Hydraulic Fracturing in the Barnett Shale

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GIS in Water Resources

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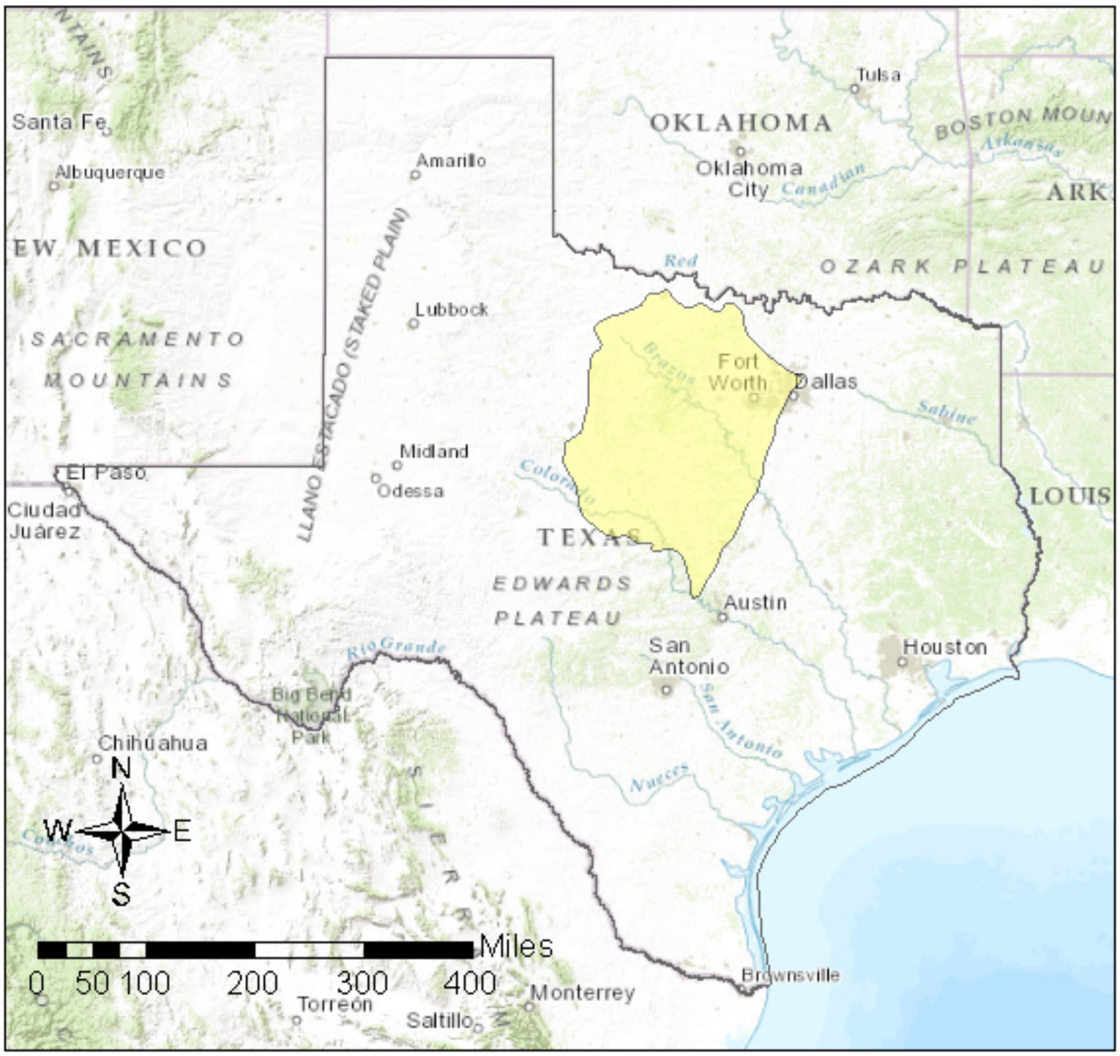

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I. Introduction

Hydraulic Fracturing, or fracking, is a process by which natural gas is extracted from shale rock. It is a well-stimulation technique where fluid is injected into deep rock formations to fracture it. The fracking fluid contains a mixture of chemical components with different purposes. Proppants like sand are used in the fluid to hold fractures in the rock open once the hydraulic pressure is removed. Fracking fluid also contains biocides, surfactants, friction reducers, buffers, and corrosion inhibitors.[1] Many different chemicals can be used to achieve particular effects. Companies change the chemical blend depending on the exact conditions found at the well. When the pressure is reduced, the gas is free to be pumped back to the surface for use.

Fracking is a key method in extraction unconventional oil and gas reserves. According to the international Energy Agency, there are an estimates 208 trillion cubic meters of shale gas alone.[2] Hydraulic fracturing can be used to access shale gas, tight gas, tight oil, and coal seam gas.[3] This large production of previously inaccessible fuel has made fracking a fast-growing and profitable industry. However, fracking remains controversial due to potential environmental fallout such as ground and surface water contamination or Earthquakes along previously unknown faults.[4]

The EPA is currently developing a report on the potential impacts of fracking on drinking water resources. They have developed an analysis of the different ways water is used in the process (Fig.1).[5] First, large volumes of water are taken from ground or surface water sources and mixed with different chemical additives. The EPA hydraulic fracturing study plan lists 1000 known chemical additives. They range from materials like silica sand for proppants to buffers like acetic acid, to metals, like cadmium. The fracking fluid mix is injected into the well at high pressure to crack geological formations and allow oil or gas to escape to the well for collection. The water that returns from the well after injection is caused Produced Water. It contains the original components of the fracking fluid along with oil or gas from the bed. This produced water must be treated specially to remove all contaminants before entering the water supply. [5]

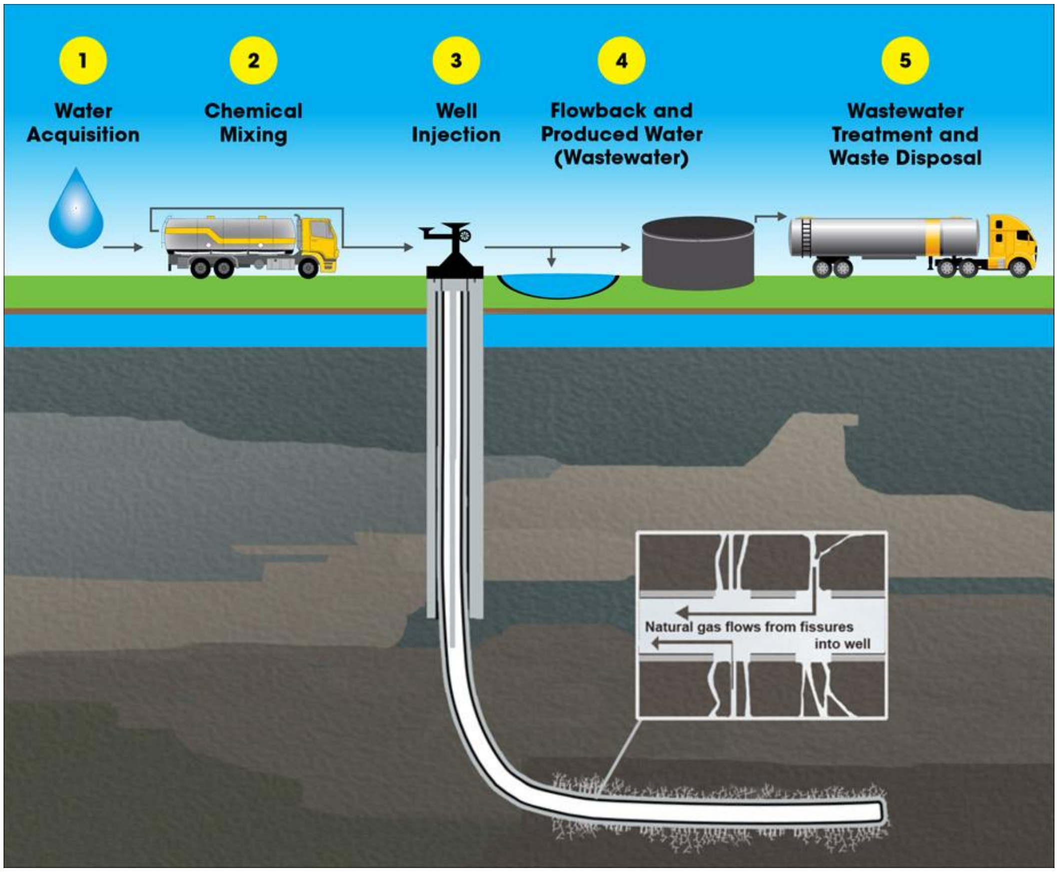

Figure 1: Hydraulic Fracturing Water Cycle [5]

Fracking puts water resources at risk in different manners. Drilling requires thousands of gallons of water to be removed from local sources and turned into a fracking fluid mixture. The loss of natural water resources can cause aquifer levels to drop or reduce necessary flow rates in rivers. For example, a single well in the Barnett Shale can use 2.8 million gallons of water in two years.[6] When the fracking fluid is injected into the subsurface, some of the water can escape through the layers of shale into groundwater, brining along contaminants dangerous to the health of people who drink from groundwater wells. Additionally, the flowback water containing the contaminants is stored, but can leak, running off into surface water and damaging the local ecosystem. A large quantity of water is consumed by hydraulic fracturing that can cause contamination to drinking water. There are many different concerns for water resources as a result of hydraulic fracking.

Shale gas is a tight gas reserve that cannot be obtained through conventional drilling. Shale is a sedimentary rock formed from particles settling in calm waters and is typically high in organic content.[7] A shale play is a specific term used by the oil and gas industry that describes an area with an "economic quantity" of oil or gas present.[7] Normally, heat and pressure cause these gases to rise into porous rock, creating conventional reservoirs; however, in the case of shale, the gas is trapped and can only be obtained through fracking. There are 38 shale plays in the continental United States (Fig 2).[8]

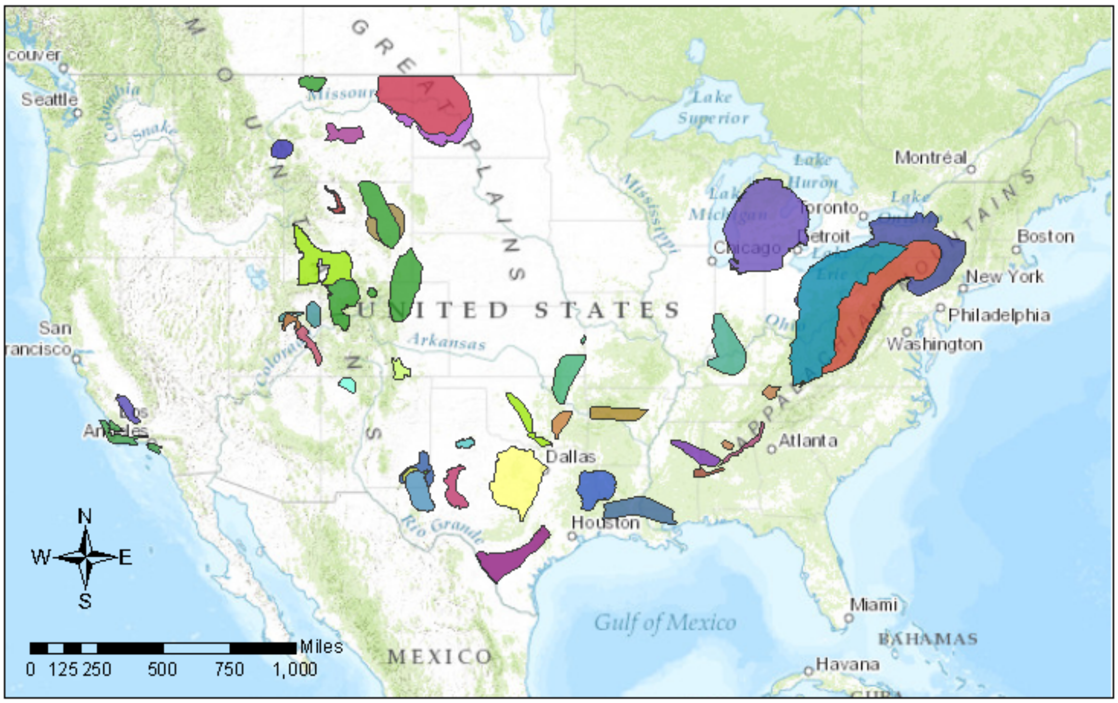

Figure 2: Shale plays in the continental United States

The objective of this research paper is to evaluate trends in the production of natural gas within the Barnett Shale and identify the risks to local water resources and the population.

II. Barnett Shale

i. Geologic Information

The Barnett Shale is a geologic feature found in north-central Texas underlying approximately 5000 square miles and at least 18 counties.[9] It is directly beneath the Dallas-Fort Worth Metroplex. Barnett shale is considered a tight reservoir, where most of the natural gas is inaccessible by traditional drilling and requires fracking.

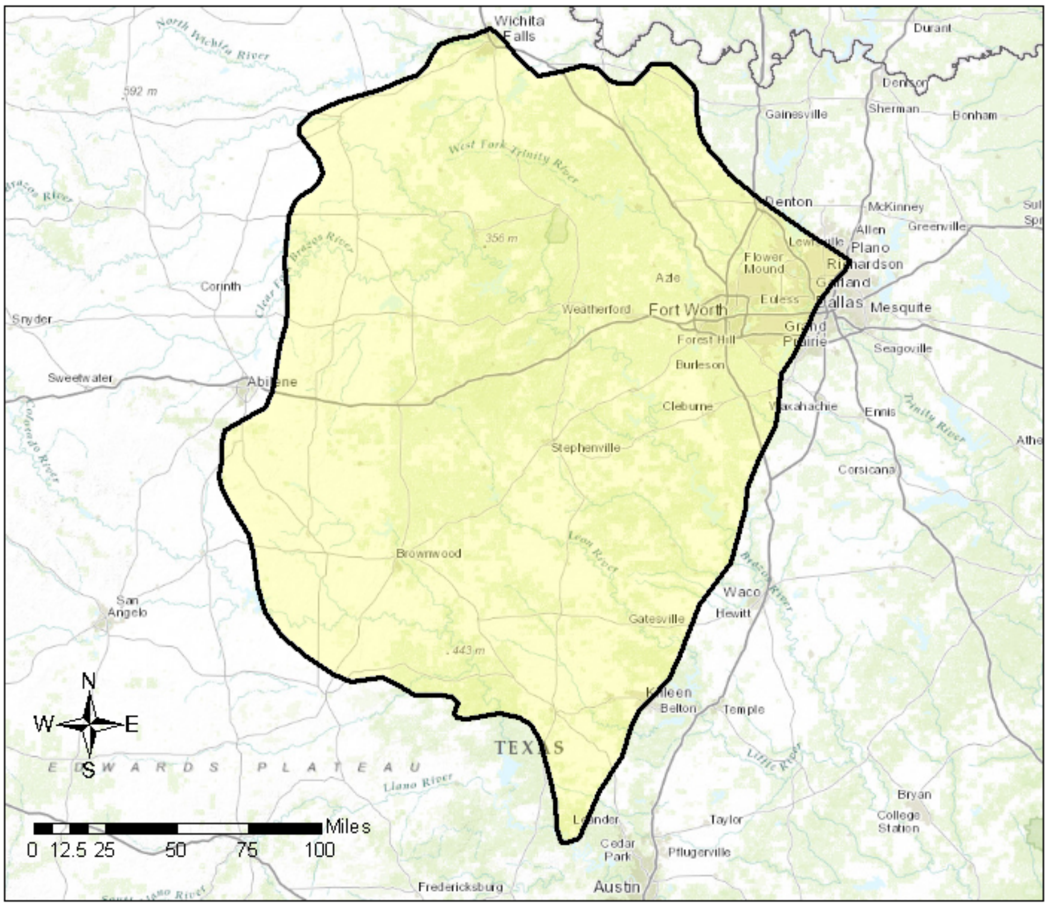

Figure 3: Barnett Shale play boundary

The boundary of the shale play is given here as determined by the Railroad Commission of Texas (RRC).[9] The outline is overlaid on a Topographic map provided by ESRI, as are all following maps.

ii. Gas Production

Although the Barnett shale extends over a large area, not all areas have significant drilling exports or high enough concentrations to be economically viable. There are 13 counties where the majority of natural gas drilling has taken place over the course of the last two decades. [9]

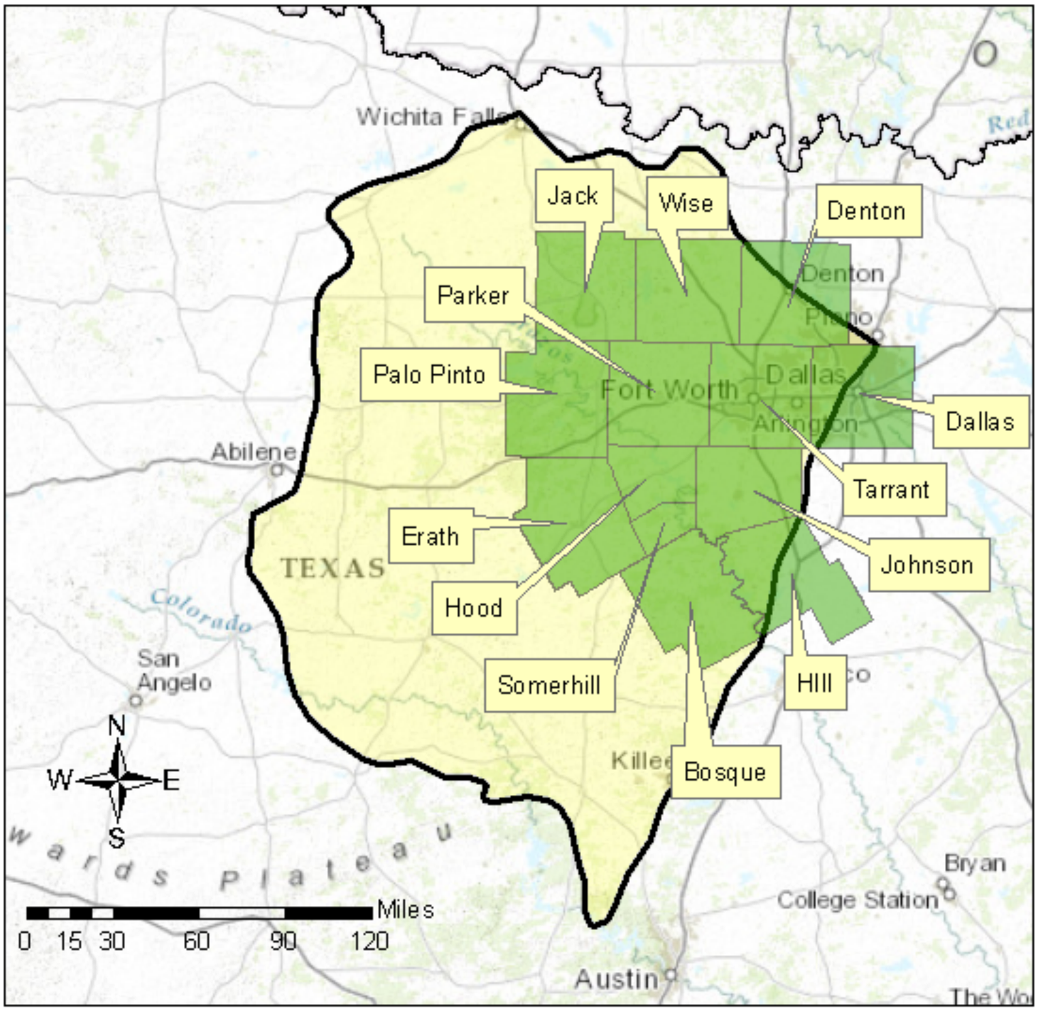

Figure 4: Production counties of the Barnett shale

Hydraulic fracturing in the Barnett shale began in the 1990s but expanded greatly in the past decade. The highest volume of production has occurred in Tarrant and Johnson counties. The production in these 13 counties was obtained from the Texas Railroad Commission (RRC), which regulates land use and permits.[9] Natural gas production values were obtained for 2001, 2006, 2011, and 2014 to provide a five-year interval along with the most recent full year's data. Production is measured by Mcf, which is one thousand cubic feet, of natural gas.

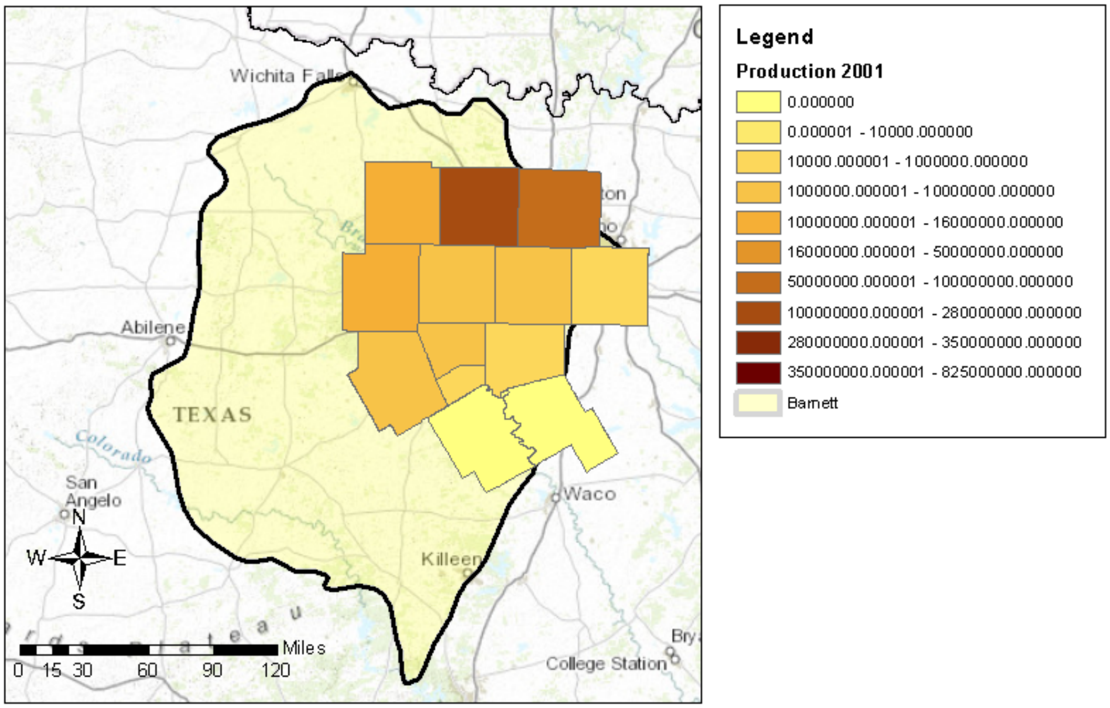

Figure 5: Natural Gas Production in 2001

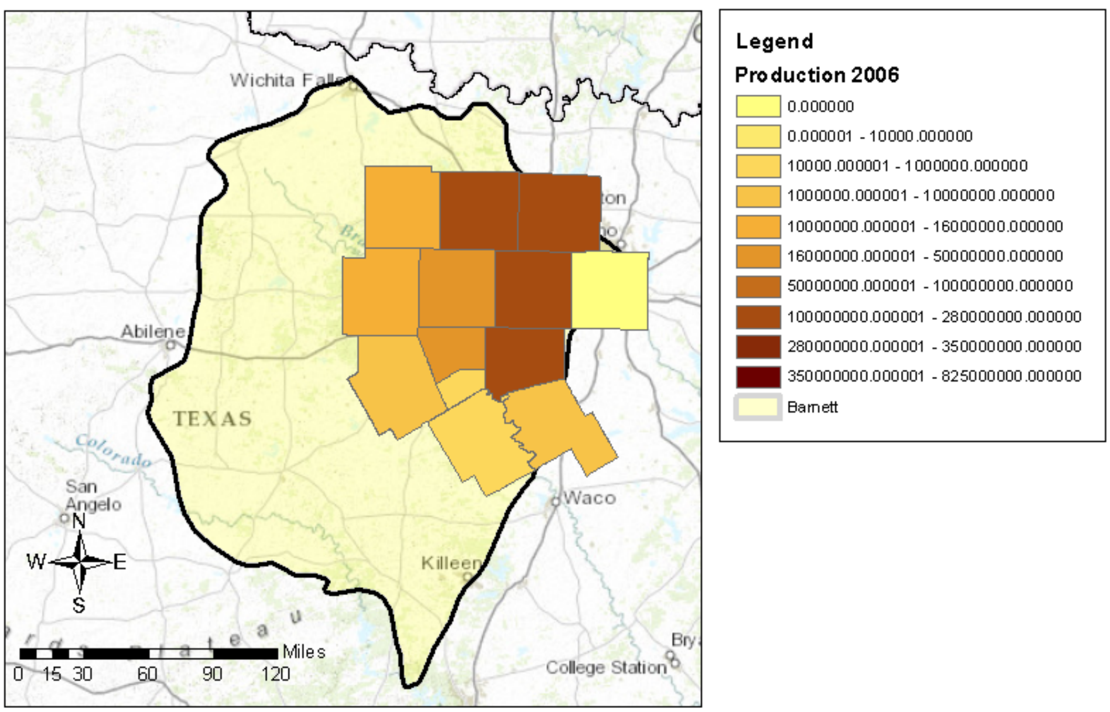

Figure 6: Natural Gas Production in 2006

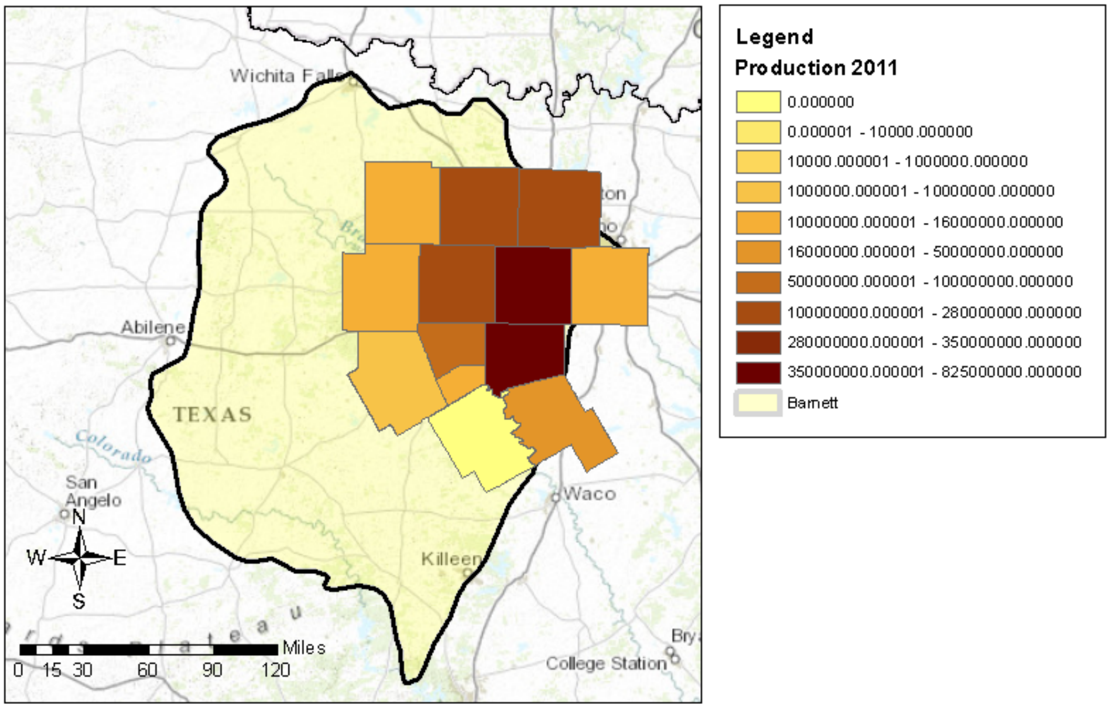

Figure 7: Natural Gas Production in 2011

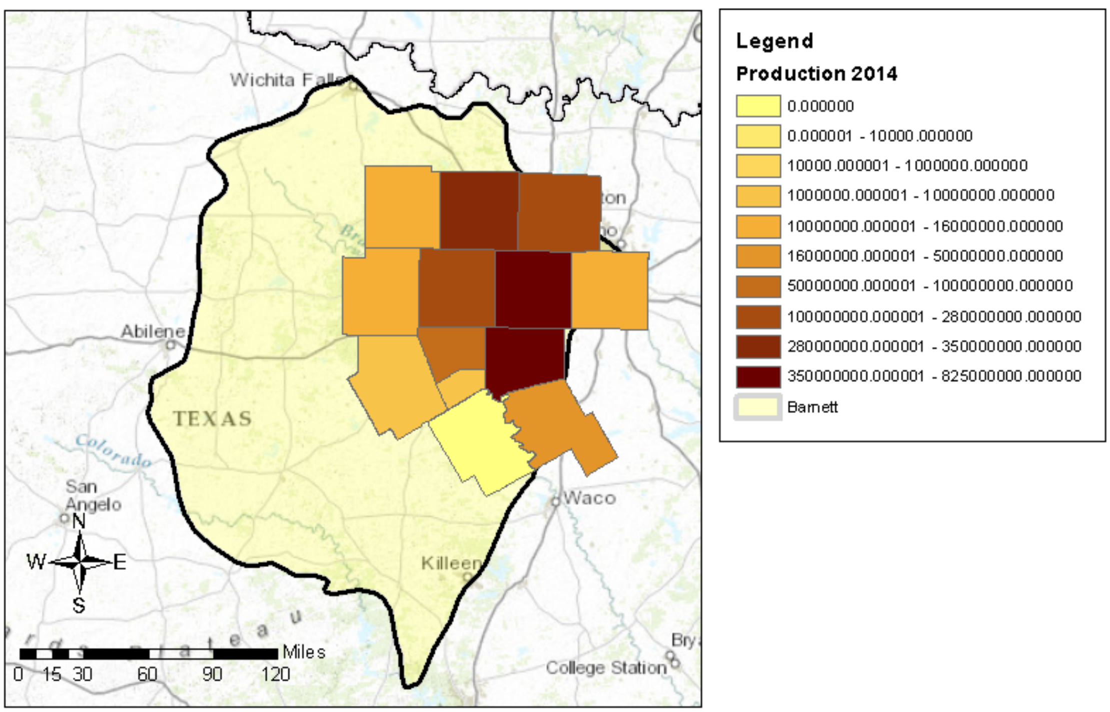

Figure 8: Natural Gas Production in 2014

Table 1: Total Natural Gas Production per County

County	Annual Natural Gas Production (Mcf)			
	2001	2006	2011	2014
Bosque	0	38350	83,581	0
Dallas	24,475	0	12,381,431	10,866,878
Denton	60,753,257	169550792	278,428,124	247,336,561
Erath	3,053,976	3713394	7,393,054	4,800,499
Hood	1,206,935	16080329	62,373,193	51,690,301
Hill	0	3413394	26,000,770	16,145,783
Jack	14,233,639	14722178	13,774,812	12,234,503
Johnson	22,366	165429145	570,891,649	350,266,558
Palo Pinto	13,864,784	15115430	13,779,093	11,840,629
Parker	6,896,674	42178676	103,116,008	108,978,306
Somerville	20,941	352078	10,805,795	5,655,496
Tarrant	3,584,227	177909974	823,110,042	738,824,997
Wise	117,113,693	175368654	263,457,508	281,343,105
TOTAL	**220,774,967**	**783,872,394**	**2,185,595,060**	**1,839,983,616**

The total natural gas produced form these 13 counties in 2011 is almost 10 times the total production in 2001. This is a huge increase in energy production and well construction, causing large draws of water and many instances of potential contamination. The increase in production was largely due to advances in fracking by using sand in the fracking fluid to hold open cracks before the high underground pressures sealed up the fissures. In the past several years, natural gas production has reduced in part due to the lack of easily acceptable drilling locations due to the urban expansion of the Dallas-Fort Worth area. However, while the trend indicates a reduction in total production, there was still over 1.8 trillion cubic feet of natural gas produced in 2014 and those high values are likely to continue.

III. Water Resources

i. Texas Aquifers

There are 9 major aquifers and 21 minor aquifers in Texas.

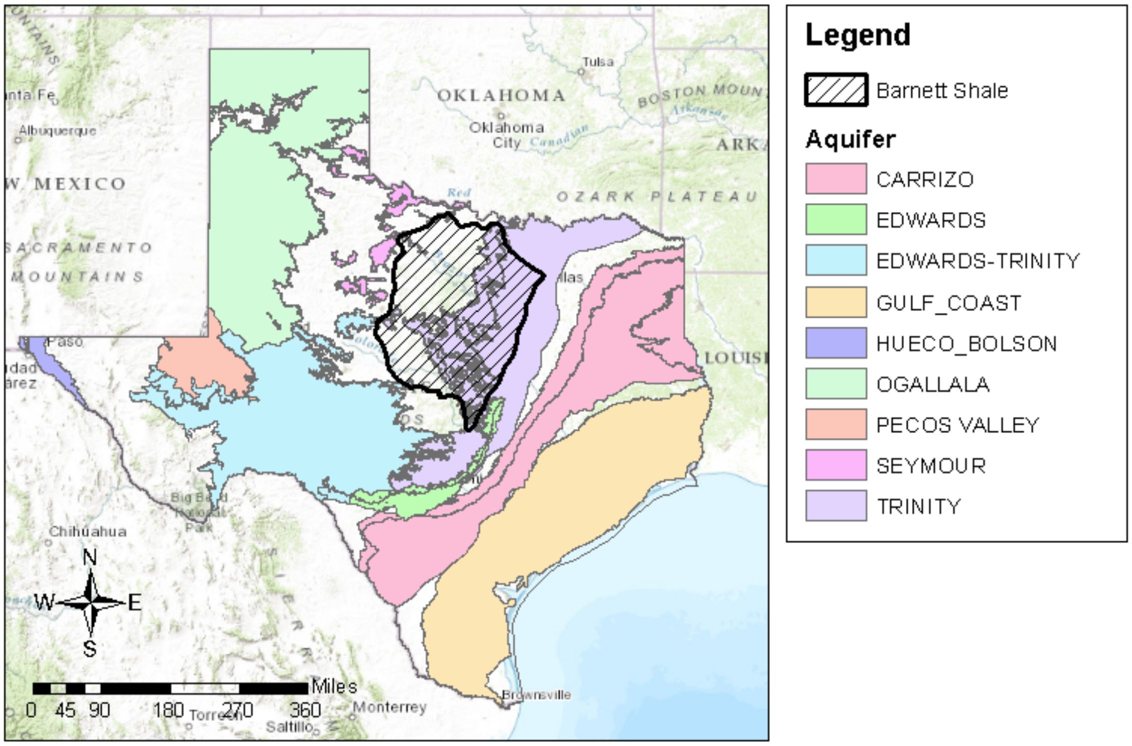

Figure 9: Major Aquifers of Texas[10]

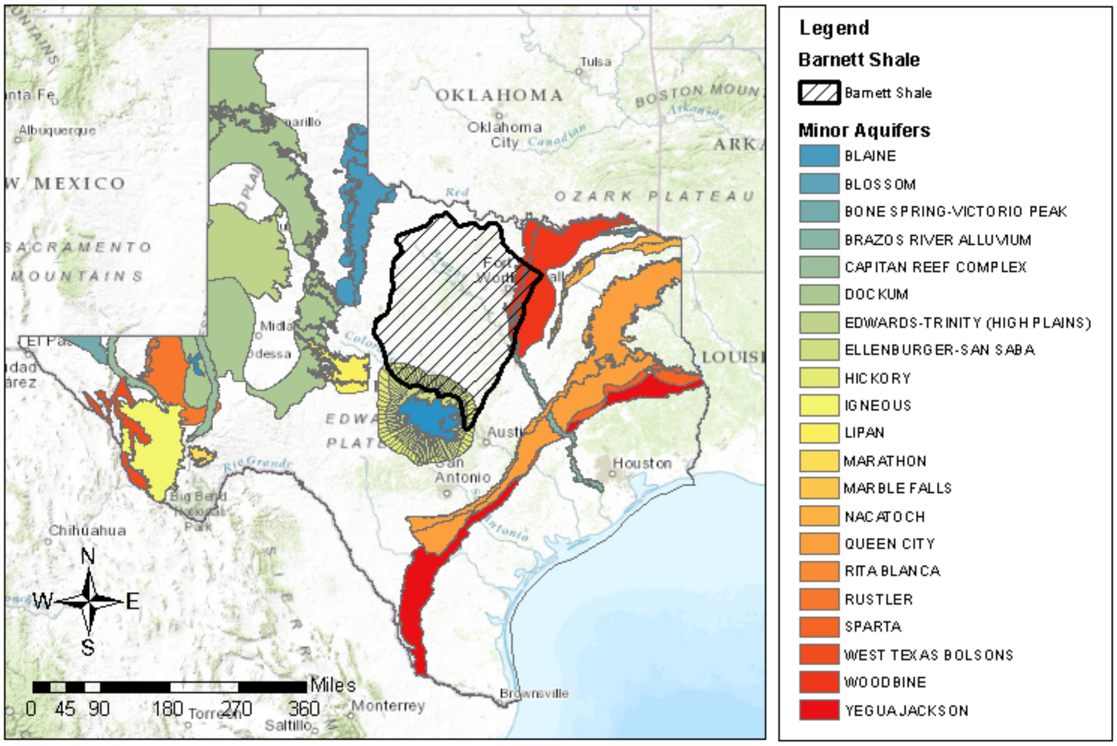

Figure 10: Minor Aquifers of Texas[11]

According to the Texas Water Resources board, the main aquifer in the Barnett Shale is the Trinity aquifer. The Trinity aquifer is composed of a number of smaller aquifers within it which result in it being on of the most highly used groundwater resources.[12] It serves primarily municipalities, but is also used for agriculture and livestock. It averages about 600 feet in North Texas, but it recharges slowly.[12]

ii. Groundwater Wells

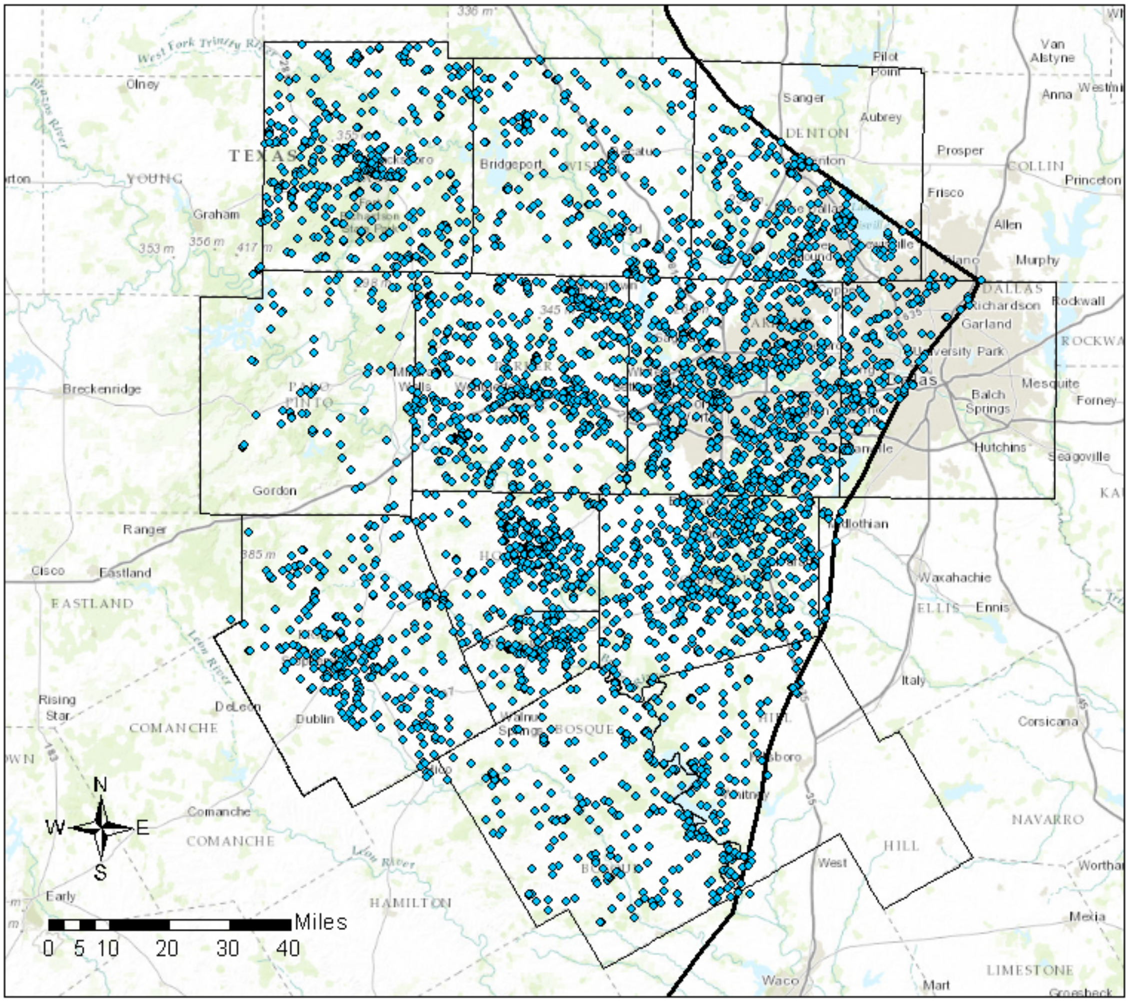

Figure 11: Groundwater wells over the Barnett shale[13]

There are 4596 wells present in the 13 production counties above the shale. Comparing Figures 9, 10, and 11 shows that these wells take water from the Trinity aquifer or the Woodbine aquifer. These wells mostly supply municipal water, which is sued for drinking, bathing, cooking, and cleaning. Possible fracking fluid contamination in these wells could have negative consequences for the public and the environment.

IV. Population and Land Cover

Table 3: Population by County from the 2010 Census[14]

County	Population	County	Population
Bosque	17,780	Johnson	157,456
Dallas	2,518,638	Palo Pinto	28,096
Denton	753,363	Parker	123,164
Erath	40,147	Somerville	8,694
Hood	53,921	Tarrant	1,945,360
Hill	34,848	Wise	61,638
Jack	8,855	**Total**	5,751,960

The Barnett Shale's size and location in north central Texas results in a large population. The highest population in is Dallas and Tarrant counties, where Dallas-Fort Worth is located, but there are still significant numbers of people living in the remaining counties on land drilled for natural gas. There are 5.75 million people in total living in the Barnett Shale production counties.

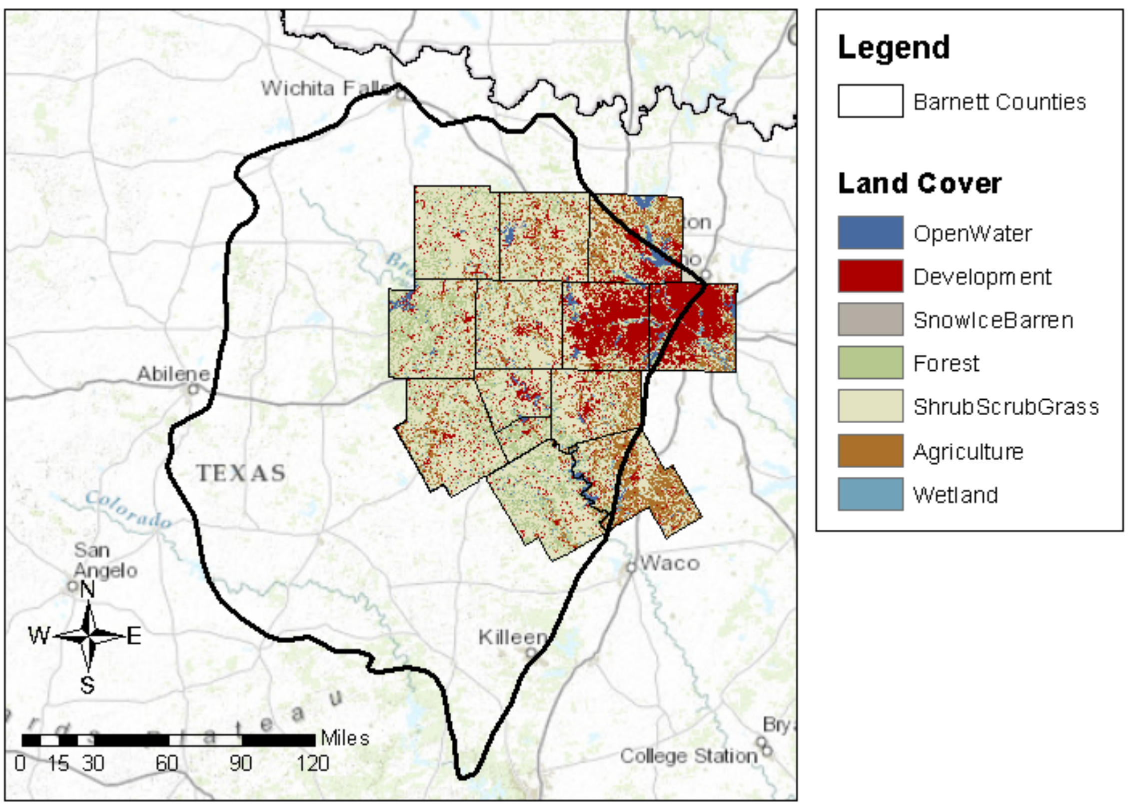

Figure 12: Land cover of the Barnett counties in 2006 obtained from the National Land Cover Database[15]

Table 2: Area of the Seven Major Land Classes from 2006 National Land Cover Database

Land Cover Class	Area	Percentage of total land cover
Agriculture	5,550,778	21.95%
Development	7,687,695	30.40%
Forest	7,960,359	31.47%
Open Water	1,236,416	4.88%
Shrub/Scrub/Grass	2,134,513	8.44%
Snow/Ice/Barren	87,303	0.345%
Wetland	635,098	2.51%

The three largest land uses over the Barnett Shale counties are Agriculture, Development, and Forest. Agricultural lands normally draw water from wells in their local region. The major aquifer turns into local aquifers in the western counties of Jack, Palo Pinto, and Erath, and thee farmers have to use local groundwater for their needs. A spill in a local aquifer would be contained, but more highly concentrated.

The high development percentage, 30.4%, is due to the Dallas-Fort Worth metroplex, which is home to 3.4 million people from the Dallas and Tarrant counties. This large urban area has not prevented the development of the fracking industry because of the use of horizontal drilling. However, the use of most available areas from which to construct wells has caused some limitations to further production. The high percentage of forest area indicates that either agricultural or developed land could expand out into less densely populated regions in the future.

V. Conclusion

There are 5.75 million people living in the main production counties of the Barnett shale, 3.75 million whom live in urban areas of the Dallas-Fort Worth metroplex. Over 30% of the land cover is developed, showing the high urbanization. The majority of public water is drawn from the Trinity aquifer, which also intersects the Barnett Shale. A total of 1.8 trillion cubic feet of natural gas was produced in the main thirteen counties of the Barnett shale. Although this number is slightly lower than the production in previous years, the production of natural gas through fracking is unlikely to cease, as there were 32.6 trillion cubic feet of proved reserves remaining in the formation as of 2011.[16]

Hydraulic fracturing is a process by which natural gas is harvested using a great quantity of water. It is profitable industry that provides jobs to many people. Fracking in the Barnett Shale alone has provided 119,000 jobs in Texas, 100,000 of them in Fort Worth.[17] With trillions of cubic feet of shale gas available and the fast consumption of non-renewable energy sources, natural gas seems like a highly beneficial option for U.S. energy interests.

However, the cost in damages from fracking is not yet entirely understood and cannot be fully quantified. From the perspective of water resources, water is used in high quantities to produce the fracking fluid that is injected into the ground. The components within the fluid can cause contamination to groundwater for drinking water. Finally, the water that is returned from fracking has to be treated carefully, requiring energy to clean the water so that it is safe to be released back into the environment. Industry representatives claim that layers of rock precludes contaminants from escaping into groundwater, but in 2009, methane was found in Colorado's water wells, all found within the same rock layer.[18] Exact proof is not easy to come by due to the lack of research into the situation and the economic interests at play. The EPA is developing a comprehensive report to analyze the impacts of fracking to drinking water that will hopefully provide concrete information regarding water risk.[5]

Although production in the Barnett Shell has somewhat reduced in the past several years, millions of cubic feet of natural gas are still produced annually. Without changes towards renewable energy or proof of causation of the negative effects of fracking, this production will continue. A great deal of information remains to be processed about the environmental ramifications of hydraulic fracturing and the potential risks to the water supply.

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