go through a process to establish a County Energy Transportation Reinvestment Zone.

The extent of roadway deterioration and lack of funding caused TXDOT to initiate a controversial program in 2013 called the high-end unpaved road conversion program. This program sought to convert 83 miles of road in the Eagle Ford Shale region from paved to gravel along with a lowering of the speed limit to 30 mph. This program was unpopular, and political pressure forced the program into moratorium shortly after the conversions began. The program was finally abandoned completely after Texas voters passed a constitutional amendment in November 2014 (Proposition 1) that allowed a portion of the state's Economic Stabilization Fund to be used for transportation projects. The change allows for 15 percent of the total available funds to be used by TXDOT in energy impacted areas.

Despite these changes, there remains a gap between needed and dedicated transportation resources. TXDOT (2014, 9) reported in its Strategic Plan that there was an annual $1 billion in additional state costs and another additional $1 billion in county costs associated with "rebuilding the infrastructure being consumed by increased energy-related activities." Additional resources were also reported as being needed to reinforce bridges due to increased loads of heavy, energy-related truck traffic. Detailed roadway cost estimates for the TXDOT Strategic Plan estimate were drawn from a Texas Transportation Institute (TTI) study evaluating detailed scenarios for roadway impact of energy-related activities in Texas (Quiroga et al., 2012, p. 131 and 132).

An overarching policy analysis conducted by Boske, Gamkhar and Harrison (2013) compares state and local transportation financing policy from across multiple states (Pennsylvania, West Virginia, Ohio, North Dakota, and Louisiana) to shale plays in Texas. They point to a suite of five options utilized in these areas: use of additional funding for transportation, impact fees, bonding, and maintenance agreements. Boske et al. (2013, 1 and 2) find that maintenance agreements and bonding are particularly effective tools in maintaining roadway quality and are "notable in that they place the costs of road repairs with energy companies rather than state or local governments."

In Texas, some local voluntary maintenance agreements have been executed, but there is no overarching state policy on this matter (Boske et al., 2013). Instead, Texas has sought to address the matter through the addition of broader state revenues such as the previously discussed examples of additional revenue from House Bill 1025 and Proposition 1. Rather than focusing payment of consumed transportation resources on the drilling companies, the Texas approach socializes the cost across all residents and, importantly as respondents will point out, still does not provide enough resources to effectively address the safety and roadway quality issues impacting shale gas affected counties.

4.0 Methods

A connected set of two surveys was developed and administered over the Internet in November of 2014. The surveys were similar but differentiated by county and city specific functions. The population for the study consisted of city and county public officials in the Eagle Ford Shale region. After consulting maps obtained for active drilling locations in the Eagle Ford Shale as of 2013, the population was narrowed to 15 counties where most of the drilling activity had already begun. These counties include Atascosa, Bee, DeWitt, Dimmit, Frio, Gonzales, Karnes, La Salle, Lavaca, Live Oak, McMullen, Maverick, Webb, Wilson, and Zavala. Within those counties, cities with populations over 2,000 were identified. The reason this threshold was used is because literature suggests that larger jurisdictions might have more expertise in responding to surveys, which could produce results that vary from those of a broader sample (Chen, Ebdon, Kriz, & Maisondieu LaForge, 2013). It is typical for smaller cities throughout Texas to lack staff and expertise making it difficult for them to assess transportation impacts. Counties on the other hand, generally conform to mandated statewide practices, thus little variation is expected between smaller and larger counties.

Since the surveys were to be administered via the Internet, email addresses for public officials in those counties were obtained. For the counties, we obtained email addresses for County Judges, County Commissioners, Sheriffs, regional planning officials, and Texas Department of Transportation liaisons to the region. For the cities, email addresses for chief executives (Mayors and City Managers), Finance Directors, and Treasurers were acquired generally from posted city and country web sites.

The surveys were preceded by an alert email which was sent in early November of 2014. The surveys were sent the following week with several reminders in the remaining weeks of the month. The county population initially consisted of 96 officials but 6 emails were incorrect leaving a population of 90. Of these, 28 individuals returned the survey for a response rate of 31 percent. The city population initially consisted of 54 executives but 10 emails were incorrect leaving a population of 44. Of those, 16 completed the survey yielding a response rate of 36 percent. The large rate of incorrect addresses is likely due to the rural nature of the population and that fact that most transactions are still conducted face-to-face rather than by electronic media. Clearly the lack of attention to updating city and county web sites to certify that posted information is correct attests to this. Survey questions are shown in the appendix.

4.1 Sub-Sample Equivalency

To test whether there were statistically significant differences between counties and cities, sub-sample equivalency testing was undertaken. Census data were gathered for each county and city in the study to assess difference between responding and non-responding jurisdictions. The assessed variables include population, percent Hispanic, percent African American, percent white (non-Hispanic), percent of residents graduating high school, median household income, and percent living in poverty. T-tests for differences in the means for each of the demographic variables were performed. The results are shown in Tables 1 and 2. The results show that there are no statistically significant differences between the non-responding and responding cities. For the counties, the only variable on which statistically significant differences can be seen is percent African American. All counties in the study have relative small percentages of African Americans (the range is from 0.6 to 9.6 percent), however non-responding counties have lower percentages of African Americans. The t-test for differences between cities and counties are presented in the tables below with the highlighted survey responses.

As Tables 1 and 2 show, in comparison to the entire state of Texas, the counties and cities in the study differ considerably. They tend to be more heavily Hispanic (the Texas average percent is 38.4 Hispanic), they have lower African American populations (the Texas average percent is 12.4 African American), and they have a lower percent of white residents (the Texas average percent is 80.3). The study counties and cities generally are apt to have less educated populations than the state of Texas (which averages 81.2 percent high school or higher completion). In terms of economics, the study counties and cities also generally have a lower median household income than does the average Texas household ($51,900) and the study population also tends to have higher percentages of persons living below the poverty level than does the state overall percent (17.6).

4.2 Eagle Ford Shale Crash Trends And Drilling Activity: Background

The Eagle Ford Shale play is located in a predominantly rural region in south Texas with a dispersed population. Prior to the fracking boom, the area had limited development pressure on its extensive rural road system. An analysis of crash trends in the region provides important background information for understanding survey respondents' perceptions.

Crash data from the TXDOT were obtained and analyzed for the 15 study area counties listed above. In line with previous research by Christopherson and Rightor (2012), the analysis sought to provide baseline information on the number of traffic crashes prior to the fracking boom. The year 2008 was used as the baseline as major fracking operations in the area did not begin until 2009.

Table 3 provides an overview of overall crash trends in the study area counties. These crash figures include both truck crashes and personal vehicle crashes. Despite some specific differences in the crash pattern changes in individual counties, crashes in the study area increased by 26 percent from 2008 to 2013. This trend contrasts with the trend in Texas as a whole, which saw a 1 percent increase in crashes during the same period. In the United States as a whole, overall crashes decreased by 2 percent during the same period (National Highway Traffic Safety Administration, 2009; National Highway Traffic Safety Administration, 2014).

Table 1. *Sub-Sample Equivalency: Responding and Non-Responding Counties*

County	**Est. Population 2014**	**Population 2010**	**Percent Hispanic**	**Percent African American**	**Percent white alone, not Hispanic**	**High School Graduate or higher, percent**	**Median household income**	**Persons below poverty level, percent**
Atascosa	47,774	44,911	62.6	1.2	35.3	73.6	47,543	16.4
Bee	32,863	31,861	57.4	8.5	33.1	70.8	43,690	22.2

DeWitt	20,684	20,097	33.8	9.6	56.1	76.8	46,454	13.5
Dimmit	11,089	9,996	85.4	1.7	12.6	61.1	36,681	26.5
Frio	18,531	17,217	78	3.9	16.1	63.9	35,849	24
Gonzales	20,462	19,807	49.1	7.7	43.2	69.3	39,248	21.9
Karnes	14,906	14,824	51.2	9.3	39.1	70.8	42,862	23
La Salle	7,474	6,886	84.8	1.0	13.8	52.9	26,756	21.7
Lavaca	19,721	19,263	17.4	7.2	74.5	79.2	44,149	8.3
Live Oak	12,091	11,531	36.9	4.8	57	79.6	42,829	17.1
Webb	266,673	250,304	95.3	0.7	3.7	64.2	39,449	31.4
Wilson	46,402	42,918	38.8	1.8	58	84.6	64,571	11.5
Maverick	***57,023***	***54,258***	***95.1***	***0.6***	***3.2***	***56.6***	***31,395***	***30.5***
McMullen	***805***	***707***	***36.6***	***1.0***	***60.5***	***67***	***39,500***	***19.2***
Zavala	***12,267***	***11,677***	***92.9***	***1.2***	***6.4***	***60.3***	***25,625***	***35***
T-test	2.26	2.26	3.18	2.17*	4.30	2.57	2.78	3.18

Note: Significance code: *p < .10; **p < .05; ***p < .01. Bold and italic data represent non-responding cities.
Source: U.S. Census data, 2010.

The most significant types of crashes (fatalities and severe injuries) also saw increases in the study area. Fatalities in the study region increased from 88 in 2008 to 131 in 2013. This 48.86 percent increase contrasts with an overall decrease in fatalities in Texas of 3 percent. Nationally, fatalities decreased by 12 percent over the same period from 2008 to 2013. The number of severe injuries in the study area also saw an increase of 40.83 percent. In Texas, the overall increase in severe injuries from traffic crashes was 5 percent. As has already been stated, recent research by TXDOT (2012) shows that the most the most likely time period for crashes was between 5PM and 6PM. They hypothesize that the potential interaction of personal vehicles of workers getting off work and heavy trucks may be a cause.

Table 2. *Sub-Sample Equivalency: Responding and Non-Responding Cities*

City	**Est. Population 2013**	**Population 2010**	**Percent Hispanic**	**Percent African American**	**Percent white alone, not Hispanic**	**High School Graduate or higher, percent**	**Median household income**	**Persons below poverty level, percent**
Beeville	13,290	12,863	71.9	2.7	23.7	71.9	37,989	23.7
Crystal City	7,446	7,138	97.1	0.8	2.4	64.1	24,503	36.7
Cuero	7,005	6,841	39.9	15.2	42.9	73.9	31,752	19.3
Eagle Pass	27,708	26,248	95.5	0.3	3.6	64.0	33,646	27.8

Jourdanton	3,973	3,871	53.6	0.0	46.0	75.6	49,167	9.7
Kenedy	3,355	3,296	72.6	2.8	23.5	65.0	35,400	39.6
Laredo	248,142	236,091	95.6	0.5	3.4	65.3	40,041	30.8
Lytle	3,053	2,492	72.6	1.9	24.7	76.3	41,087	17.5
Pearsall	9,618	9,146	85.1	1.3	10.0	59.4	31,564	23.3
Pleasanton	9,512	8,934	56.3	0.7	41.6	78.0	51,981	17.7
Poteet	3,310	3,260	94.5	0.0	5.3	66.6	38,708	29.0
Yoakum	5,954	5,815	43.8	10.3	44.9	65.7	36,402	11.9
Yorktown	2,716	2,082	41.6	1.8	53.7	68.3	39,792	18.3
Carizo Springs	***5,870***	***5,368***	***89.6***	***1.3***	***8.3***	***64.2***	***37,448***	***26.0***
Cotulla	***3731***	***3603***	***92.0***	***0.0***	***7.8***	***54***	***25,283***	***27.4***
Dilley	***3,954***	***3,894***	***67.0***	***10.7***	***21.9***	***68.0***	***36,806***	***29.2***
El Centro	***3,296***	***3,273***	***99.5***	***4.2***	***0.0***	***31.5***	***21,134***	***46.5***
Floresville	***7,021***	***6,448***	***65.1***	***1.6***	***32.5***	***73.2***	***43,125***	***22.4***
George West	***2,467***	***2,445***	***60.1***	***7.2***	***35.6***	***67.4***	***42,882***	***23.8***
Gonzales	***7,410***	***7,237***	***53.1***	***12.6***	***33.6***	***67.1***	***33,417***	***29.4***
Hallettsville	***2,572***	***2,550***	***9.2***	***20.8***	***68.9***	***77.2***	***34,567***	***14.6***
Karnes City	***3,118***	***3,042***	***72.6***	***5.6***	***22.3***	***63.0***	***32,656***	***25.4***
Nixon	***2,826***	***2,385***	***81.5***	***1.8***	***16.2***	***49.4***	***29,442***	***24.4***
Rio Bravo	***4,849***	***4,794***	***97.9***	***0.0***	***2.0***	***42.6***	***27,174***	***37.9***
Shiner	***2,173***	***2,069***	***16.9***	***7.0***	***76.8***	***75.4***	***44,421***	***10.0***
T-test	2.17	2.17	2.08	2.08	2.07	2.14	2.06	2.06

Note: Significance code: *p < .10; **p < .05; ***p < .01. Bold and italic data represent non-responding cities.
Source: U.S. Census data, 2010.

Table 3. *Crash Trends Before and After Major Shale Development in the Eagle Ford Region*

County	**Total Crashes 2008**	**Total Crashes 2009**	**Total Crashes 2010**	**Total Crashes 2011**	**Total Crashes 2012**	**Total Crashes 2013**	**Percent Change 2008 to 2013**
Atascosa County	639	486	690	726	895	931	46%
Bee County	366	381	311	361	410	444	21%
DeWitt County	298	270	320	352	395	376	26%
Dimmit County	115	70	36	235	337	301	162%

Frio County	132	192	151	215	211	192	45%
Gonzales County	290	274	314	336	417	468	61%
Karnes County	172	130	180	307	411	404	135%
LaSalle County	60	85	86	187	258	232	287%
Lavaca County	298	227	238	229	244	232	-22%
Live Oak County	253	216	246	281	426	498	97%
Maverick County	453	506	639	636	712	707	56%
McMullen County	22	17	49	87	139	107	386%
Webb County	5240	5159	4965	5184	5295	5449	4%
Wilson County	377	366	386	433	531	623	65%
Zavala County	35	28	25	41	32	30	-14%
Total Crashes Study Area	8750	8407	8636	9610	10713	10994	26%

Source: Texas Department of Transportation (2015a; 2015b; 2015c; 2015d; 2015e; 2015f).

To provide context in terms of increased drilling activity, Table 4 shows the number of wells completed in the region during the same time period. It is important to note that much road activity would take place before a well completion. This table shows that over the period in question 12,818 wells were completed in the region.

Several researchers have provided estimates of transportation impacts associated with well development. Prozzi et al. (2011), for example, estimate the increased truck traffic associated with well development. The range for a single well runs from 295 to 455 for one-way truck trips. Extrapolating to the Eagle Ford region, the estimated increased truck trips associated with only well-development range from 3,781,310 to 5,832,190 increased trips. This figure does not account for well-operations or individual construction crew transportation. These operations can significantly increase transportation volume for an area.

Table 4. *Drilling Well Completions in Energy-Impacted Counties in the Eagle Ford Shale Region, 2008-2013*

County	**Total Wells Completed 2008**	**Total Wells Completed 2009**	**Total Wells Completed 2010**	**Total Wells Completed 2011**	**Total Wells Completed 2012**	**Total Wells Completed 2013**	**Total Wells Completed 2008 to 2013**
Atascosa County	0	0	3	21	185	293	502
Bee County	0	0	1	29	57	105	192

DeWitt County	0	0	7	70	360	644	1081
Dimmit County	0	0	30	239	413	1211	1893
Frio County	0	0	4	35	84	109	232
Gonzales County	0	0	0	97	335	464	896
Karnes County	0	0	1	162	720	1042	1925
LaSalle County	0	0	6	185	542	982	1715
Lavaca County	0	0	3	13	72	127	215
Live Oak County	0	0	5	39	202	352	598
Maverick County	0	0	17	128	46	48	239
McMullen County	0	0	10	102	452	829	1393
Webb County	0	1	102	285	307	900	1595
Wilson County	0	0	0	17	39	98	154
Zavala County	0	0	0	15	77	96	188
Total Completions Study Area	**0**	**1**	**189**	**1437**	**3891**	**7300**	**12818**

Source: Texas Railroad Commission (2015).

One way to understand the potential increased costs associated with this development is to examine technical roadway studies that establish transportation costs associated with well development. Abramzon et al. (2014), for example, estimate that transportation costs associated with well development in Pennsylvania are between $13,000 and $23,000 for each well based on roadway characteristics, intensity of drilling, and number of and type of trucks used. Using a similar methodology, Naismith Engineering (2012) analyzed the costs associated with transportation in shale development in DeWitt County in the Eagle Ford Shale play. The authors found that roadways in the area were often constructed for very light traffic flows and were being significantly degraded by both the weight of vehicles used in drilling and by the intensity of drilling in concentrated areas of the county. Naismith's analysis of transportation costs associated with each well drilled is significantly higher than that of Abramzon. Naismith calculates a $133,000 transportation impact from each well drilled.

While more research needs to be done on the specific transportation impacts in other sections of the Eagle Ford Shale region to analyze specific costs and crash mechanisms, the volume of increased traffic, type of large truck traffic, and negative pavement impacts appear to be placing a strain on local resources. Analysis of the survey results below presents a more nuanced portrait of the local perceptions of the transportation situation in the study area.

5.0 Survey Results

The crash data analyzed above presents one frame for understanding the impact of increased fracking activity on the transportation sector in the Eagle Ford Shale play. In order to assess the perceptions of counties and local cities in the impacted regions, a survey of county and city transportation stakeholders was crafted and administered in the fall of 2014. Results of the survey appear to suggest that impacted areas of the Eagle Ford Shale play are experiencing significant challenges in meeting the increased demands placed on their transportation system by the increases in fracking development. The overarching result of the increased fracking on the transportation system, according to respondents, has been a significant decline in quality of roadways, increased congestion and traffic, and increased roadway crashes. These impacts have stretched the ability of local communities to cope with increasing demands on local transportation services. County and city respondents reported that these increasing transportation demands have not been met with needed state resources to maintain and/or upgrade transportation facilities to meet the increased volume and weight of vehicles using the transportation system in local communities.

Specifically, at the county level, most respondents perceived that there had been a substantial increase in traffic in their areas (Table 5). All respondents reported that there had been either a moderate or great amount of increased traffic in their counties. Of that total, eighty-eight percent of respondents reported that there had been a great amount of increase in traffic.

County respondents perceived that this large increase in traffic was negatively impacting both road safety and roadway quality. All county respondents noted that there had been a moderate or great amount of increase in roadway crashes. Eighty-eight percent of respondents reported that traffic congestion had increased a great amount with the remaining respondents (12 percent) reporting a moderate increase in congestion. In terms of roadway quality, 94 percent of respondents reported that their counties were experiencing a great amount of increase in the cost of roadway maintenance.

Like the county survey respondents, city survey respondents perceived an increase in traffic with 87 percent pointing to either a moderate or great increase. The majority of respondents also perceived either moderate or great increases in congestion (80 percent), cost for road maintenance (60 percent), and crashes (73 percent).

An interesting distinction between county and city respondents is that county level respondents seemed to have perceived a much more significant and intense transportation problem. Seventy-two percent of county level respondents noted a great amount of increased congestion compared with 47 percent of city respondents. County level respondents also perceived a much more significant crash problem with 83 percent reporting a great amount of increased crashes as compared to 27 percent of city respondents that perceived the same intensity of the problem. In addition, 94 percent of county respondents perceived a great amount of increased roadway maintenance cost as compared with only 27 percent of city respondents that perceived the same problem. These differences likely reflect both the more rural geographical intensity of fracking development in the Eagle Ford area and the increased transportation responsibilities of counties in Texas rural regions. City survey responses in regions where fracking activity is occurring in more urban settings, such as portions of the Barnett Shale region around Forth Worth, may report more significant transportation and land use problems (Eaton, 2014).

Table 5. *Perceived Transportation Impacts County/City*

Has Fracking Boom Resulted In:	**None**		**A Small Amount**		**A Moderate Amount**		**A Great Amount**	
	County	City	County	City	County	City	County	City
Increased Road Maintenance Cost	0%	0%	0%	40%	6%	33%	94%	27%
Increased Congestion	0%	7%	0%	13%	28%	33%	72%	47%
Installation of Traffic Cameras	41%	80%	18%	13%	29%	7%	12%	0%
Increased Traffic	0%	0%	0%	13%	11%	20%	89%	67%
Increased Crashes /Accidents	0%	7%	0%	20%	17%	47%	83%	27%

In terms of planning for transportation impacts, about half of all counties had collected some type of baseline data on roadway safety and quality before the fracking boom. Baseline data on roadway safety was collected by 56 percent of respondents. The same percentage (56 percent) reported that they had collected baseline data on roadway quality and traffic volumes. Cities were not collecting baseline road data at the same rate. Most city respondents (80 percent) did not collect any baseline data on roads before the boom. Sixty percent did not have access to baseline data on crashes. None of the city respondents had collected baseline photo/video documentation of road conditions. This difference in baseline transportation data collection likely reflects the more substantial role that counties play in administering transportation projects in rural Texas and the potentially limited institutional resources of local communities. As has been pointed out by Christopherson and Rightor (2012), this type of baseline data collection is an important best practice for local communities as they assess the transportation impacts of shale development on local roadways.

In terms of responding to the flow of traffic in their counties, county respondents focused on the need to enhance roadways, EMS, and police services (Table 6). Sixty-eight percent of respondents argued that there was a moderate or great amount of need to widen roadways and/or add shoulders. Sixty-eight percent of respondents also reported that there had been moderate or great amount of increased costs for

EMS in their counties. Eighty-seven percent of respondents also reported that there was a moderate or great amount of increase needed in police services. The focus of county responses was almost exclusively focused on enhancements to improve the flow of vehicles rather than pedestrian or bicycle enhancements. None of the respondents reported that that there was a moderate or great increase in the need for crosswalks and/or sidewalks in their counties.

At the city level, while the transportation problems appear to be perceived as growing and important, city respondents do not appear to be increasing spending on infrastructure responses. Less than half of respondents pointed to a moderate or great increase in spending dedicated to traffic signals (26 percent), widening roads (26 percent), or enhanced street lighting (26 percent). Again, this distinction between county and city respondents likely reflects the more rural geographical concentration of fracking activity in the Eagle Ford shale region.

In terms of policy response, most respondents at the county level where the bulk of transportation decisions are being made in the Eagle Ford region felt that the state response was inadequate. As mentioned previously, the state of Texas established the County Energy Transportation Reinvestment Zone as a tool to help address the increased stress on roadway safety and quality associated with the increase in fracking activity. Sixty-nine percent of county respondents reported that they had established County Energy Transportation Reinvestment Zones. Of those respondents that had established zones (n=16), 93 percent had requested funding from the program. Despite the high rate of participation in the program, most respondents felt that there were insufficient resources available to meet their increased transportation needs. All respondents felt that the funds were either slightly or significantly less than needed. Eighty-nine percent of these respondents reported that the amount received from the program was substantially less than what was needed to cover expected costs to maintain roadway quality.

Table 6. *Perceived Transportation Budgetary Impacts County/City*

Has Fracking Boom Caused Enhanced Spending on:	**No**		**A Little**		**Moderately**		**A Great Deal**	
	County	City	County	City	County	City	County	City
Street Lights/Public Lighting	63%	47%	19%	27%	19%	20%	0%	7%
Traffic Signals	38%	20%	6%	53%	38%	7%	19%	20%
Stop Signs	12%	27%	24%	53%	59%	7%	6%	13%
Yield Signs	31%	43%	38%	36%	25%	14%	6%	7%
Pedestrian Cross Walks	67%	60%	33%	27%	0%	7%	0%	7%
Sidewalks	87%	60%	13%	20%	0%	13%	0%	7%

Widening Roads/Adding Shoulders	12%	53%	18%	20%	47%	20%	24%	7%
Roadside Trash/ Litter Collection	50%	47%	13%	13%	13%	33%	25%	7%

Finally, respondents at both the county and city level felt that the fracking boom was just beginning in their area. At the county level, 72 percent of respondents reported that the boom would continue 10 or more years (Table 7). City level respondents perceived an even longer boom period with 87 percent of respondents reporting that the boom would continue for 10 or more years. In addition, 81 percent of both county and city respondents perceived either a moderate or great increase in economic development associated with the fracking boom.

These responses are particularly interesting as prices have plummeted since the survey was administered leaving doubt about the future extent of fracking in the Eagle Ford region (Saefong, 2015). It is possible that this survey was conducted at the peak of the boom cycle. Perceptions on the overall impact of fracking in the region may change if the boom cycle dissipates and local communities are left with a network of poorly maintained roads and significantly diminished economic resources to address the transportation problems.

Table 7. *Perceived Length of Fracking Boom County/City*

How Long Do You Expect the Fracking Boom to Last:	**Percentage of Respondents County**	**Percentage of Respondents City**
1-5 years	11%	7%
5-10 years	17%	7%
10-15 years	33%	20%
15-20 years	28%	40%
More than 20 years	11%	27%
Total	**100%**	

6.0 Discussion And Conclusion

The analyses of crash and survey data create a portrait of the initial transportation stresses associated with the fracking boom in the Eagle Ford Shale play. While respondents broadly remained positive about the long-term economic development impacts, transportation issues were perceived as a significant and costly expenditure for county and city communities.

While transportation associated problems were reported to be impacting both city and country respondents, respondents at both levels also perceived increased economic development associated with a long-term boom. Fluctuations in oil pricing, changes in technology, and other unforeseen issues have in the past resulted in a boom and bust cycle for oil and gas development (Christopherson and Rightor, 2012). This boom and bust cycle makes transportation infrastructure planning an especially difficult issue, as long time horizons are needed for project scoping and construction. In addition, by the time projects are completed, transportation demand may have shifted to other areas. Recent price fluctuations make it possible that the survey was conducted at the top of the boom cycle. If the current downturn in prices persists, future research may find significantly more pessimistic perceptions of the overall impact of fracking on the region.

Analysis of the transportation impacts of Eagle Ford Shale play suggest the need for a more robust state presence in coordinating transportation needs for impacted rural communities. While the state has dedicated additional transportation resources through the County Energy Transportation Reinvestment Zones and through a recently passed change in the use of Economic Stabilization Funds, county and city respondents still perceived a gap between available funds and need. If roadway quality, congestion, and road crashes are not effectively addressed, the perceived impact of the fracking boom may change for local and county respondents. This is particularly important if the boom cycle has peaked.

From a state policy perspective, the state of Texas has relied almost exclusively on the use of additional resources through the County Energy Transportation Reinvestment Zone and Economic Stabilization funds as a way to address shale development transportation issues. This singular reliance on additional funding runs counter to successful approaches in other shale development impacted states that have used a more diverse suite of policies including the use of bonding and maintenance agreements. Boske et al.'s work (2013) shows that these type of agreements can be successful for managing transportation stresses. In addition, the management agreement approach also links the use of the resource (in this case, the oil and gas company's use of roadways) to payment for the incurred cost to the county or state. This type of approach has not been successful in Texas where oil and gas companies have significant political clout, and have successfully socialized the cost of transportation.

From a local policy perspective, future research should seek to better understand how local communities might effectively work within differing regulatory and political climates to establish local management agreements. Given the historic tendency for boom and bust cycles in energy resource development, future research should also seek to track local perceptions of transportation impact over a longer time horizon to provide a more comprehensive depiction of the long-term impacts on local communities.

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