BARNETT SHALE MUNICIPAL OIL AND GAS ORDINANCE DYNAMICS: A SPATIAL PERSPECTIVE

An Undergraduate Research Scholar Thesis

by

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ABSTRACT

Barnett Shale Municipal Oil and Gas Ordinance Dynamics: A Spatial Perspective. (May 2014)

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Previously unattainable shale gas deposits have become accessible since the late 1990s using a technique called hydraulic fracturing — the injection of chemicals, water, and sand into subsurface shale to free extractable gas. This practice, along with the recent optimization of horizontal drilling, has substantially increased United States oil and gas production. Hydrocarbon firms perfected and use hydraulic fracturing on the Barnett Shale in North Texas; due to the nature of the formation, gas companies have installed wells in urbanized areas. Hydraulic fracturing generates employment and royalties for many Texas communities and mineral estate holders, but perceived health, safety, and environmental risks have prompted municipal policymakers to enact ordinances that regulate shale gas pad sites in urban areas. This thesis analyzes several facets of this series of policies: 1) the setback distance between residences and gas well pad sites and 2) the similarities in municipal ordinance texts. These objectives were carried out through the qualitative coding and analysis of 79 Barnett Shale municipal ordinances; these codes were then investigated using a GIS software package and Excel to search for spatial

trends. Additionally, from October 2013 to February 2014, the investigator traveled to several North Texas municipalities and interviewed key-actors who have proposed and enacted such ordinances. Finally, a case study of the Dallas intra-municipality debate regarding the wording and context of their oil and gas ordinance has been used to show how municipalities conceptualize their own regulations. While limited spatial correlations were found, this thesis determined that policymakers selectively create and copy ordinance text that best conforms to a preexisting bureaucratic and political culture.

ACKNOWLEDGEMENTS

I would like to extend a special thanks to my advisor, Dr. Christian Brannstrom. It is impossible for me to fully express my gratitude for allowing me to join his research project and for his constant guidance as I bombarded him with questions throughout the development of this thesis. I would also like to thank the co-primary investigator of the National Science Foundation (NSF) grant, Dr. Matthew Fry. His insight into oil and gas policy on the Barnett Shale has been essential in the development of this thesis. I owe a special debt of gratitude to my fellow researchers working on the NSF project: Sarah Gossett, Martin Acouin, Mackenzie Evans, and Victoria Knaupp. A special mention goes to Sarah, who has been the most pleasant of officemates and a trusted coworker as we have delved into the mystery of Texas oil and gas ordinance dynamics. Also, I would like to take this opportunity to thank Sasha Broadstone, Emily Vandewalle, Heather Lee, and other members of the Texas A&M Geography Department whose expertise of ATLAS.ti aided in our search for oil and gas ordinance commonalities. This project would be incomplete without the assistance of the many anonymous interviewees who have helped the NSF research team understand the eccentricities of ordinance dynamics and municipal politics. Finally, I would be remiss if I did not mention how much I appreciate the kind support and encouragement of my parents in this project and my other (sometimes outlandish) academic ambitions.

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NOMENCLATURE

CAS	Chemical Abstract Service
CPC	Dallas City Plan Commission
EPA	United States Environmental Protection Agency
Fracking	Hydraulic Fracturing
FWCanDO	Fort Worth Citizens Against Neighborhood Drilling Ordinance
GIS	Geographic Information Systems
Mcf	Thousand Cubic Feet
NCTCA	North Central Texas Communities Alliance
NSF	National Science Foundation
RRC	Texas Railroad Commission
SUP	Special Use Permit
TCEQ	Texas Commission on Environmental Quality
ZOAC	Dallas Zoning Ordinance Advisory Committee
ZOC	Dallas Zoning Ordinance Committee

CHAPTER I

INTRODUCTION

Recent advances in shale gas extraction techniques have led to a boom in the production of domestic natural gas. These novel drilling practices have allowed access to shale gas deposits that were once inaccessible. Occasionally, these gas plays are found in semi-urban or urban settings, which places petrochemical extrication activities adjacent to residences and businesses. The spatial proximity of gas exploration to urban lifestyles has created dilemmas for municipal governments, which have assumed the responsibility for regulating oil and gas extraction through ordinances. These ordinances may address the hours in which work will be carried out on a shale gas pad site, the types and quantities of emissions allowed, the frequency of inspections by city officials, the issuance of permits that are needed to commence drilling, and other similar procedures.

Despite the fact many municipalities in oil and gas production basins have adopted such policies, there is very little scholarly research regarding the motivation and content of these regulations. Therefore, this thesis sets out to explain the transmission of oil and gas policy knowledge between municipalities and the spatial distribution of the regulated setback distances between residences and wellheads. To address these research goals, this study has adopted two investigative approaches: 1) analysis of 79 municipal gas exploration ordinances in the Barnett Shale in North Texas and 2) a comprehensive case study examination of the manner by which Dallas, Texas, policymakers crafted their gas regulations. It is believed that the debates

surrounding the Dallas ordinance can serve as an example of how deliberations took place in the other 78 municipalities that are part of this study.

CHAPTER II

BACKGROUND

Barnett Shale context

In 1981, after petrochemical firms had exhausted deeper, yet more accessible, oil and natural gas deposits, Mitchell Energy Corporation drilled a test well near Newark in North Texas to pursue the Greater Newark East natural gas field a small section of the larger Barnett Shale. The geologic nature of the formation — predominately shale — determined that returns were meager until Mitchell Energy developed a site-specific hydraulic fracturing (conventionally called "fracking") fluid in 1998, spiking the number of wells by nearly 400% between 1997 and 2002 (Martineau 2007). Fracking involves the forced injection of patented slurries of sand, water, and chemicals into well boreholes to extricate and harness petrochemicals from subsurface geologic formations. As this solution is introduced into the shale, the surrounding rock is perforated, and the shale gas seeps from the rock to the well for collection (Figure 1). While the technique was first perfected in North Texas, the "fracking revolution" has since spread to other major shale deposits in Texas, North Dakota, Pennsylvania, and Europe (Wright 2012).

While this new form of fracking was essential to developing the Barnett Shale, when Devon Energy (the firm that purchased Mitchel Energy) established a new method of tapping the play through horizontal drilling, the number of wells jumped from 2,616 in 2003 to over 6,000 in 2006 (Martineau 2007). Horizontal drilling allows a producer to develop multiple wells from the same pad site parallel to the surface, obtaining returns from shale gas deposits laterally displaced

thousands of feet away from the wellhead in multiple directions (Figure 1). Firms established wells in vacant parcels of land and sequestered petrochemical deposits from beneath nearby residences, businesses, lakes, or other surface features. Some pad sites in North Texas have upwards of 20 individual horizontal wells emanating from an single pad site, thereby increasing production efficiency and reducing the number of environmentally damaging pad sites (City of Dallas 2013).

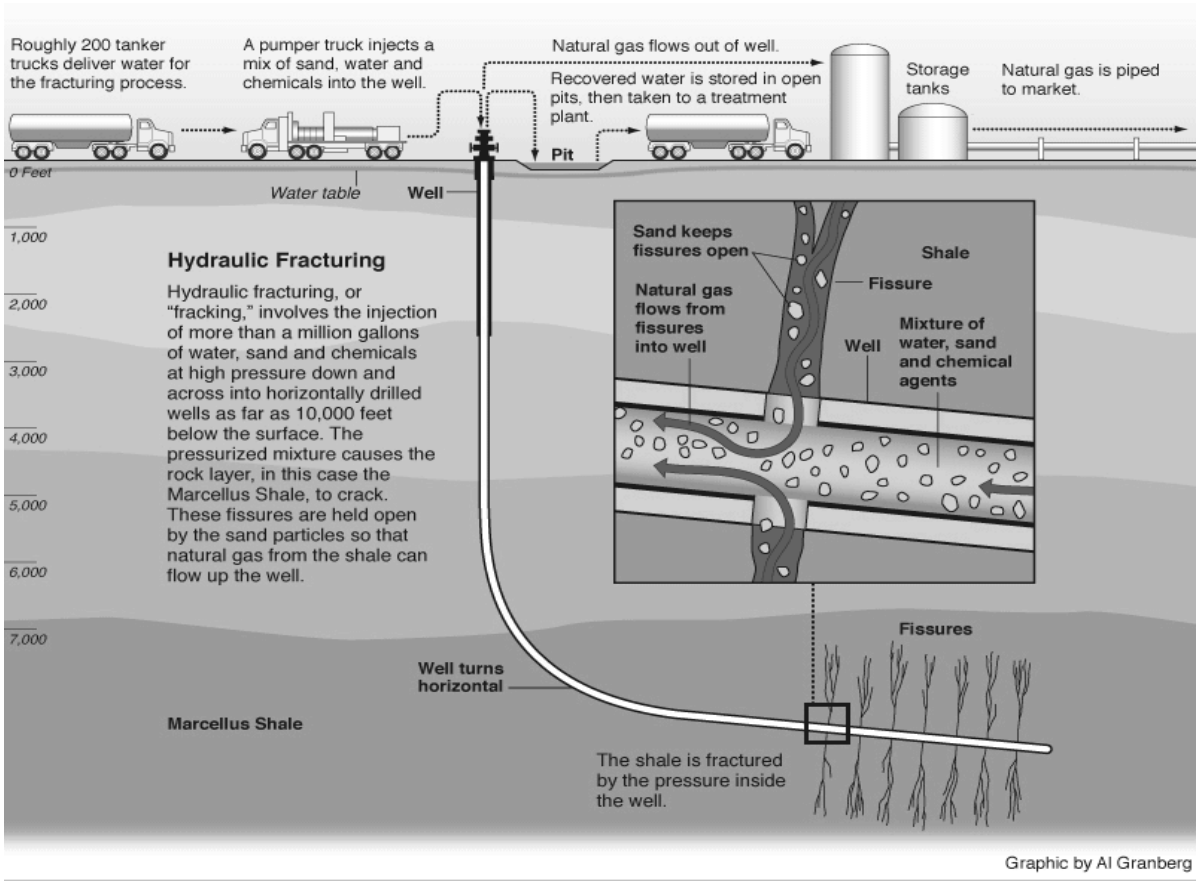

Figure 1: A ProPublica graphic that explains the intricacies of shale gas extraction in the Marcellus Shale in Pennsylvania. The production methods used on the Marcellus Shale are similar, if not identical, to those on the Barnett Shale (Granberg 2014).

After analysis by geologists, it is believed that extractable quantities of shale gas in the Barnett Shale can be found under at least 25 Texas counties (Railroad Commission of Texas 2013), above which approximately three million people live in cities such as Fort Worth, Denton, and Dallas. The eastern edge of the Barnett Shale ends abruptly at a subsurface geologic feature called the Ouachita Thrust-Front, which runs from northeast of Dallas to the southwest toward the Texas Hill Country. The northern edge is characterized by a similar geologic formation called the Muenster Arch, which runs from northeast Dallas to the Texas-Oklahoma border (Figure 2). At the deepest portion of the Barnett (approximately 6,000 to 12,000 feet), gas deposits are thickest along these two structures. Therefore, these drilling locations are highly desired (Pollastro et al. 2007).

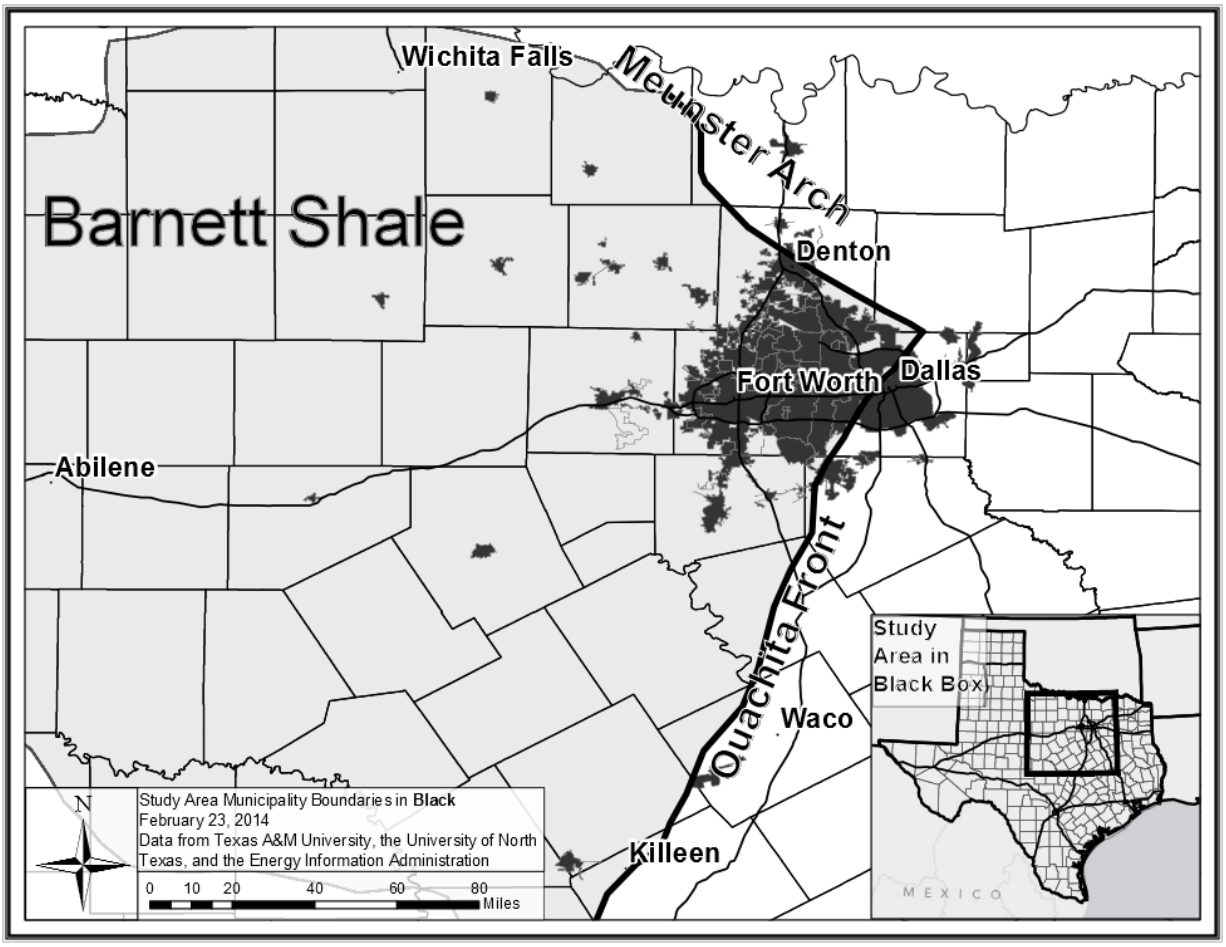

Figure 2: An overview map of the study area. The Barnett is in light grey, while the municipalities that will be considered in this study are in black (n = 79).

The Barnett has 32.6 trillion cubic feet of proven natural gas reserves — approximately 25% of the known shale gas reserves found in the United States (U.S. Energy Information Administration 2013). As of July 2013, over 17,000 wells tapped into the Barnet Shale, from which 5,000 million cubic feet of gas was extracted daily, making this play the largest onshore gas deposit in the United States. Although the number of new drilling applications has decreased significantly since its peak in 2008, it is believed that firms will continue to exploit the Barnett

Shale (Railroad Commission of Texas 2013) — especially as the demand (and, consequentially, the price) increases for domestically produced natural gas.

Shale gas impacts

The development of the Barnett Shale has fueled an unprecedented economic revitalization of some North Texas towns. A 2008 study showed that the Barnett had generated over $11 billion for the Dallas-Fort Worth Metroplex, while simultaneously creating over 100,000 jobs. Between 2000 and 2006, Denton County, a Barnett Shale county with one of the highest concentrations of gas wells in the region, had a population increase of more than 5.5% and a 2.5% jump in median household income, which regional policymakers attribute to the shale gas exploitation in the region (Kinnaman 2011). Property owners who control both surface and mineral rights are also in a lucrative position to benefit substantially from natural gas pad site leases with some contracts valued at tens of thousands of dollars per acre along with monthly royalties from the production site. Municipal entities, such as schools, airports, and undeveloped city property, have also benefited by exercising their mineral rights. These monies are typically reinvested in that particular municipal service to increase the quality and reduce taxpayer burdens. For example, gas drilling at Dallas-Fort Worth International Airport allowed the airport management to reduce landing fees, thus attracting new airlines (City of Dallas 2013). Moreover, cities can directly gain through the collection of taxes and fees imposed on the energy exploration firms. Finally, petrochemical companies producing shale gas in the region have made a commitment to donating millions of dollars to local non-profits and community development projects (Theodori 2012), which has been used to improve the quality-of-life in the region. All of these cash flows,

of course, have economic multiplier effects, as that money is recycled throughout the community, bolstering all areas of the local economy.

This prosperity has generated challenges. One of the major criticisms of shale gas wells is the environmental impact, not the least of which is watershed and aquifer degradation due to the usage of fracking fluids (Mantell 2011) that contain known carcinogens including benzene, toluene, and formaldehyde (Rahm 2011). The complete composition of fracking fluid is protected through patents; indeed, of the 944 suspected chemical products used in shale gas fracking operations, only 353 can be identified through Chemical Abstract Service (CAS) numbers, and of those classifiable compounds, more than half can cause severe brain and nervous system damage (Colborn et al. 2011). Depending on the site, situation, and underlying geologic formation of the well, only between 10% and 60% of the fracking fluid is recovered; the remainder is either dispersed into the environment or lost during the drilling process (EPA 2011).

A secondary concern is air pollution in proximity to well sites. Many cities have introduced stringent air quality controls. Of the 353 known chemical compounds in drilling fluids, 126 — the vast majority of which are toxic — can become airborne. Air pollution is exacerbated in and around pad sites by the roughly 1,000 trucks that are needed to service the well and through the practice of open-air evaporation pits for the storage of spent fracking fluid (Colborn et al. 2011; Wright 2012). Moreover, citizens who live in proximity to shale gas wells are fearful of potential

accidents and explosions at the pad sites. Particular anxiety is also directed at the higher number of vehicular accidents resulting from the surge of tractor-trailers on local roads (Wynveen 2011).

Residents near gas drilling must also contend with loud noises — many times exceeding 85 decibels (or the equivalent of a food blender) during fracking operations — and nighttime light pollution. Frequent, sometimes violent flares can also disquiet nearby residents, who can confuse the blazes for pad site explosions. There are also aesthetic concerns, as each well requires five to eight acres of cleared land (Penn State Public Broadcasting 2011), which could have a detrimental effect on nearby property values (Boxall, Chan, and McMillan 2005) and a lasting ecological imprint on the landscape, disrupting vegetation growth and animal habitats. Occasional accidents or spills may result in toxic fluids being released into the environment, thereby causing a health and safety hazard to nearby residents and fauna. Finally, small magnitude earthquakes near some of the drill sites have residents concerned that drilling — or more precisely, the injection of spent fracking fluids deep underground — is jeopardizing the underlying geologic stability of the Barnett Shale (Malewitz 2014a).

Municipal responses to impacts

In an effort to allay these and other potential dangers confronted by residences, municipal policymakers have crafted ordinances that regulate shale gas well sites. Although gas drilling is monitored and, to a lesser extent, governed by the Texas Railroad Commission (RRC), the Texas Commission on Environmental Quality (TCEQ), and the Environmental Protection Agency (EPA), municipalities assume the role of regulator for petrochemical exploration which is carried

out within the city limits (and occasionally the extra-territorial jurisdictions). Municipalities generally institute these ordinances when drilling is ongoing or is perceived to be likely to occur within the city boundaries.

The statutes that are most relevant to this research pertain to gas ordinance setback distances, which regulate the minimum distance that wells can be positioned from a residence, business, or other habitable structures. Extra-municipal regulations on setback distance are few. The Army Corps of Engineers prohibits shale gas drilling within 3,000 feet of a Corps constructed dam and other critical structures without explicit permission (City of Flower Mound 2011). As dictated by the 1987 Texas Legislature, a municipality of any size cannot issue a lease for a gas well "in a section of street, alley, or public square… in the thickly settled part of a municipality, or within 200 feet of a private residence." However, many municipalities have decided to increase this minimum setback distance because of the perceived harm and potential impacts of shale gas pad sites on nearby communities (Riley 2007). Although a city may have some ability to regulate surface activities, the RRC has authority with regard to the subsurface and the TCEQ and EPA monitor air quality (Fry 2013).

Unlike other industries and infrastructure, such as solid waste incinerators (Tavares, Zsigraiová, and Semiao 2011) or waste water treatment plants (Stellacci et al. 2010) that have a strong scientific literature base to support a particular setback distance, there is a dearth of comparable studies for shale gas pad sites. Municipalities have chosen a wide range of setback distances as explained by Fry's (2013) study of Denton County. Municipal oil and gas regulations tend to go

through a lengthy vetting period, in which numerous proposals and counter-proposals are deliberated before agreeing on the text of an ordinance and an associated setback distance. However, if policymakers enact regulations that are perceived to exceed the protection of citizen health and safety, a petrochemical firm may file suit against the city on the grounds of regulatory takings — a legal expression referring to regulations that diminish the full economic viability of a property (Fry 2013).

The nature of this investigation

There are only a handful of studies related to oil and gas policy in the Barnett Shale. Anderson and Theodori (2009) interviewed community leaders concerning their opinions of shale gas extraction in Wise and Johnson counties —both of which are in the Barnett Shale — while multiple 2007 studies sought to examine public perceptions in the same study area (Theodori 2012; Wynveen 2011). These analyses found that the citizenry and policymakers were, at first, relatively supportive of shale gas exploration in their communities, but despite the positive economic gains, that enthusiasm had since waned as the negative impacts, such as threats to public health, the environment, and quality of life, have become more apparent. More recently, a study has found that approximately 28% of 1,000 Dallas-Fort Worth area residents believe that hydraulic fracturing was the most salient hazard to North Texas water supplies (Fry et al. 2012).

Rarely has the scientific community engaged with the topic of setback distances between non-renewable energy industry equipment and residences. Branch (1972) briefly explained the city planner's approach to managing oil extrication in an urban environment and whether the setback

distance implemented in Los Angeles was appropriate given the impacts to the city (e.g. such as noise, light, ecological disturbance, and traffic). Fry (2013) examined spatial variability among setbacks in Denton County, Texas, but did not incorporate policymaker perceptions of those distances or an analysis of the text of the ordinances. This study will incorporate and expand upon Fry's findings, while outlining municipality-defined setback policy evolution.

The overall objective of this study is to explain the motives behind Texas municipal leaders who enact ordinances that alter the state-determined minimum distance between shale gas wells and habitable structures. It is hypothesized that municipal actors are at work copying and translating text and setback distances between municipalities; this thesis will test whether that stimulus is spatial in origin (e.g. spatial diffusion). In addition to the investigation of policy transfer in North Texas, this thesis will examine Dallas, Texas, as a case study for how oil and gas policies originate. From the text analysis and the case study, this investigation will suggest the process of policy transmission between municipalities. It is hoped that this study will help clarify the main mode of policy transmission while giving some context as to how oil and gas ordinances come into being.

CHAPTER III

METHODS

The research for this thesis is being conducted as part of a collaborative NSF grant between the Texas A&M University and University of North Texas Geography Departments; therefore, many of methods supported by the NSF research are being incorporated into the framework of this investigation. The methodology of this research can be broadly divided into qualitative and quantitative categories.

From the qualitative perspective, which can be found in both the case study and the larger regional investigation, the research focused mainly on examining oil and gas ordinances. This was carried out through the study of city documentation of the ordinance creation process and examinations of city council minutes and agendas for the Dallas case study. For some of the larger municipalities, such as Fort Worth and Dallas, the researcher had access to video and audio recordings of city council sessions. Based on these recordings, I made extensive notes and transcribed portions of council and committee meetings to better understand the regulation creation process. During the ordinance formation period, several municipalities created task forces and advisory boards to gain input from citizens, outside experts, and industry leaders. Materials from those committees are usually publically available. Auxiliary data was attained through interviews of key policymakers who crafted oil and gas ordinances. These interviews were scheduled, organized, and transcribed by the student researchers employed by the NSF grant with the intent of gaining a better understanding of the inter and intra municipality

dynamics exercised in the formation of the ordinance and setback distance (Appendix A). Although much of the interview data was not incorporated into this thesis, the insights shared helped put the current study's findings into perspective. Many times, the interviewees would voluntarily give the researchers relevant study materials, such as PowerPoint presentations and conclusions from their own research to complement their verbal answers. Finally, due to the potential region-wide impacts of the policies implemented, media coverage of some of the ordinances and their implementation was extensive. Consequently, I was able to tap into these broadcast resources to gain a better understanding of the municipal dynamics and the public reaction. Many of these resources were downloaded, thoroughly examined, and incorporated into this thesis to give context to the ordinances.

Regarding the quantitative methodology, the vast majority of this analysis was done with respect to the ordinances. The oil and gas ordinances of every municipality in the Barnett Shale (79 ordinances in total) were obtained through city government websites, public information acts, and interviewees. Any municipality that lacked a setback distance or an easily accessible year of implementation were discarded from the study, thus four municipalities were removed. All the valid municipal ordinances were then imported into ATLAS.ti, whereby each portion of the regulation was analyzed against the text of other Barnett Shale municipalities through a coding scheme (Appendix B). The ordinances were scrutinized through 40 codes, which characterized the way the municipality introduced the ordinance (i.e. purpose statements), regulated the setback distance, variance procedure, emissions guidelines, and noise protocols. These comparisons were then exported to Excel where both visual and quantitative analyses could be

performed. Finally, those data values were cartographically represented in a geographic information system (GIS) to uncover spatial relations.

CHAPTER IV

RESULTS

Ordinance text analysis

Examination of Barnett Shale municipal oil and gas ordinances through qualitative coding and analysis revealed that verbatim transfer of text best demonstrates the inter-ordinance relationship. For example, of the 79 municipal oil and gas ordinances in this study, 38 had identical purpose statements — the declaration that explains the intent of the ordinance (Table 1). Interestingly, these identical purpose statements are clustered in the western half of the Metroplex but exclude Denton and Dallas (Figure 3). While Table 1 describes the possible origins of the components of a purpose statement based on the current municipal ordinance and the date of implementation, my analysis does not take into account whether the regulations have been updated since the initial enactment. Additionally, I determined there were eight ways in which an ordinance described the residential setback distance; 37 ordinances could be classified into one of those eight clusters. Another 18 had text that was similar — language that was clearly based on the text of the cluster phrases — to at least one of the clusters. With regard to the method by which a municipality measured the setback distance, 35 had the same text, while another 14 had similar semantic structure yet presented their measurement techniques somewhat differently.

Table 1: Commonalities in the purpose statement across municipal ordinances

Portion of Purpose Statement	Number of Municipalities with Identical Wording for Specified Clause	Possible Local Origin of Wording
Entire Purpose Statement	38	Justin
Reference to Health and Welfare	55	Lakeside City
Reference to Property Owner Safety	42	Justin
Reference to Environment	49	Lakeside City

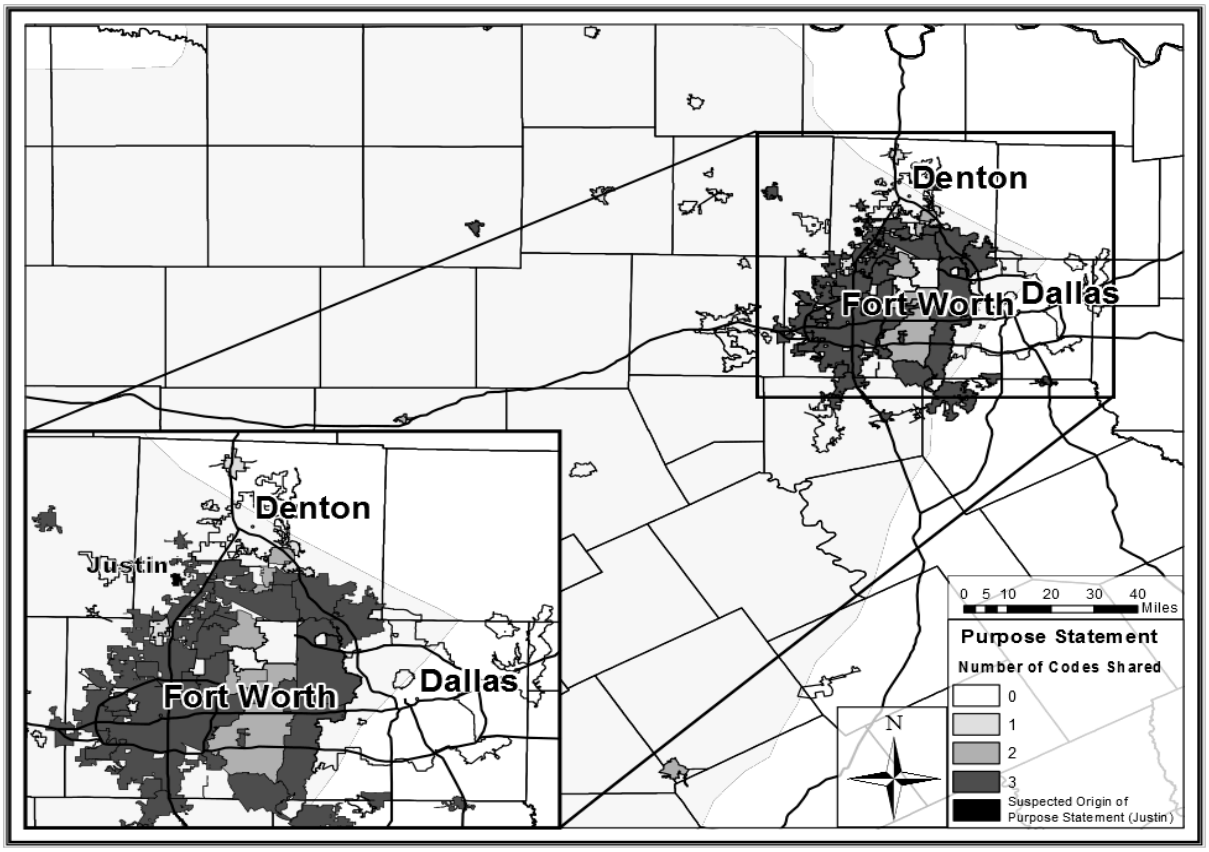

Figure 3: Purpose statement codes shared (out of 3) in each municipality

Many municipalities have clauses in their ordinances that regulate the noise levels permitted from pad sites. These noise regulations can range from specific requirements while drilling in residential neighborhoods to encouraging the operator to use noise reduction technologies, such as mufflers and electric engines. Table 2 indicates some of the common noise statutes found in oil and gas ordinances and the number of municipalities on the Barnett that shared verbatim language in those ordinances. It is believed that many of these clauses were replicated from Fort Worth's ordinance based on the date of ordinance adoption and the current text of the ordinance. Indeed, there is a concentration of municipalities near Fort Worth that share many of the same regulations (Figure 4). Similarly, many cities opt to regulate emissions originating from oil and gas pad sites due to the perceived health risks. These regulations come in many forms, not the least of which is frequent air quality testing, requiring operators to submit emissions management plans, or regulating the types of emissions that can be released from a well site. Table 3 shows some of the larger clusters of municipalities that had the same wording in their ordinances with regard to emissions. Again there is apparent clustering near Fort Worth where municipalities share the same emissions regulations (Figure 5). This is not to state that other municipalities did not have emissions regulations; rather, their statutes were unique from the main cluster.

Table 2: Commonalities found in municipal ordinance noise regulations

Portion of Sound Regulation Ordinance	Largest Cluster of Municipalities with the Same Text in the Ordinance	Possible Local Origin of Wording
The Method of Measuring Noise on the Pad Site	18	Fort Worth
The Repercussions for Exceeding the Prescribed Noise Limits	14	Justin
The Regulation of Particular Acoustic Frequencies	13	Fort Worth
Responsibility for Managing the Noise on the Pad Site	11	Haslet
The Requirement of a Noise Management Study Prior to Drilling	7	Fort Worth

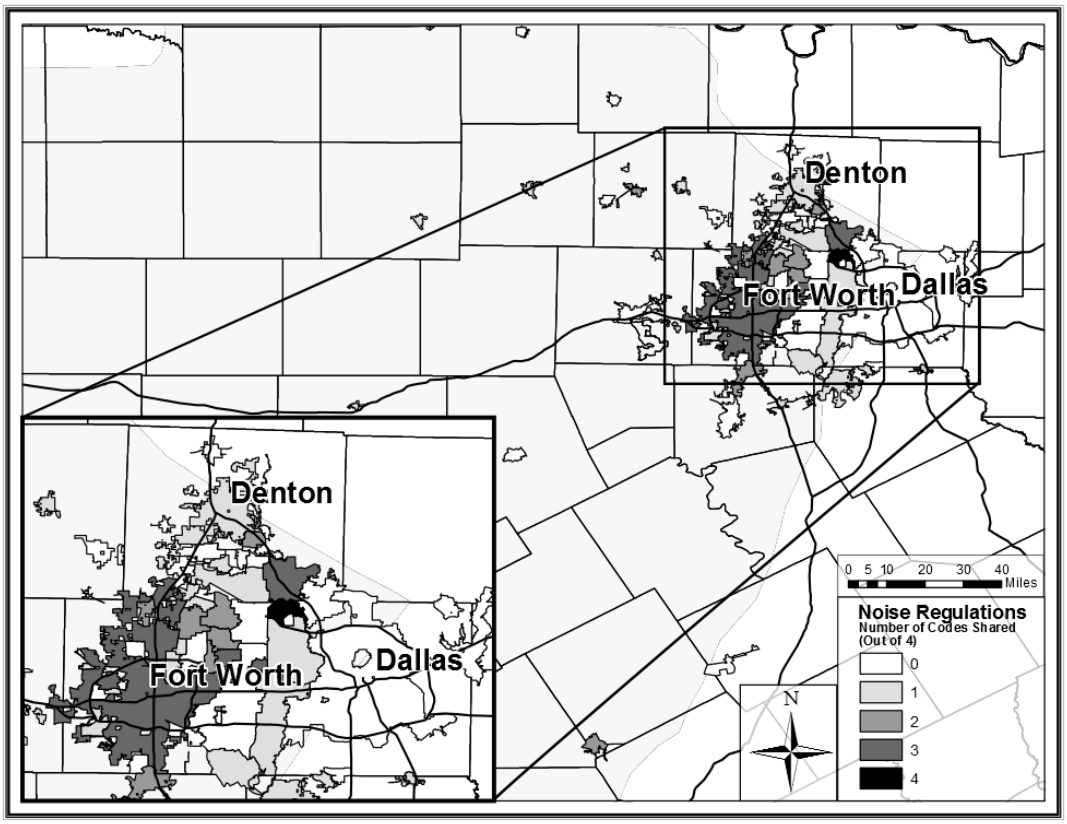

Figure 4: Noise regulation codes shared (out of 4) in each municipality

Table 3: Commonalities found in municipal ordinance emissions regulations

Portion of Emissions Regulations	Largest Cluster of Municipalities with Verbatim Text in the Ordinance	Possible Local Origin of Wording
Ambiguous Emissions Requirements	17	Hickory Creek
Maintenance of Equipment on Pad Site	12	Haslet

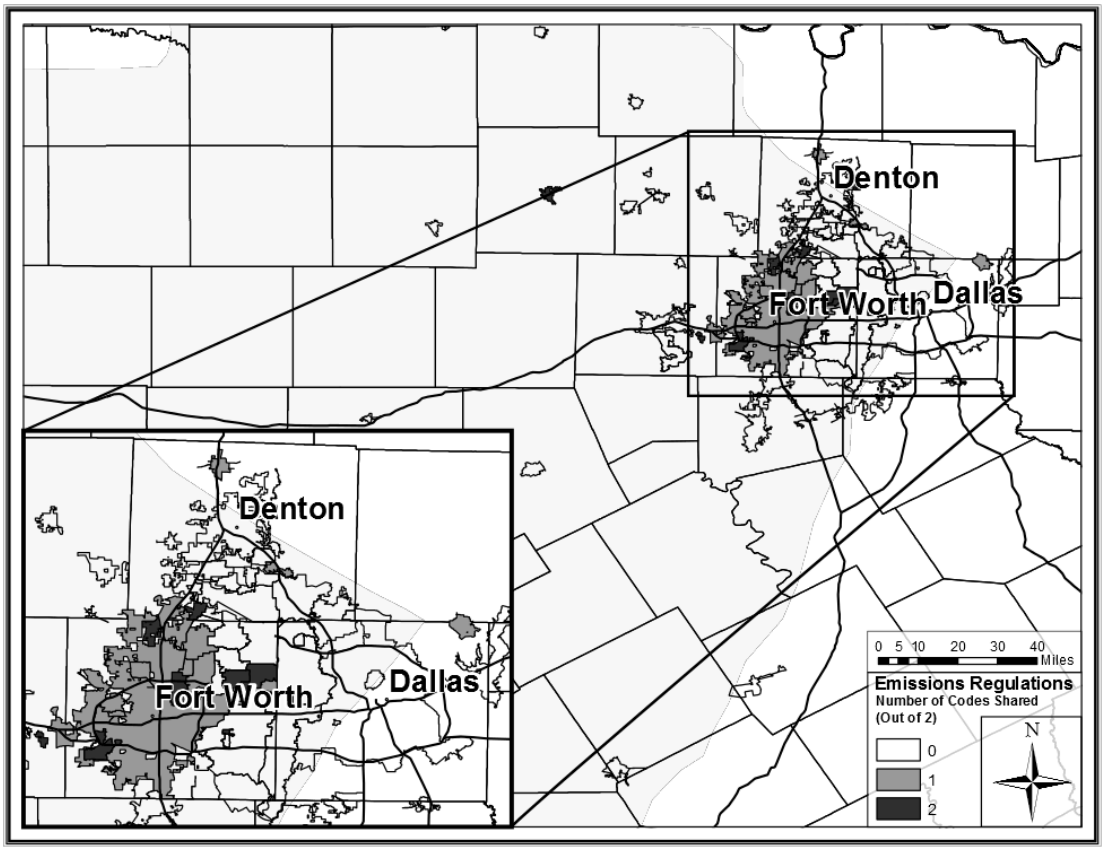

Figure 5: Emissions regulations codes shared (out of 2) in each municipality

Municipal Commonalities

A deeper analysis of the commonalities between ordinances reveals the municipalities whose regulations show concurrent patterns of variability. There was no instance in which one city's ordinance completely mirrored that of another municipality, but in several cases, many phrases were shared between ordinances. Typically, these municipalities would have the same purpose statement with several other regulatory clauses, such as noise, emission, and setback distance (Table 4, Figure 6). Below is an example purpose statement from the Fort Worth oil and gas ordinance whose identical phrasing can be found in 37 other Barnett Shale municipal ordinances (Table 1, Figure 3):

> The exploration, development and production of gas in the City are activities which necessitate reasonable regulation to ensure that all Property Owners, mineral and otherwise, have the right to peaceably enjoy their property and its benefits and revenues. It is hereby declared to be the purpose of this Ordinance to establish reasonable and uniform limitations, safeguards and regulations for present and future operations related to the exploring, drilling, developing, producing, transporting and storing of gas and other substances produced in association with gas within the City to protect the health and general welfare of the public; minimize the potential impact to property and mineral rights owners, protect the quality of the environment and encourage the orderly production of available mineral resources. (City of Fort Worth Code of Ordinances 2009)

Table 4: Clusters that shared a high number of codes in their oil and gas ordinances

Municipal Cluster	Number of Codes (phrases) Shared Between the Municipalities
Fort Worth, Burleson	9
Aledo, Haltom City, Jacksboro	7
Decatur, Irving	7
Benbrook, Joshua, Keller	6
Pantego, Hurst	5
Pantego, Bedford	4

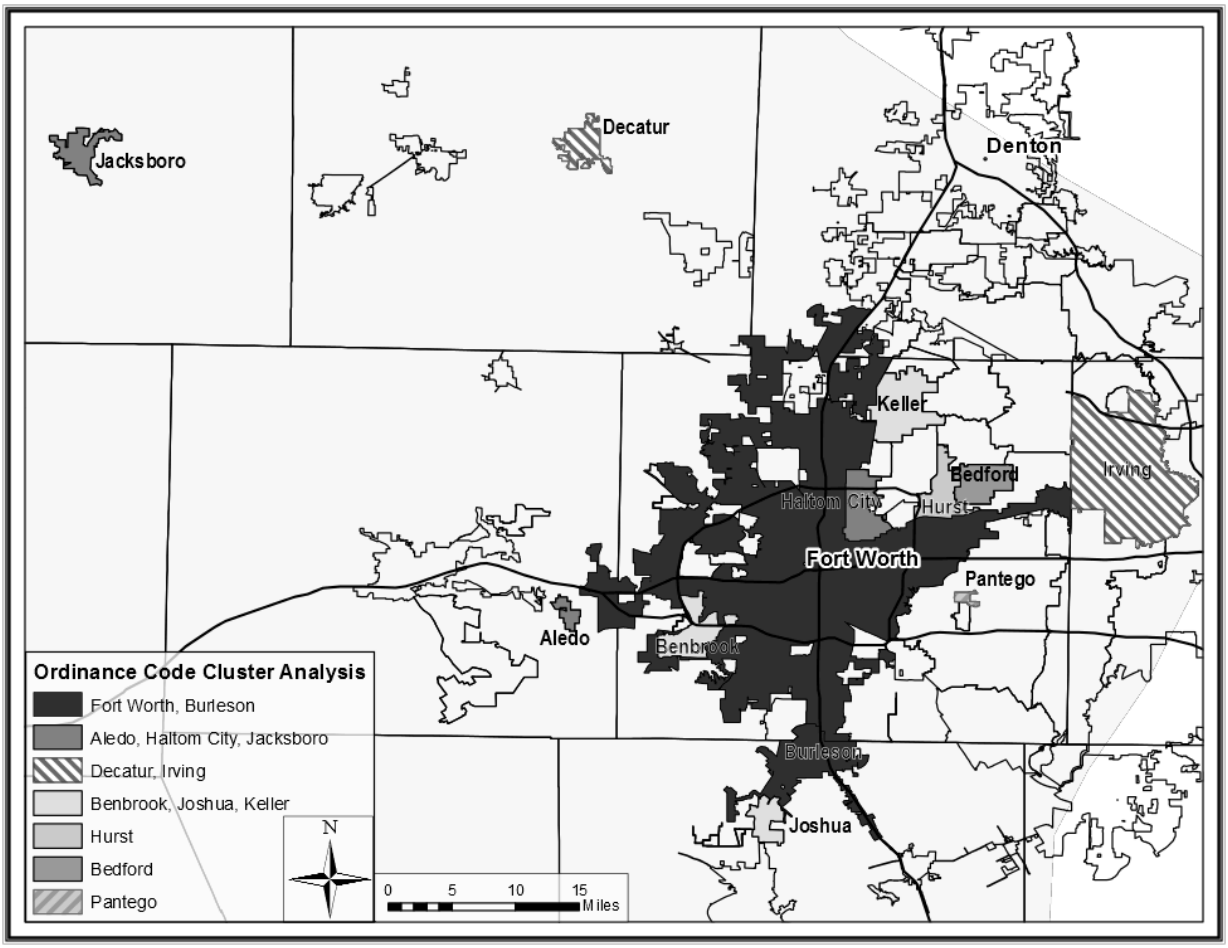

Figure 6: The spatial distribution of cluster cities in Table 4

City of Dallas case study

Of all the cities analyzed in this study, Dallas is the largest municipality with a 2013 estimated population of over one million and a land area of approximately 340 square miles stretching across five counties (U.S. Census Bureau 2014). The city was established in the mid 1840s as a trading post due to the readily availability timber in east Texas, the cattle ranches to the west, Native Americans with whom to do business, and the strategic confluence of several branches of the Trinity River (Holmes 1992, 40-42). However, this distinction as a small trading post was quickly erased when one of the world's largest oil fields was struck by "Dad" Joiner 100 miles to the east of Dallas in 1930 (Graff 2008, 289). The very lucrative oil field spurred many petrochemical companies to locate headquarters and technical bases in the city, and by 1939 approximately 280 oil and gas firms had established themselves in Dallas (Holmes 1992, 128). As the oil boom slowly gave way to other businesses, such as transportation, electronics, and basic manufacturing, many believed that Dallas's characterization as an oil industry town would live on only through popular media (Graff 273, 68, 273). However, as discussed earlier, the underlying geology and advances in gas extraction techniques disproved this.

Leading into the early 1990s and the start of the Barnett Shale boom, many oil and gas experts were convinced that mineral deposits were absent under Dallas; however, further geologic studies and a few test wells demonstrated that this was not the case. Indeed, the highest concentrations of dry gas (a type of shale gas with few impurities) in the Barnett Shale can be found along the Ouachita Fault, which runs through central Dallas, making the reserves under the city some of the most profitable in the region (Figure 2). The depth of the field in and around the

city of Dallas (between 6,000 and 12,000 feet), however, makes harvesting these minerals difficult. As a result, most gas extraction takes place west of Dallas with the vast majority of the activity occurring around Fort Worth and to the west of Denton where deposits are much closer to the surface (Pollastro et al. 2007).

2007 Ordinance

As the fracking boom progressed in the Barnett Shale, oil and gas companies expanded eastward toward the Dallas city limits. By 2007, a series of events spurred the Dallas City Council to approve an oil and gas ordinance that promoted and regulated drilling within the city. First, at the height of the commodities boom in 2007, the price of natural gas had skyrocketed from $2 in 2000 to over $7 per thousand cubic feet (Mcf), making the profitability of a comparatively deep well more likely for petrochemical companies. Second, this time period also coincided with firms exploring riskier plays in the hopes of finding profitable deposits. Third, the Dallas-Fort Worth International Airport, which is jointly owned by the cities of Fort Worth and Dallas, had entered into negotiations with geologic exploration companies to take advantage of the mineral deposits beneath the airport. The result of these discussions was a $181 million contract with Chesapeake Energy in 2006, which allowed for multiple drilling rigs on the property and a 25% royalty payment for revenues generated from the wells. As part of this contract, the city of Dallas was privy to a small portion of this sum (approximately $1 million), but the vast majority of the profits remained within the airport budget (City of Dallas 2014c). At that point, the Dallas municipal government was starting to realize the possible financial gain from production wells within the city. Finally, due to some foreseen financial turmoil, the city manager and council

charged municipal staff with aggressively finding and developing new sources of revenue for the 2007-2008 fiscal year, which was projected to have a $90 million shortfall (City of Dallas 2014a).

These factors prompted the Dallas City Council to task the Economic Development and Housing Committee in mid-2006 to create an ordinance with safeguards for the public while at the same time realizing the economic potential of gas extrication. Prior to the creation of an oil and gas specific ordinance, all mineral exploration was considered through a mining ordinance that was originally passed in 1958 and had very few regulations specific to urban gas exploration. In September 2006, the Economic Development and Housing Committee returned to the city council with a preliminary investigation. In the presentation, staff suspected that natural gas prices would remain at the $7-$8 per Mcf level for several years, and that consequentially, the city could receive upwards of $2 million dollars in royalties per well drilled on city property that tapped municipal mineral holdings. Using the Argyle, Texas, oil and gas ordinance as an example, it was also in this presentation that utilizing a special use permits (SUPs) approach — authorizations that must be approved by city council prior to the sanction of a well permit — was first suggested. These permits would eventually become an integral part of the city's oil and gas ordinance. Indeed, as suggested by interviewed city official Y1A, the SUP process is reflective of the Dallas political and bureaucratic culture, which prefers case-by-case city council approval instead of automatic permit authorizations. A total of seven city-owned properties were identified in west Dallas that could host oil and gas wells and generate royalties for the city. Finally, the committee recommended that the city make changes to the mining ordinance to

allow for drilling in city parks while a proper oil and gas ordinance was drafted. This would allow for the energy companies to drill wells in the Trinity River floodplain, which is one of the few areas in west Dallas that did not have significant preexisting residential, commercial, or industrial development. Immediately following the implementation of the oil and gas ordinance, a large public relations campaign would notify petrochemical companies of Dallas's intent to exercise its mineral rights (City of Dallas 2014c).

From September 2006 to July 2007, the Economic Development Committee, the Transportation and Environment Committee, the Zoning Ordinance Advisory Committee (ZOAC), and the City Plan Commission (CPC) worked together to draft an ordinance with final authorship given to the CPC and the ZOAC. These groups met on eight occasions and consulted approximately ten other nearby cities' ordinances, not the least of which were Fort Worth, Irving, Arlington, North Richland Hills, and Southlake. As part of the proposed ordinance, an approved SUP would be required for all drilling. In addition to a 300 feet setback distance from residences — one of the shortest in the Barnett Shale and only 100 feet longer than the RRC minimum (Railroad Commission of Texas 2013) — the ordinance also required that fracking take place during daytime hours, instituted sound regulations, road repair requirements, prohibition of production water disposal wells, insurance requirements, and a 500 feet notification radius to nearby residences and businesses of an impending SUP hearing. Incorporating one of the major suggestions from the Economic Development and Housing Commission, the ordinance allowed for shale gas drilling in city parklands. The CPC and ZOAC had also consulted with industry leaders, industry regulators (evidence suggests RRC and EPA), and regional staff members from

other municipalities (City of Dallas 2014a, 2012). Furthermore, CPC and ZOAC meetings were carried out in the city council chambers, so citizens would have had the ability to witness and comment on the development of the ordinance. In fact when the CPC voted on the proposed statute, only one citizen speaker addressed the committee, and her reaction was positive to the ordinance.

During the final months of the regulation-drafting period, three SUPs were in preparation and presented to the Dallas City Council before the passage of the ordinance. These permit requests were approved on June 13, 2007. The City Attorney's Office, the Public Works and Transportation Department, the Office of Environmental Quality, the Human Resources Department, and Development Services reviewed the final ordinance text prior to the Dallas City Council voting on the proposed statute on September 12, 2007. Public input was allowed prior to the passage of the ordinance at the city council meeting in the form of a citizen speaker commenting period. Of the four individuals who commented on the proposed ordinance, two were industry representatives of ExxonMobil and Harding Company. The motion passed eleven-to-one with three councilmembers absent. On the September 26, the council approved a budget for the 2007-2008 fiscal year, which incorporated projected revenues of over $20 million from gas lease bonuses (City of Dallas 2014c). Shortly after the passage of the budget, the city staff worked to identify other possible gas leases and marketed those locations to petrochemical companies. In the fall of 2008 the city of Dallas received approximately $19 million from Trinity East Energy, a subsidiary of Fort Worth based Keystone Exploration, for two additional approved SUPs and the associated contractual bonuses (City of Dallas 2012).

The Inter-Ordinance Years (2008-2011)

It was not long after the ink had dried on the Trinity East Energy SUPs that the price of natural gas dropped from a record high of $11.32 in July of 2008 to $3.45 per Mcf a year later (U.S. Energy Information Administration 2014). With prices dropping precipitously, the petrochemical companies with interests in Dallas — specifically XTO Energy, Dale Resources, Chesapeake, and Trinity East — decided not to exercise their drilling rights. Interestingly, this led to a situation in which there were several approved SUPs but no wells within the city limits (City of Dallas 2012). Despite this pause, drilling continued immediately to the west of the city (with several leases in southwestern Dallas County having ties to the now infamous Bernie Madoff ponzi scheme [Lee Loftis 2010].)

Even though drilling had slowed across the entire Barnett Shale with decreased natural gas prices, distrust by citizens and environmental activists toward oil and gas companies was on the rise. North Texas residents were, at first, apparently, content with gas drilling; however, as the negative externalities (e.g. noise, truck traffic, emissions) arose, the mood became progressively negative (Theodori 2012). Starting around 2009, the gas industry received national scrutiny of natural gas production in the United States. Local anti-shale activist groups like the North Central Texas Communities Alliance (NCTCA), Dallas Area Residents for Responsible Drilling, Downwinders at Risk, Earthworks, Texas Campaign for the Environment, Blue Daze, and Fort Worth Citizens Against Neighborhood Drilling Ordinance (FWCanDO) began to mobilize and denounce oil and gas industry practices, while national attention was drawn to the 2010 John Fox

documentary, *Gasland.* By early 2011, the Texas Campaign for the Environment asserts to have demanded a revision of the city's 2007 oil and gas ordinance (Texas Campaign for the Environment 2013), thus sparking an interest within the Dallas city government to reexamine the regulation.

2013 Ordinance

In the spring of 2011, the Dallas City Council decided to reconsider the gas ordinance after postponing a renewal of a XTO Energy SUP (Hundley 2011; Watson 2011). On April 20, 2011, the Dallas city manager gave a presentation to a closed session of the city council. He discussed the several issues: concerns associated with shale gas drilling; the environmental studies being carried out by the city of Fort Worth, the North Texas Clean Air Steering Committee Oil and Gas Task Force, the TCEQ, and the EPA; the existing city ordinance; the status of the 5 approved and 8 pending SUPs; how to institute a temporary city-wide moratorium on drilling until the passage of an updated ordinance; and finally, the possible options for moving forward, which included form a task force, institute a new environmental study and consult experts, or keep the *status quo* (City of Dallas 2014a).

After some deliberation, the city council proceeded with the creation of a task force. Mayor Dwaine Caraway appointed eight councilmembers to select from the 67 applicants for the 11 member gas drilling task force (City of Dallas 2011). Those applicants were vetted through interviews held by the eight councilmembers, Lois Finkelman (the Dallas Gas Drilling Task Force Chair) — who was appointed by Mayor Carraway — and several members of the

executive city staff. The final task force was composed of three citizen or environmental group representatives (Ramon Alvarez, Cherelle Blazer, and John McCall Jr.), three industry agents (Bruce Bullock, David Biegler, and Patrick Shaw), three subject matter experts (Terry Welch, Margaret Keliher, and David Sterling), one Parks and Recreation Board delegate (Joan Walne), and the already mentioned supervising chairperson, Louis Finkelman (City of Dallas 2012).

Once the members of the gas drilling task force had been established, from July to October 2011, industry consultants; the TCEQ; EPA; RRC; local environmental activists; and municipal representatives from Southlake, Grand Prairie, Hurst, and Fort Worth briefed the team. They also took field trips to shale gas wells and held public hearings to obtain citizen input. After the consultation meetings, the task force entered into three months of deliberations where they continued to evaluate other municipal ordinances and consider the optimal procedures for drilling in Dallas (City of Dallas 2012).

By February 2012, the task force had nearly come to a set of recommendations. However, according to at least one witness, the last day was not marked with solidarity. Rather, at the suggestion of several of the task force members, last-minute changes were made to allow drilling in city parks, to reduce the variance distance to 500 feet, and to increase the number uses (buildings and properties that must adhere to the setback) regulated under the proposed 1,000 feet setback distance (City of Dallas 2014a). During the recommendation creation process, many aspects of the Dallas ordinance were scrutinized with particular attention given to those characteristics that would affect quality-of-life. It was in this way that the task force read through

selected oil and gas ordinances of nearby municipalities and selected clauses that would most accurately describe the desired effect in Dallas; only portions of the recommendations were in fact original to the task force (City of Dallas 2012, Table 1). After consolidating the eight months of task force work, these final recommendations were then presented to mayor and city council in May of 2012 (City of Dallas 2014a).

Table 5: The source of the oil and gas ordinance suggestions by the Dallas Gas Drilling Task Force to the city council. *Note*: "Dallas" refers to the original 2007 oil and gas ordinance. "Task Force" indicates an idea that was believed to be original to the Dallas Gas Drilling Task Force. This is an adaptation of a table released by the Dallas Gas Drilling Task Force (City of Dallas 2012).

Topic	Sub Topic	Origin
Air Quality	Engine Requirements	Fort Worth, Southlake, Hurst, Task Force, Grand Prairie, Dallas
	Emissions	Dallas, Fort Worth, Task Force
	Monitoring Requirements	Dallas, Task Force
	Emissions Migration	Flower Mound, Task Force
Water Quality and Usage	Ground Water	Dallas, Southlake, Task Force
	Disposal Wells	Dallas
	Conservation	Taskforce
	Fracking Ponds	Grand Prairie, Fort Worth
	Waste Storage	Dallas, Southlake
	Fracking Fluid Disclosure	Dallas
Pad Site	General	Dallas, Grand Prairie, Southlake
	Hours of Operation	Task Force, Southlake, Fort Worth, Hurst
	Lighting	Fort Worth
	Dust, Vibrations, Odor	Southlake, Dallas
	Noise	Southlake, Grand Prairie
	Trucks	Dallas, Southlake, Fort Worth
	Landscaping	Dallas
	Fencing	Dallas, Task Force
	Equipment	Dallas
	Electric Lines	Dallas
	Wells	Dallas
	Hazmat Storage	Dallas, Fort Worth, Southlake
	Spill Clean-up	Dallas, Fort Worth
	Containment Devices	Dallas
	Tanks	Dallas, Southlake, Flower Mound, Task Force, Fort Worth
Well Abandonment		Dallas, Fort Worth, Flower Mound, Task Force
Pipelines	Flow/Gathering	Southlake, Dallas, Flower Mound
Pipelines	Routing/Planning	Southlake
	Compressor Stations	Fort Worth
Land Use	Location	Dallas, Southlake, Task Force
	SUP	Dallas, Task Force

Table 5 Continued		
Topic	**Sub Topic**	**Origin**
Well Permit	Pad Site Requirements	Dallas, Flower Mound
	Drilling Requirements	Dallas, Grand Prairie
	Insurance Requirements	Dallas, Fort Worth, Hurst, Southlake
	Operator Responsibility	Dallas
Seismic Permits		Grand Prairie, Flower Mound
Distance Requirements	Setback	Task Force, Dallas
Variance		Dallas
Required Plans	Studies, Reports, Plans	Fort Worth, Southlake, Grand Prairie, Dallas, Hurst, Task Force
Bonding Requirements		Dallas
Site Monitoring	Gas Inspectors	Dallas, Task Force
	Enforcement	Dallas
	Advisors	Dallas
Emergency Response		Southlake

After presenting the final recommendations, the task force was officially disbanded; however, work on the ordinance was far from complete. At the request of Mayor Mike Rawlings, two city councilmen, one opposed to shale drilling in urban locales and the other supportive, were to select two experts who would represent each side's view. During the summer of 2012, Councilman Scott Griggs — an opponent of unregulated urban gas drilling — chose Terry Welsh, a local attorney specializing in municipal law and a member of the Dallas Gas Drilling Task Force, to represent a more conservative approach. Over the course of his 30-minute lecture and several hours of councilmember questioning, Welsh brought up three main arguments — some of which were later incorporated into the Dallas ordinance. First, he recommended that the setback distance advocated by the task force, 1,000 feet, was too short based on an Integra Real Estate study carried out in nearby Flower Mound (See Fry 2013; Integra Realty Resources-DFW

2010), where property depreciation in proximity to shale gas pad sites was measureable to 1,500 feet, but beyond this distance there was no discernable negative impact. To address this issue, Welsh recommended extending the setback to 1,500 feet with a minimum variance of 1,000 feet. The presentation finished with Welsh suggesting that gas wells should be banned in floodplains and prohibited in parklands (City of Dallas 2014a).

Councilman Sheffie Kadane selected Ed Ireland, PhD, an executive director of a non-profit shale well education program funded by gas industry and a petrochemical businessman for 25 years, to present a supportive stance for urban gas drilling in Dallas. Ireland substantiated his arguments by citing the financial benefits collected from the City of Fort Worth and the Dallas-Fort Worth International Airport. In addition to advocating for a 600 feet setback, which is the same that is employed by Fort Worth, Ireland was supportive of drilling in floodplains and parklands. Ireland also mentioned that the deposits found under Dallas were dry gas, some of which would be pure enough to inject directly into residential distribution lines. Finally, he also wanted the city council to reconsider forcing pad sites to use electric motors, which he contended were just as loud and produce equivalent emissions to conventional gas motors (City of Dallas 2014a).

With the outside consultant lectures completed, the city moved slowly into the ordinance-drafting phase. From August 15, 2012 to April 3, 2013, the Dallas City Council met at least five times in closed sessions to discuss gas drilling and production with the city attorney (City of Dallas 2014a). All the while, the Dallas Zoning Ordinance Committee (ZOC) — an advisory

board to the CPC composed of three CPC commissioners and five citizens — was rewriting the Dallas oil and gas ordinance with the aid of the city attorney and the Dallas Gas Drilling Task Force recommendations. On April 18, 2013, the ordinance moved from the ZOC to the CPC, where it was further scrutinized through eight topical workshops and three public hearings. On September 26, the CPC recommended approval of the ordinance amendments and assigned responsibility of the regulation to the Dallas City Council (City of Dallas 2014b). While the CPC finished their work on the proposed ordinance, the Dallas City Council rejected a renewal of Trinity East Energy's drilling permits in August; therefore the company was unable to commence drilling after paying a $19 million bonus to the city of Dallas in 2008 for the original permit (City of Dallas 2014a). In January 2013, XTO, which had paid $14 million in bonuses to the city of Dallas, had voluntarily withdrawn their drilling application citing the "continued uncertainty surrounding local regulations governing gas well drilling" (Bush 2013).

On November 20, the city council met with Assistant City Manager Theresa O'Donnell, who explained the final ordinance that was to be put forth before the Dallas City Council for a vote on December 11. The proposed ordinance incorporated many of the recommendations from the Dallas Gas Drilling Task Force with a few significant modifications. The CPC regulation mandated a 1,500 feet setback, which could be reduced to 1,000 feet through variance by a ¾ vote of the city council; an increase to the number of uses subject to the 1,500 feet setback; and more stringent requirements for drilling in public parks. Smaller adjustments included firmer requirements for fracking fluid spill prevention, increased noise abatement, and limiting activities to daytime hours. Following the ordinance summary, the council transitioned into a

multi-hour question and answer period, during which the assistant city manager defended the recommended ordinance. As is the case of every open council meeting, the public was allowed to comment on the proposed ordinance, but they were unable to ask questions directly to O'Donnell. At the end of this meeting, only one citizen came forth with comments regarding the proposed ordinance (City of Dallas 2013).

On December 11, the city council moved to vote on the recommended regulations. Prior to the vote, however, 19 citizens voiced their opinions on the topic — the vast majority of which were staunchly opposed to urban drilling. Two amendments, one calling for the setback to be reduced to 1,000 feet with a 500 feet minimum variance while the other requiring a 2/3 majority (instead of a simple majority) of the city council to approve a new setback distance in any future updates to the ordinance, were put forth along with the CPC recommended regulations. The former amendment failed, while the latter was approved. Leading up to the final vote, Councilman Lee Kleinman, one of advocates for urban gas drilling, thought it would make more sense to "write a one-line ordinance that says there will be no gas drilling in the city of Dallas" than implement the 93 page regulation. He said this in response to both the bureaucratic regulations that the industry must contend with when submitting a permit as well as the long 1,500 feet setback distance that significantly restricts placement of shale gas wells in the city. Councilman Dwaine Caraway and Councilwoman Carolyn Davis agreed that the ordinance was an attempt at a compromise and that the law would ensure the safety of Dallas citizens. The overall ordinance passed with a nine-to-six majority, putting an end to the saga that had begun two and a half years earlier in the spring of 2011 (City of Dallas 2013, 2014a).

Local and regional media coverage immediately reported the results of the ordinance. *The Dallas Morning News* Metro headline for December 12 was "Dallas Oks Gas Drilling Rules that are Among Nation's Tightest" (Lee Loftis 2013), while the local NPR station focused on the reaction from policymakers and environmental groups to the long 1,500 feet setback distance (Austin and Zeeble 2013). *The Texas Tribune* echoed the restrictive nature of the ordinance, which noted that "Dallas has significantly tightened its drilling rules, following years of debate about what natural gas production should look like inside its city limits — if it comes at all" (Malewitz 2013). Many local and national environmental activist groups claimed victory with the passage of the ordinance. Zach Trahan of the Texas Campaign for the Environment argued that the regulations were a "huge, huge step in the right direction and we're very pleased the mayor and council voted to approve the ordinance" (Gillett 2013). Jim Schermbeck, a staff member of Downwinders at Risk, posted on the organization's website that "environmentalists actually have some clout in city politics in Dallas for the first time" (Schermbeck 2013).

The industry's response was decidedly negative. The Consumer Energy Alliance Texas, a statewide pro-drilling advocacy group, condemned the ordinance by calling it a "de facto moratorium on drilling activities due to its unreasonable setback" (Sakelaris 2013), while Meagan Baker at Energy In Depth — a research, education, and public outreach campaign by the Independent Petroleum Association of America — called the regulation a strategy that "deceptively [calls] for 'rules' instead of a ban, when the hidden agenda is still a ban…" (2013). These remarks point toward veiled threats of a regulatory takings lawsuit against the city based

on the industry perceived unreasonable setback distance, which they contend hinders the full economic viability of the mineral resources under Dallas. If such a case were to go to court and gas firms were to win, then the city of Dallas could potentially be forced to pay petrochemical companies for the gas that they were unable to extract. The most recent development in the industry's reaction was a lawsuit filed by Trinity East against the city of Dallas. The company claims that the city accepted the $19 million bonus payment, yet by rejecting their permit renewals in 2013, had denied them access to minerals without just compensation (Malewitz 2014b). As of April 2014, there has not been a resolution to this lawsuit.

The adoption of restrictive bureaucratic policies is not new and is reflective of "the Dallas Way": once a derogatory term describing the city's penchant for a disconnected municipal oligarchical government, now a colloquial term used by Dallasites to refer to the city's perceived unique bureaucratic philosophy (Graff 2008). Additionally, local policy responses to citizen environmental activism also has a strong precedent in the city as expressed by Hill (1996, 170-171):

> The focus of neighborhood groups on quality-of-life issues and increased concerns about the environment combined with single-member election districts to force city council members to pay more attention to their constituents. Grassroots campaigns opposing projects endorsed by local business leaders were no doubt encouraged by national movements and by their improved chances of success in the more inclusive political atmosphere of the mid-1970s.

The environmental activism that Hill is referring to was an attempt to build a navigable canal from the Gulf of Mexico to Dallas using the Trinity River. Although the subject matter of the activism has changed, the city's response to it has not. The Dallas bureaucratic philosophy appears to embrace discourse from opposing viewpoints and frequent citizen input while making significant decisions. This "urban legacy…[of] fairness, cooperation, and greater attention to human services" (Hill 1996, 173) has been engrained into the city over the course of decades and as such appeared in the oil and gas ordinance debates — especially in the most recent revisions. This incorporation of opposing viewpoints is likely the reason why city officials decided to pursue one of the most restrictive ordinances in the nation through the implementation of a long setback distance.

Regional Ordinance Analysis

Setback Trends

The Dallas case study makes it apparent that one of the most scrutinized aspects of oil and gas ordinances in the Barnett Shale is the setback distance between residences and well sites. This distance determines the amount of land free of protected uses that is necessary to implement a shale gas well (Table 6). A shorter setback (e.g. 300 feet) allows for more wells with a more thorough extraction of subsurface geologic deposits. A higher amount of extractable gas could allow more mineral right owners to receive royalties from drilling. However, a longer setback distance can shield residents from some of the negative quality-of-life externalities that were mentioned in the Background. Nevertheless, a setback distance that is perceived to be too long

may subject the municipality to a regulatory takings lawsuit. There is a great variety of setback distances employed on the Barnett Shale, however the most common is the 600 feet setback (Figure 7).

Table 6: Area free of a protected use for a given setback distance. As a point of reference, shale gas pad sites typically need five to eight acres of cleared land. For this example, the distance would be measured from the wellhead.

Setback Distance (Feet)	Area Free of Protected Uses (Acreage)
300	6
600	25
1,000	72
1,200	103
1,500	162

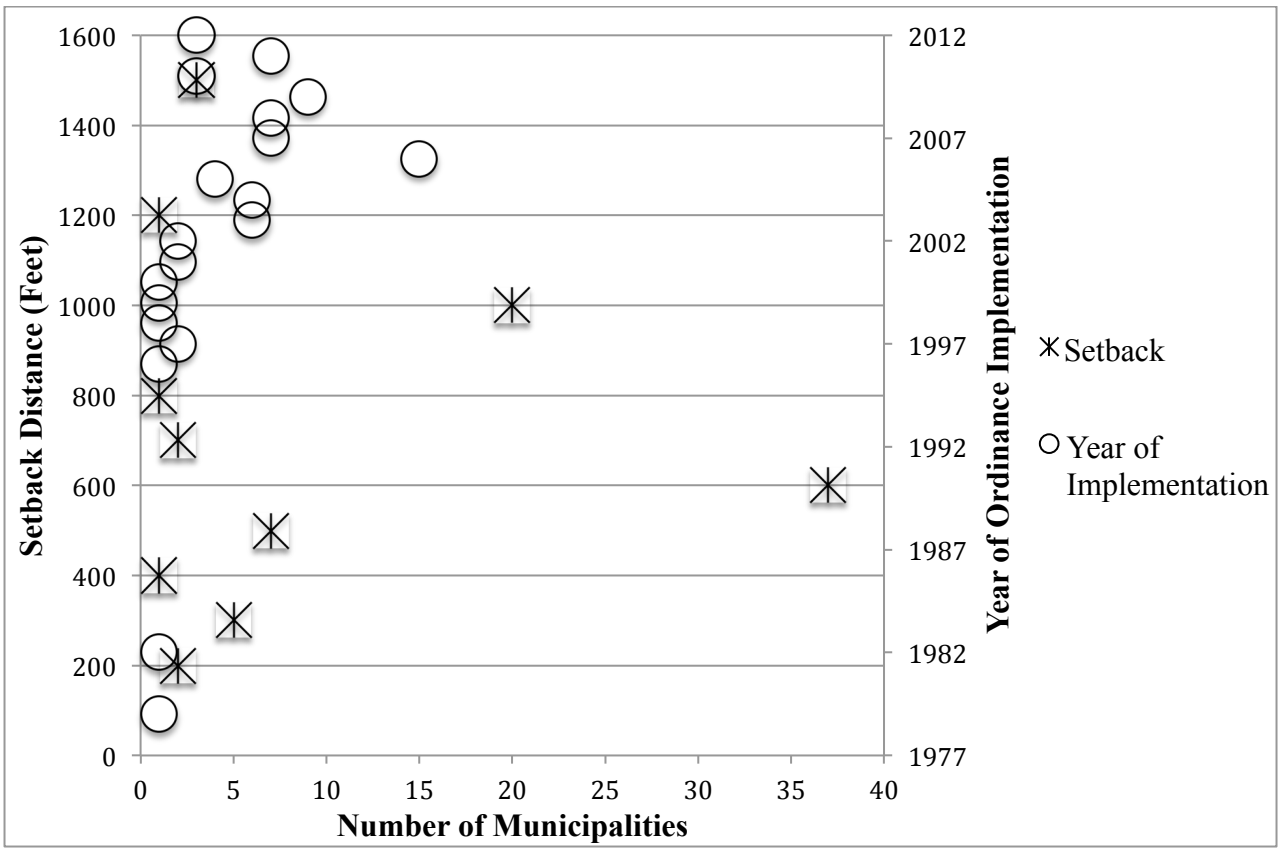

Figure 7: Frequency of the of setback distances and the year of ordinance implementation by municipalities in the Barnett Shale (n = 79)

Although the relative frequency of setback distances in the Barnett is noteworthy, the spatial distribution is perhaps more significant, because it reveals more about the nature of the ordinances and the possible movement of policies in the region. Fort Worth was the first large municipality in the Barnett Shale to institute an oil and gas ordinance in 2001; however, several smaller municipalities to the west of the Dallas-Fort Worth Metroplex (e.g. Chico, Henrietta, Lakeside City) already had ordinances in place from oil drilling that had occurred several decades earlier (Table 7). The eight municipalities with an oil and gas ordinance prior to Fort

Worth had an average setback of 463 feet. This contrasts with the 70 municipalities that implemented their ordinances after Fort Worth, averaging a setback distance of 737 feet. The average setback across the entire Barnett (n = 79) is 707 feet. When a localized study of the core urbanized Barnett shale counties — Denton, Dallas, and Tarrant— is carried out, the majority (52%) have a 600 feet setback, while 27% have a 1,000 feet setback (Figure 8). Interestingly of the municipalities sampled in Tarrant County (n = 34), 62% had a setback of 600 feet, which mirrors Fort Worth (Figure 9).

Table 7: The implementation year of a municipality's first oil and gas ordinance, the current setback distance, the municipality's distance from Fort Worth, and the number of permitted gas wells in each municipality (n = 79)

Municipality	Setback (Feet)	Date of First Oil and Gas Ordinance	Kilometers From Fort Worth	Number of Wells
Henrietta	200	1982	142	0
Runaway Bay	200	1997	68	3
Chico	300	1979	74	0
Crowley	300	2006	20	91
Decatur	300	2004	58	39
Krum	300	1998	58	11
McGregor	300	2004	148	0
Graham	400	2007	122	1
Bowie	500	2003	101	2
Burleson	500	2009	26	244
Double Oak	500	2005	40	6
Lewisville	500	2009	46	38
New Fairview	500	1997	41	248
Sachse	500	2004	75	0
Springtown	500	2006	40	1
Alvarado	600	2006	40	12
Arlington	600	2003	21	470
Bartonville	600	2011	40	36
Bedford	600	2008	21	0
Benbrook	600	2009	15	67
Bridgeport	600	2008	65	11
Carrollton	600	2007	48	1
Cleburne	600	2007	45	225
Copperas Cove	600	2009	189	10
Dalworthington Gardens	600	2006	18	18
Eastland	600	2011	144	0
Euless	600	2009	26	74
Ferris	600	2006	67	0
Fort Worth	600	2001	0	2817
Glenn Heights	600	2008	51	0
Haltom City	600	2008	9	87
Haslet	600	2004	23	140
Hurst	600	2011	17	22
Irving	600	2005	36	29
Joshua	600	2006	33	41
Justin	600	2000	37	2

Table 7 Continued				
Municipality	**Setback (Feet)**	**Date of First Oil and Gas Ordinance**	**Kilometers From Fort Worth**	**Number of Wells**
Keller	600	2009	22	22
Kennedale	600	2004	17	66
Lake Worth	600	2006	11	1
Lakeside	600	2011	16	6
Lakeside City	600	1996	164	0
Midlothian	600	2010	45	24
Newark	600	2001	31	2
North Richland Hills	600	2007	16	100
Northlake	600	2006	37	140
Ovilla	600	2009	48	0
Pantego	600	2008	18	7
Ponder	600	2002	47	50
River Oaks	600	2012	6	1
Watauga	600	2012	15	0
Westworth Village	600	2007	8	15
White Settlement	600	2007	12	18
Grand Prairie	700	2011	31	203
Saginaw	700	2007	13	8
Argyle	800	2011	42	32
Aledo	1000	2006	26	3
Annetta North	1000	2003	32	3
Colleyville	1000	2006	23	7
Coppell	1000	2009	40	24
Copper Canyon	1000	2006	44	26
Corinth	1000	2005	50	4
DISH	1000	2006	42	18
Grapevine	1000	2006	32	187
Hickory Creek	1000	1999	49	4
Highland Village	1000	2006	45	0
Jacksboro	1000	2012	93	2
Mansfield	1000	2008	29	278
Roanoke	1000	2005	30	10
Sanger	1000	2010	70	0
Shady Shores	1000	2003	53	0
Southlake	1000	2011	28	14
Trophy Club	1000	2003	31	40
Venus	1000	2006	42	0

Table 7 Continued				
Municipality	**Setback (Feet)**	**Date of First Oil and Gas Ordinance**	**Kilometers From Fort Worth**	**Number of Wells**
Weatherford	1000	2004	40	30
Westlake	1000	2009	28	2
Denton	1200	2002	54	296
Dallas	1500	2008	54	0
Flower Mound	1500	2003	37	116
Stephenville	1500	2010	102	0

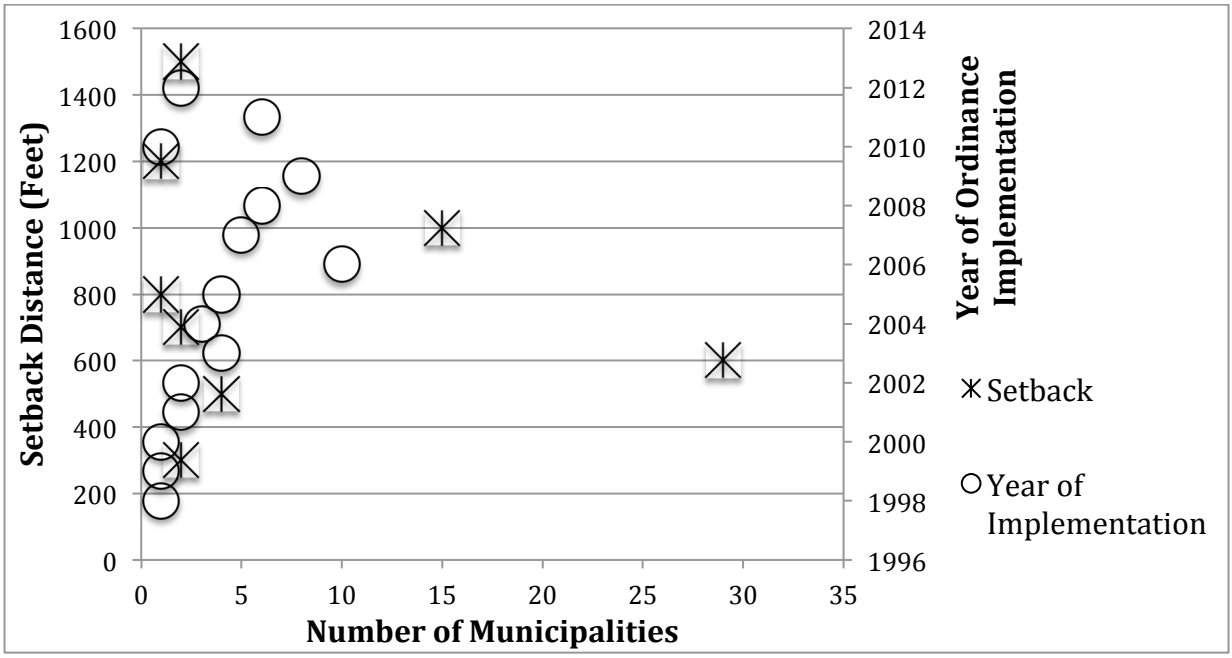

Figure 8: Frequency of setback distance in municipal ordinances and ordinance origination dates in Denton, Dallas, and Tarrant counties (n = 56)

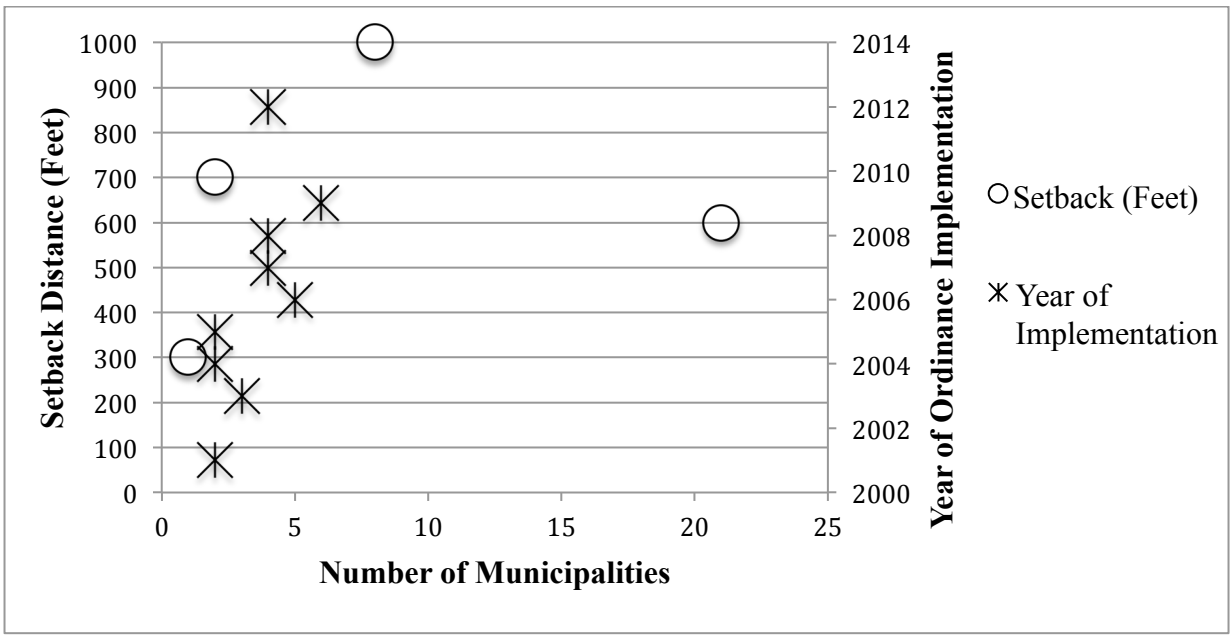

Figure 9: Frequency of setback distances and year of ordinance implementation in Tarrant County (n = 34)

Due to the suggested importance of Fort Worth's oil and gas ordinance (i.e. one of the first in the region, the first for a large metropolitan area in North Texas, the present day publicity regarding the ordinance, etc.), this analysis will employ Fort Worth as the focal point for ordinance evolution. When the entire Barnett Shale is analyzed, there is no correlation between a municipality's distance from Fort Worth and its setback (Figures 10 and 11) or the year of ordinance implementation (Figures 12 and 13). Finally, any relationship between the year of ordinance implementation and the setback distance can be attributed to early ordinance adopters (Figure 14), which once removed, eliminated the correlation (Figure 15). This analysis also took into account the number of active shale gas wells in each municipalities (Table 8, Figure 16). However, no statistically significant relationship was found with regard to the number of wells versus the date of ordinance implantation or setback distance (Table 8).

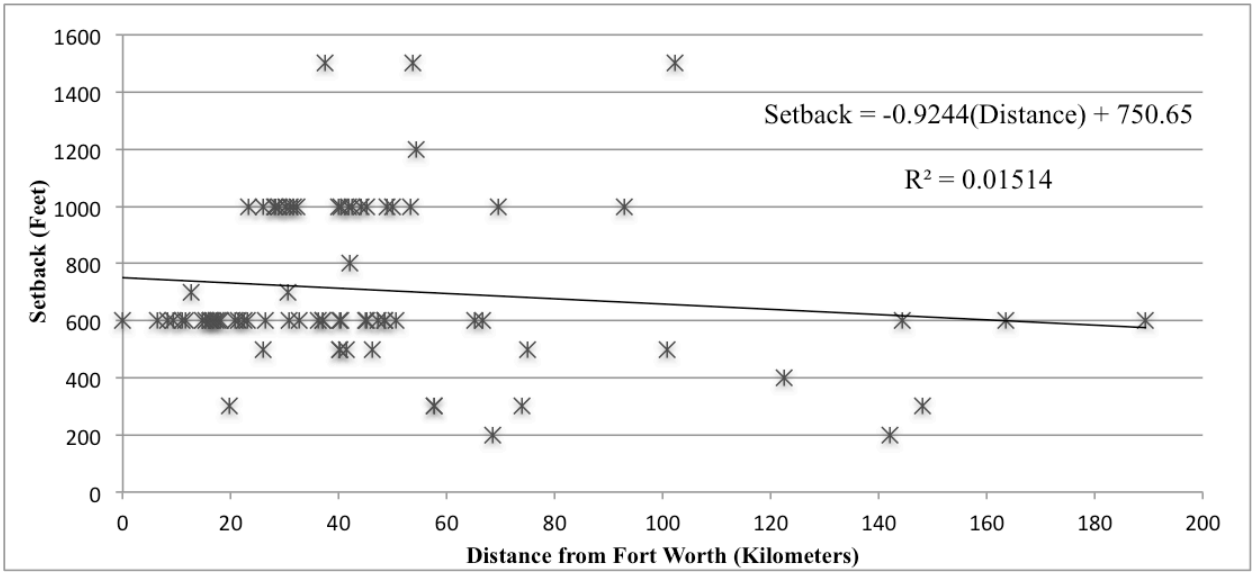

Figure 10: Setback distances versus municipal distances from Fort Worth ($R^2 = 0.015$)

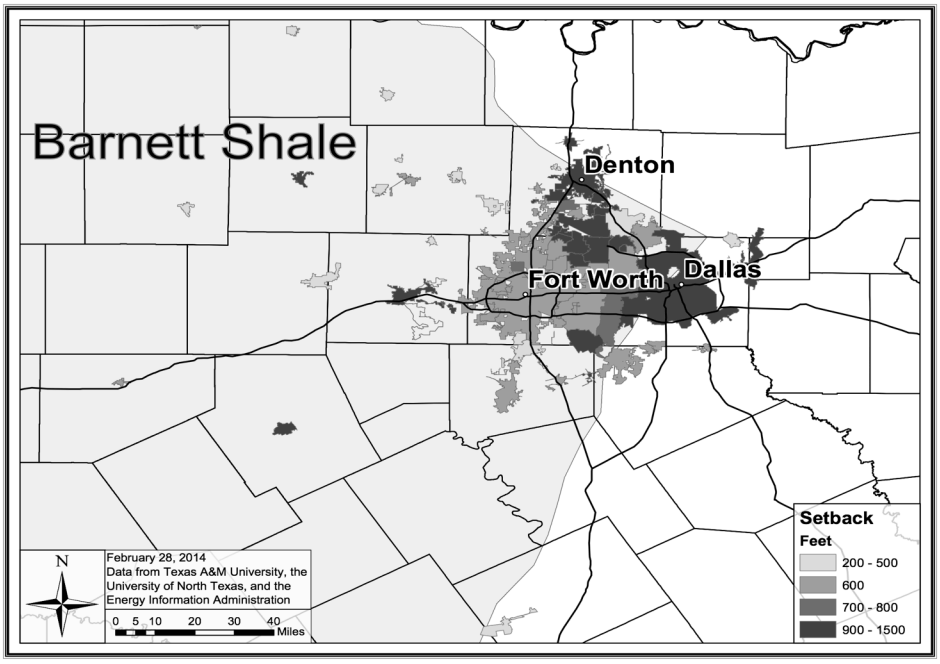

Figure 11: Setback distance distribution in Barnett Shale municipal ordinances

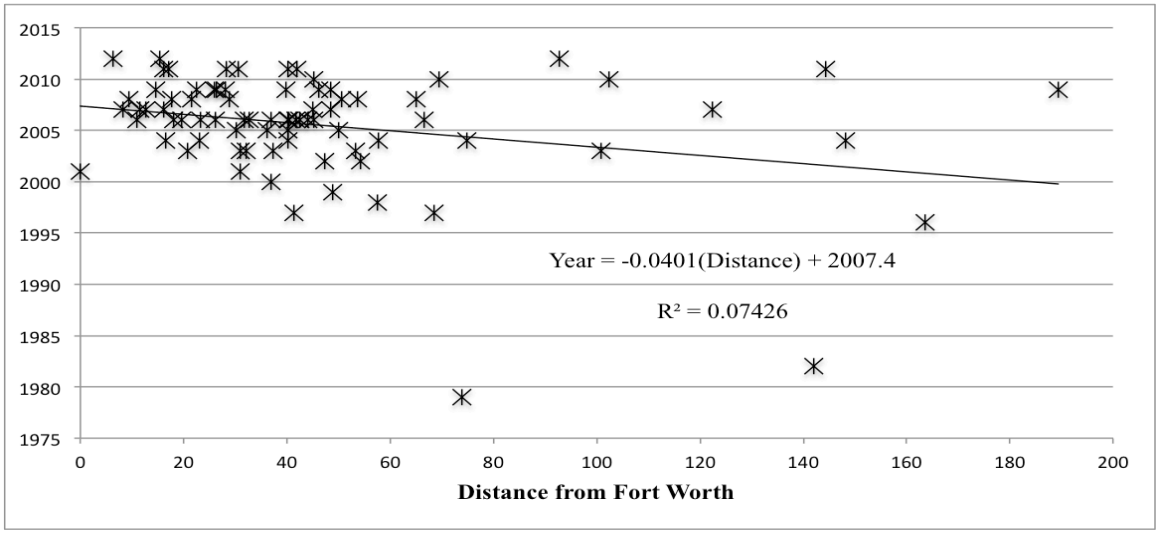

Figure 12: Year of oil and gas ordinance adoption versus municipality distance from Fort Worth ($R^2 = 0.074$)

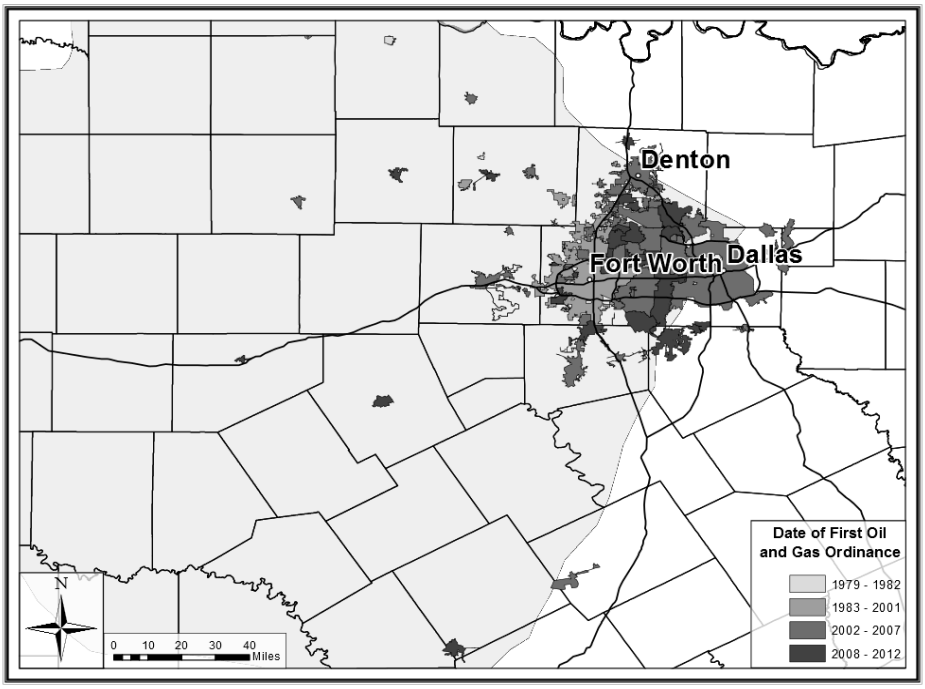

Figure 13: Distribution of oil and gas ordinance by adoption year

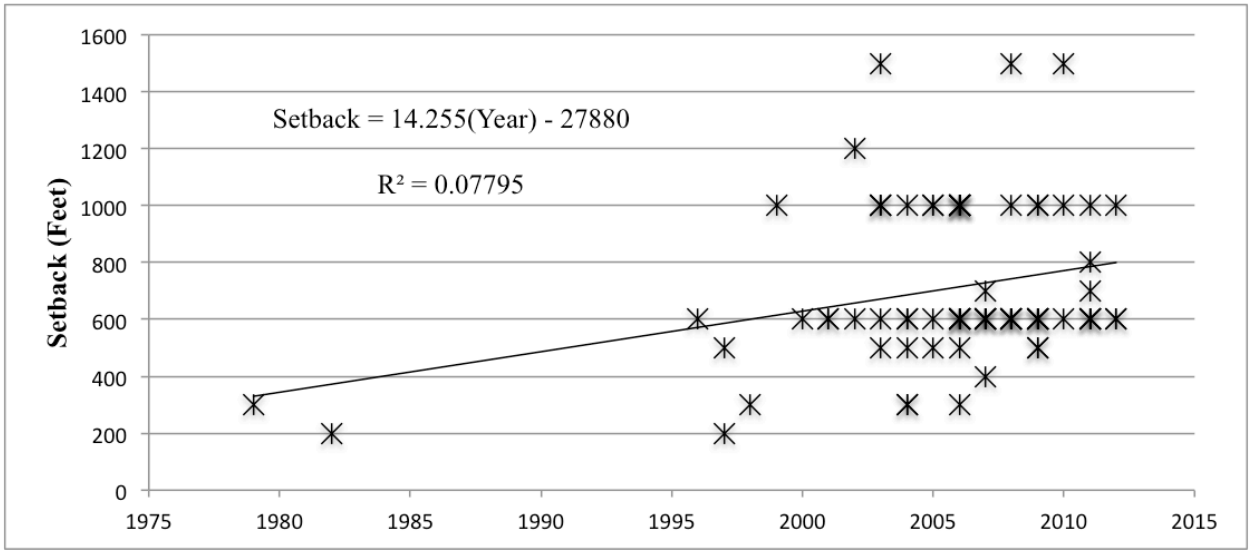

Figure 14: Year of ordinance implementation versus setback distance ($R^2 = 0.078$)

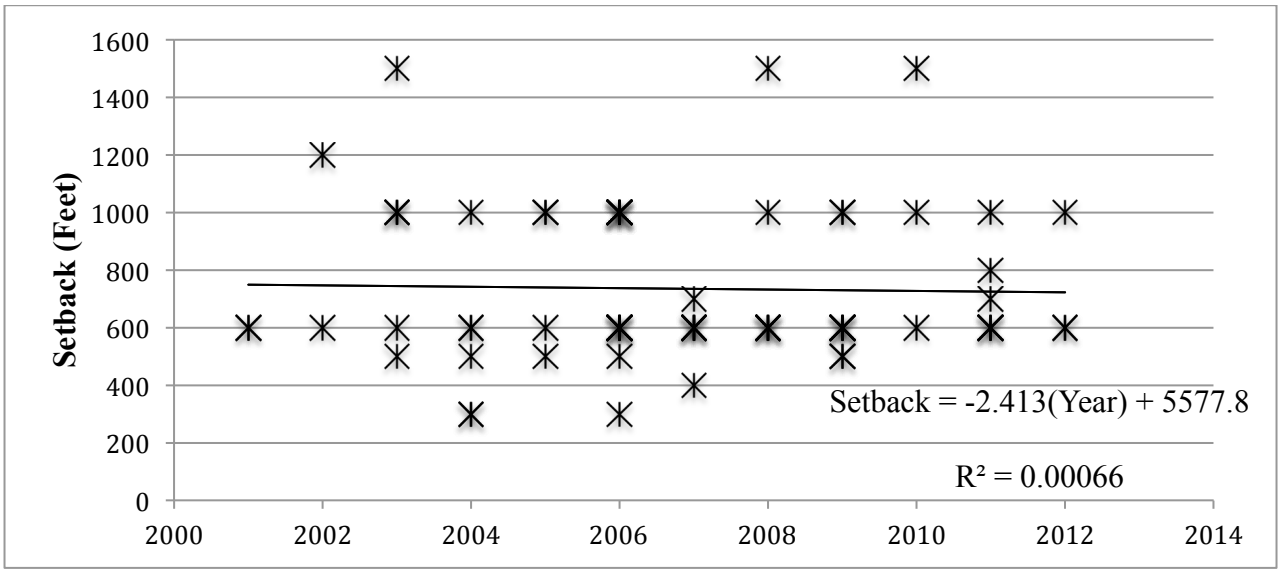

Figure 15: Year of ordinance implementation versus setback distance without ordinances prior to Fort Worth (n = 71; $R^2 = .001$)

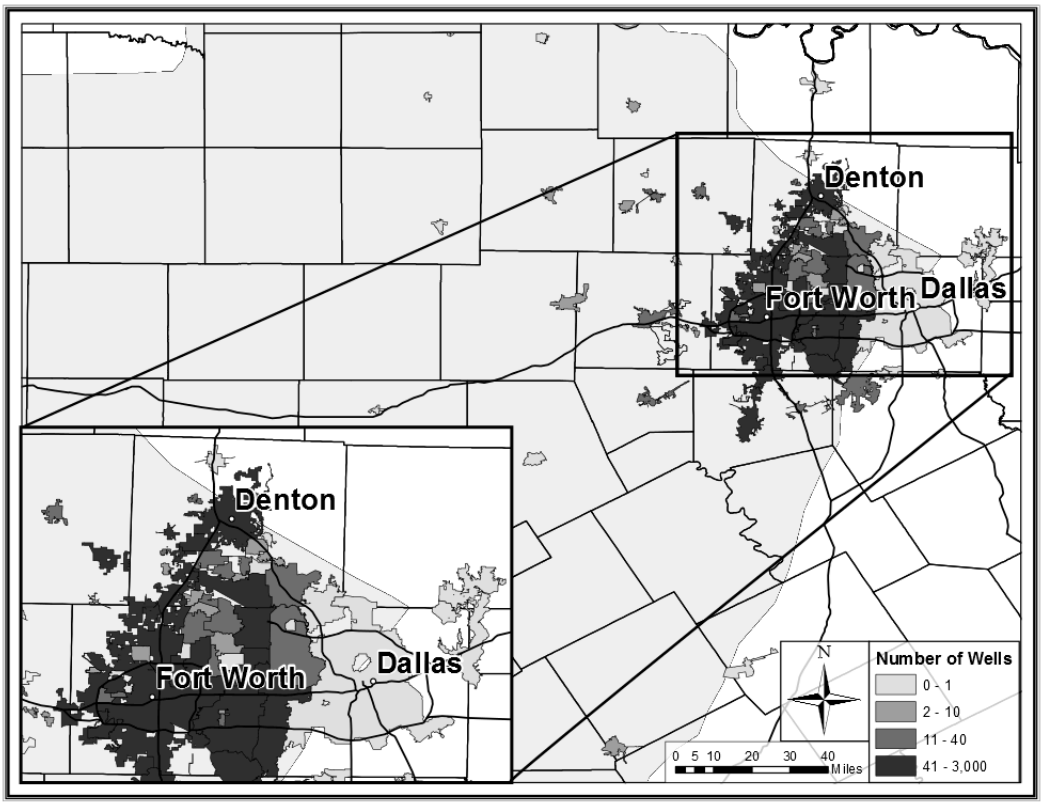

Figure 16: The number of oil and gas wells in each municipality

Table 8: Number of wells in a municipality versus year of ordinance implementation and setback distance (n =79).

Type of Relation	R^2 Correlation Coefficient
Number of Wells and Year of Ordinance Implementation	0.01
Number of Wells and Setback Distance	0.001

When considering ordinances in the core counties (in terms of population) in the Metroplex, 56 of the 79 municipalities (71%) that have oil and gas ordinances are in Dallas, Tarrant, or Denton counties. When a municipality's distance from Fort Worth and its associated setback are investigated, no correlation is found (Table 9, Figure 17). The year that a municipality's

ordinance was implemented and that town's distance from Fort Worth has a very weak correlation (Figure 18, Table 9), and there is no correlation between the setback distance and the implementation year (Table 9).

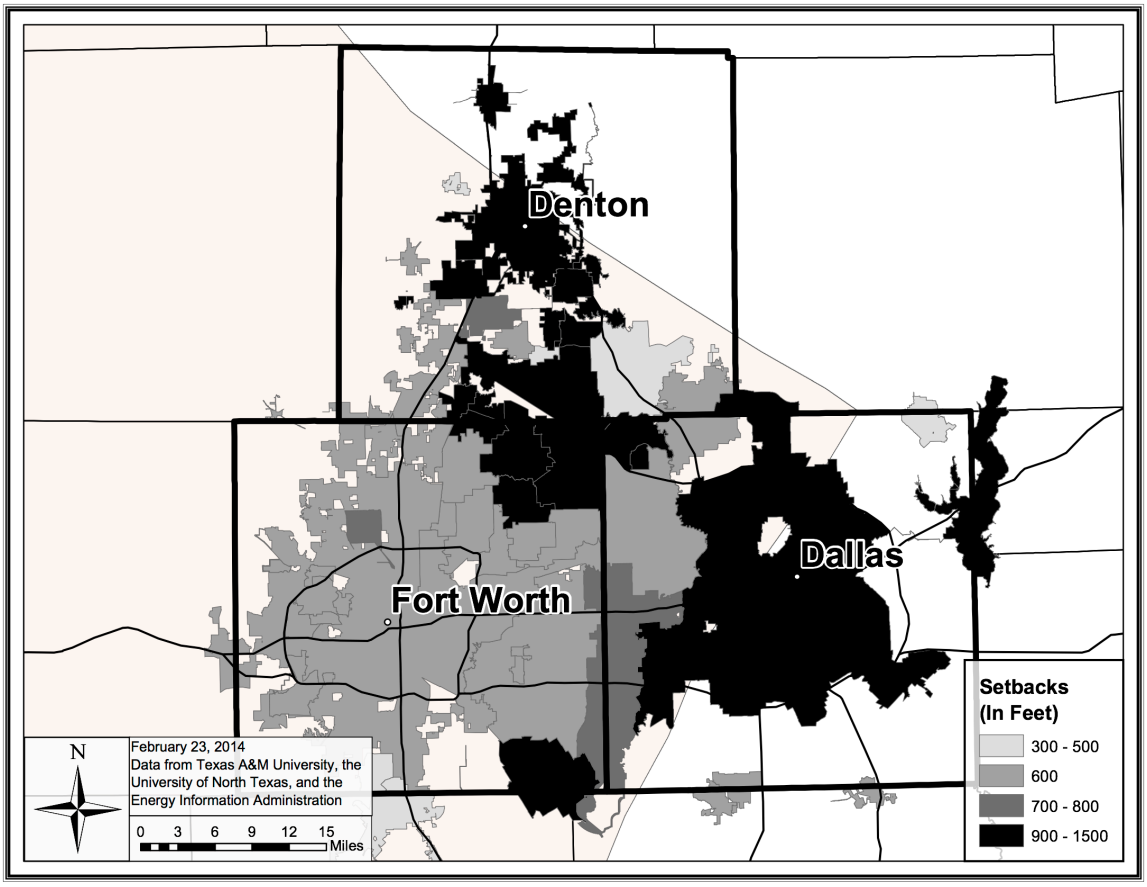

Figure 17: Variation in setback distances across the Dallas-Fort Worth Metroplex

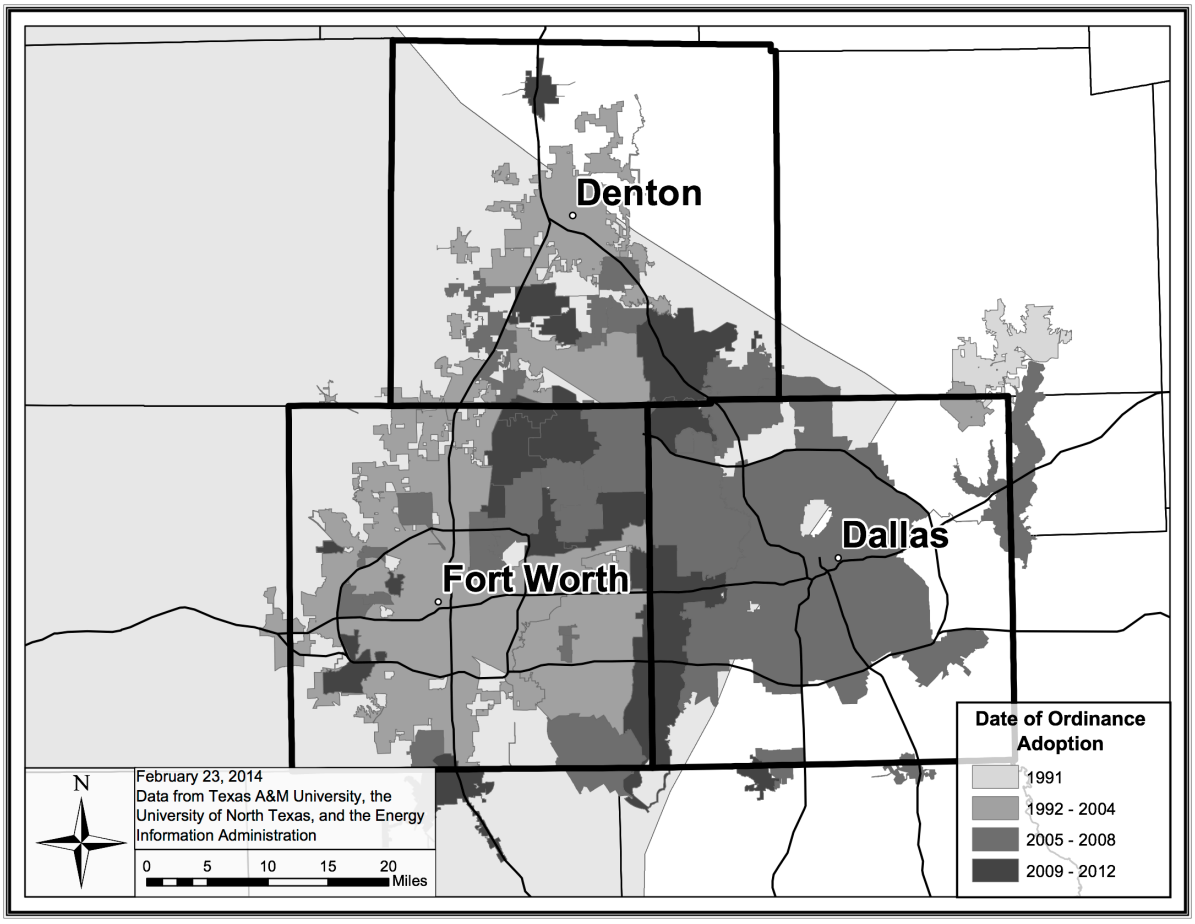

Figure 18: Variation in ordinance adoption dates in the Dallas-Fort Worth Metroplex

Table 9: Correlations between setback distances and years of ordinance implementation in the Tarrant, Denton, and Dallas counties (n = 56)

Type of Relation	R^2 Correlation Coefficient
Distance from Fort Worth and Setback	0.083
Distance from Fort Worth and Year of Ordinance Implementation	0.058
Year of Implementation and Setback	0.003

When examining municipalities in Tarrant County alone, there is a strong positive relationship between the distance from Fort Worth and setback distance. Conversely, there is no correlation between the distance from Fort Worth and the year of implementation, and between year of implementation and setback distance (Table 10).

Table 10: Municipal correlations found in Tarrant County alone (n = 34)

Type of Relation	**Type of Correlation**	**R^2 Correlation Coefficient**
Distance from Fort Worth and Setback	Positive	0.348
Distance from Fort Worth and Year of Implementation	Negative	0.010
Year of Implementation and Setback	Negative	0.018

CHAPTER V

DISCUSSION

Municipalities must balance a property owner's expectation to receive a return on property investment — be it through surface or subsurface means — while regulating the negative externalities (such as noise, truck traffic, and emissions) that can degrade quality-of-life in shale gas production regions. Though cities could regulate each well permit individually, municipalities often choose to turn this political decision into a technical checklist that dissociates politics from the decision making process. Therefore, the oil and gas ordinances free the municipality to focus on more political matters while standardizing the regulations and reducing the possibility of a regulatory takings lawsuit based on unreasonable and capricious statutes. Although all municipalities in this study have created ordinances that systematize regulatory procedures, some cities prefer to have more oversight in the permitting process, such as Dallas, while others prefer to keep the procedures purely technical.

While the results of this study demonstrate that selected municipal regulation clauses "travel" between municipalities without alterations, in no instance did I find one ordinance that was completely copied from another. Indeed, municipal officials seem to selectively choose regulatory clauses from other municipalities that correspond with a preexisting policy culture. This process probably relies on city staff, outside expertise, and inter-municipal organizations to create (or in many cases, find) the specific language for their ordinances. This premise is substantiated by the spatial results of this study, which exhibited no discernable correlation

between the focal point for regional oil and gas ordinance policy creation, Fort Worth, and the setback distances or the years of ordinance implementation. The only exception was a slight association found in Tarrant County. The results of the present investigation, therefore, supports the findings found in Fry (2013), who argued that setback distances are the product of a political process based on somewhat ambiguous reasoning that needs further research. An exception to this perspective is the highly publicized 1,500 feet setback distance enacted by Flower Mound based on an Integra (2010) real estate study (Fry 2013). As mentioned previously, this land value study was also the basis for the identical Dallas setback distance.

In lieu of proximal policy transmission, there must be other dynamics at work — such as experts "carrying" knowledge between municipalities or local politics dictating the policies that must be implemented. However, testing which of those is the primary mode of policy transmission is beyond the scope of this thesis. Although the mode of policy transmission is not completely understood, there is evidence to suggest why officials choose the language that is found in a particular oil and gas ordinance. It is possible that those municipalities in Tarrant County with a correlation between setback distance and proximity to Fort Worth have a shared bureaucratic culture; it is unlikely that the policies diffused by spatial proximity from the regulatory origin. This is corroborated by my case study of Dallas. In fact, during the 2007 oil and gas ordinance discussions, the city had considered a regulatory procedure similar to Fort Worth, in which drilling authorization would be inside the ordinance and city approval only necessary when variances were requested. Instead, city officials opted for a SUP process that mirrored the zoning regulations of Argyle and Dallas. This regulatory methodology did not naturally shift to Dallas;

rather policymakers probably sought regulations that conformed to the perceived preexisting bureaucratic culture of the city. I focus on the Dallas ordinance deliberations neither to extol nor denounce the manner by which the city created its oil and gas ordinance. Alternatively, I propose that North Texas policymakers in many municipalities engaging in and regulating urban gas drilling considered those regulations that conformed to the preexisting bureaucratic cultures of their respective cities.

However, I acknowledge that there were other arguments at play during the ordinance creation process besides a purely cultural progression. At least one Dallas city official has admitted that the main impetus for the creation of the 2007 oil and gas ordinance was to have a regulatory structure that allowed for and consequently provided a method for adding financial resources to the city's ailing coffers during fiscally stringent years. Even with a liberal setback distance, the city still selected the SUP process, a potentially relatively slow regulatory arrangement, as the main mode of vetting potential gas well permits. It is in this vein that one can note the bureaucratic and inclusive political culture of Dallas, even in the first ordinance.

These policies though implicitly involve the citizens' approval. Indeed, this is where the validation of municipality created policies, such as a shale gas well setback distances, interacts with the ordinance creation process. The long (1,500 feet) setback distance chosen by Dallas — despite opening the municipality to possible future regulatory takings litigation and being against the recommendations of the Dallas Gas Drilling Task Force — is perceived as being valid (by city officials) through the city's bureaucratic culture and the Integra (2010) real estate study. It is

likely that other cities must grapple with this policy creation procedure, during which the seeking of regulatory clauses (both "homemade" and from other municipalities) for proposed oil and gas ordinances is motivated by an underlying citywide bureaucratic culture or philosophy that is implicitly endorsed by the citizens through the election of town officials.

In addition to demonstrating the reasoning why city officials selectively choose clauses from other ordinances, I have also tracked the manner by which Dallas developed its oil and gas ordinance from 2006 to present. I have established that as the goals and attitudes of the city shifted, so did the ordinance. This is especially true considering the Dallasite cultural bent toward activism. City officials had to contend with powerful competing interest groups — some of which were vehemently against urban gas drilling while others were supportive. Dallas policymakers, especially those associated with the city attorney's office and the CPC who were the main authors of the ordinance, attempted to create a series of regulations that would allay the fears of citizen activists while still providing an avenue for urban gas drilling, thus in theory reducing the city's exposure to a regulatory takings lawsuit. Although the amount of activism and the types of concerns regarding urban gas drilling varies from city to city, it is believed that all North Texas municipalities engaged in mineral extrication must contend with these competing interests, while creating an environment that turns political decision making into technical procedures through the creation of ordinances. In short, the Dallas debates can serve as a microcosm for both the public and private deliberations that municipalities experience while preparing their cities for urban gas drilling.

CHAPTER VI

CONCLUSION

This thesis searched for spatial relationships in North Texas oil and gas ordinance dynamics and found few. However in doing so, I have narrowed down the possible main policy transmission actor of setback distances and the wording of the oil and gas ordinances. I have also outlined the process of oil and gas ordinances creation through a case study of Dallas. In doing so, I have revealed that a municipal ordinance likely mirrors the preexisting bureaucratic policy culture of that city. This is predominately carried out through the selection and replication of regulatory clauses from preexisting municipal ordinances.

Geographers and spatial scientists have the opportunity to provide useful input in shale gas public policy debates while examining the intricacies of oil and gas ordinance dynamics. I echo the calls of Fry (2013) for a scientifically proven setback distance that incorporates ecological, health, legal, quality-of-life, land values, and other parameters. Competing quasi-scientific claims of the optimal setback distance and regulatory conditions arose frequently and occasionally paralyzed progress on writing an ordinance during the Dallas discussions. This is perhaps inevitable given the novelty of urban shale gas drilling in North Texas. Geographers can provide practical answers to theoretically challenging shale gas questions, thus providing a scientifically backed method for determining optimal policy regulations.

Future studies will have the opportunity to investigate other modes of policy transmission, such as the capacity of outside experts to influence regulatory decisions or the role of inter-municipality communication. Further research can also be used to advance the argument that municipal oil and gas ordinance policymakers, though selectively copying clauses in other municipal ordinances, choose regulations that mirror the bureaucratic and political culture established over the lifetime of the city. Finally, deeper data mining on the Barnett Shale ordinances can be carried out to discover complex connections between municipalities beyond the "clusters" discussed in this thesis.

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APPENDIX A

INTERVIEW QUESTION

Interviews will begin after reading, signing, and discussing the Informed Consent Form. Question five in the consent form asks: What will I be asked to do in this study? Begin by following up on that question.

Drilling Ordinance

What is or was your role in the establishment, revision, or enforcement of the gas drilling ordinance?

[Allow for respondent to discuss this answer in his/her own terms]

Obtain professional credentials of respondent:

Elected or career official?

Expertise or credentials [degree; training; experience]?

How long in current position [years or months]?

City/town of _____ established its drilling ordinance in _____ [month/year].

Who were the key figures involved in the development of (and/or later amendments to) your city/town's ordinance?

[prompts: municipal officials; elected officials; industry representatives; prominent citizens; external figures]

Why did you establish an ordinance at this time?

[prompts: respond to drilling; anticipate drilling; respond to public; respond to industry]

Setback Distances

Objectives:

Use these cards to rank the importance of the following objectives as they were raised during the establishment of setback distances, beginning with the most to the least important.

_____Prevent noise complaints (___;___)

_____Preserve home property values (___;___)

_____Protect public safety (___;___)

_____Protect public health (___;___)

_____Encourage mineral production (___;___)

_____Reduce exposure to regulatory takings lawsuit (___;___)

_____Other (___;___):

If setbacks were amended, did these change? [Repeat ranking if necessary]

In your professional opinion, how would you rank these objectives? [Repeat ranking if necessary]

Meeting Participants:

Were the same individuals listed above involved in the internal deliberations over setback distances?

Were experts or consultants involved?

Did you seek advice from other elected or career officials within or outside your municipality?

Did you hold public deliberations over setbacks?

If YES: what individuals were most involved? What were some of themes discussed?

If NO: why not?

Setback Options

During the discussions over the lengths of setbacks, what options were brought up?

During these discussions, what were the justifications for and against the various lengths?

Were the setback distances of other municipalities discussed at any time during the deliberations over setback distances?

If YES, which municipalities? and What components of their setback ordinance were discussed?

If NO, why was it not necessary to seek advice of other municipalities?

Setback Rational

How did you or your colleagues finally choose the distance?

What was the rationale for the distance chosen?

If the setback distance changed, when, why, and how did it change?

Setback Variances

The variance for your town/city is _____. Why were these distances chosen?

How many variance appeals have been filed in your town/city?

What has been the rationale for these appeals?

Outside Consultants

Are any of these individuals still involved in gas well ordinances in this region or in the state?

Ordinance outcomes

After the implementation of the ordinances, were there lawsuits, conflicts, or litigation?

Have there been complaints about drilling?

What was the nature of the complaints?

Were these before or after the adoption of the ordinances?

Are there plans to amend current policies?

Staff and Council (Questions for Staff)

Within the city government and at the time of the gas ordinance drafting and implementation:

How well did each department work together?

How well did you work with council at the time of the ordinance drafting?

What was your working relationship with the public?

If "regulatory takings" generate discussion, provide copies of: Fry 2013; Welch 2012; Riley 2007. The position of the project is stated in Fry 2013 section 6.3 "Standardizing setbacks".

APPENDIX B

ATLAS.TI ORDINANCE CODING LIST

Emissions

-Venting Setback: The actual setback distance of the venting/open flame from nearby residences
-Nondescript Emission Requirements: ambiguous or vague working that restricts or limits emissions.
-Emissions Testing Techniques: The required methods set forth in order to properly measure emissions (entire phrase/paragraph/ etc.)
-Emissions management plan: Phrasing and specific requirements of a plan to manage and control emissions.
-Emissions monitoring: phrasing and specific requirements related to procedures for continuously or periodically monitoring emissions.
-Pre-Drilling Study: phrasing and specific requirements of a pre-drilling air quality study.
-Substance regulations: phrasing and specific requirements related to concentration limits of certain substances.
-Emissions setbacks: the distance at which the substance concentrations will be measured.
-Measurement technique: phrasing related to the techniques for measuring emissions.
-Maintenance of equipment: phrasing related to maintenance of the drilling or extraction equipment in order to manage or reduce emissions.
-Exceedance regulations: what happens when emissions requirements are exceeded.

Noise

-Above ambient noise level: The wording in the ordinance that references exceeding “ambient” noise levels
-Acoustics Monitoring: The wording the in ordinance that refers to specifics tones and monitoring of those tones (example: 8dB for center frequencies between 160 and 400 Hertz)
-Allowable Exceedance Levels: The amount and duration that the drilling rig can exceed the predetermined maximum noise levels
-Exceedance Regulations: What happens when the noise level exceeds the regulated/accepted value
-Maximum Sound Level: the maximum decibel amount allowed (just the value)
-Maximum Fracking Noise Level: the maximum decibel amount allowed during fracking (just the value or the amount it can exceed “ambient” noise levels—only daytime if given option)
-Noise Level Responsibility: who is responsible for enforcing noise level regulations
-Noise Management Plan: wording in the ordinance that refers to the gas pad company submitting a “noise management plan” or something similar prior to drilling
-Noise Measurement Technique: how the noise level is ascertained
-Nondescript Noise Maximum- ambiguous wording that implores the gas extraction company to keep noise to a minimum

Residential Noise Maximum: The actual amount that noise can be measured to a residence (value + wording)
Distance of Measurement: Phrasing pertaining to distance at which maximum sound levels will be measured.

Purpose

-Environmental Protection: those phrases that pertain to environmental protection
-Property Owner Safety: those phrases that pertain to property owner safety
-Public Health and Welfare: those phrases that pertain to public health and welfare
-Reasons for regulation: the reasoning behind the creation of the gas/oil ordinance

Setbacks

-Distance: the actual residential setback distance
-Measurement technique: the technique used to determine the setback distance
-Residential setback: The phrasing of the residential setback distance (includes actual distance and additional wording)
-Rural Setback Regulation: Phrasing that pertains to setbacks in a rural portion of the municipality and how those setbacks differ from normal setbacks
-Zoning District Ban: Any phrasing pertaining to the ban of drilling within specific zoning districts.

Variance

-Additional Requirements: city-defined regulations that can be created after the issuance of the drilling permit (Usually contains the phrase: “additional requirements”)
-Minimum distance: the actual minimum distance of the variance
-Variance Pre-conditions: The necessary requirements for the creation of a variance regardless of whether it is from the council’s perspective or the company’s
-Preexisting Pad Sites Variance: the issuance of a variance if the pad site was preexisting prior to implementation of the well
-Variances banned: the wording that refers to the banning of a variance
-Council considerations: the wording that refers to the city council’s management of a variance
[New construction]: phrases pertaining to new construction occurring near the wellhead