Journal of Rural Social Sciences

Volume 24
Issue 3 *Special Issue: The Pedagogy of Rural Sociology*

Article 7

12-31-2009

Paradoxical Perceptions of Problems Associated with Unconventional Natural Gas Development

Gene L. Theodori
Sam Houston State University

SOUTHERN RURAL SOCIOLOGY, 24(3), 2009, pp. 97–117.

PARADOXICAL PERCEPTIONS OF PROBLEMS ASSOCIATED WITH UNCONVENTIONAL NATURAL GAS DEVELOPMENT*

GENE L. THEODORI
SAM HOUSTON STATE UNIVERSITY

ABSTRACT

Data collected in a general population survey from a random sample of individuals in two counties located in the Barnett Shale region of Texas were used to empirically explore potentially problematic issues associated with unconventional natural gas development. Moderate support was found for the hypothesis that individuals residing in places with diverse levels of energy development exhibit dissimilar perceptions of potentially problematic issues. The results indicate residents of the county where the natural gas industry was more mature (Wise County) were significantly more likely than residents of the county where the natural gas industry was less established (Johnson County) to view one social and/or environmental issue more negatively and five economic and/or service-related issues more positively. Johnson County residents, however, were more likely than their Wise County counterparts to view two social and/or environmental issues as getting worse. These findings may prove beneficial to community leaders, government and regulatory agencies, environmental organizations, and other stakeholders, as well as the oil and gas industry in decision-making processes. The results may also serve as a foundation around which to design future studies to assess the objective social and environmental effects of unconventional energy development.

The exploration and production of natural gas in unconventional reservoirs (i.e., tight gas sands, coal bed methane resources, and gas shales) has greatly increased over the last several decades (Kuuskraa, Godec, and Reeves 2007). In 2006, of the 18.6 trillion cubic feet (tcf) of natural gas produced in the U.S., roughly 43 percent (8.5 tcf) was from unconventional sources (EIA, 2008a). A decade and a half earlier, in 1990, the ratio of unconventional gas production to total domestic production was .16 (or 2.8 tcf of the total 17.2 tcf produced) (Kuuskraa and Stevens 1995). Recent projections by the Energy Information Administration (EIA 2009), the statistical agency of the U.S. Department of Energy, suggest onshore production of unconventional natural gas will increase to 13.3 tcf in the year 2030. In essence, unconventional natural gas will constitute over half (56%) of the projected 23.6 tcf total natural gas production in approximately twenty years (EIA 2009).

---

*Support for this research was provided by the Renewable Resources Extension Act. An earlier version of this paper was presented at the annual meetings of the Southern Rural Sociological Association held in Dallas in February 2008. I wish to thank Ann Theodori, Al Luloff, John Veil, David Burnett, and Rich Haut for helpful comments on the paper. Address correspondence to: Gene L. Theodori, Sam Houston State University, Department of Sociology, Box 2446, Huntsville, TX 77341-2446; gtheodori@shsu.edu.

Presently, tight sand formations account for the largest share of unconventional gas production in the U.S., and natural gas produced in gas shale formations is "the fastest-growing source" (Stowers 2009: 38). According to Stowers (2009: 38), "With an estimated 267 trillion cubic feet of undiscovered, technically recoverable resources, production of natural gas from shale formations is forecast to rise from 1.2 tcf in 2007 to 4.2 tcf, about 18% of total U.S. production, in 2030." As of August of 2009, it was estimated that roughly 70% of gas shale production in the United States came from one gas shale basin located in north-central Texas known as the Barnett Shale (*Oil & Gas Financial Journal* 2009).

The Barnett Shale is currently the most productive gas field in the state of Texas and is considered, at the time of writing this paper, to be the most productive in the nation (see Smith 2009a, 2009b). Estimates for 2007 placed production in the Barnett Shale reservoir at 3.7 billion cubic feet per day (bcfd) (The Perryman Group 2008). More recent estimates place production in the Barnett between 4.9 bcfd (see Smith 2009a) and 5.5 bcfd (see Smith 2009b). As of 2007, the Barnett Shale accounted for 4.3 percent of the total natural gas production in the U.S. (The Perryman Group 2008). In 2008, production in the Barnett Shale was estimated at 1.396 tcf, which represented 19.0% of Texas production and 5.3% of total U.S. production (The Perryman Group 2009).

Substantial energy development in the Barnett Shale began in 2001. Technological advances in horizontal drilling techniques and hydraulic fracturing methods (commonly called "fracing"), coupled to a favorable price environment, were the primary factors spawning the unprecedented exploration and production activities in the once written-off gas shale of north-central Texas. Engineers and geologists for years have documented the development of the Barnett Shale (Ambrose, Potter, and Briceno 2008; Bowker 2003, 2007; Kuuskraa et al. 1998; Montgomery et al. 2005; Pollastro 2007). They have assessed the amounts of known, undeveloped, and technically recoverable natural gas in the reserve. The aggregate economic impact of the Barnett Shale also received much attention over the past few years (The Perryman Group 2007, 2008, 2009; Weinstein and Clower 2004, 2006). In 2008, the total economic impact of Barnett Shale-related activity on the local economy was estimated at $11.0 billion, an increase of roughly $2.6 billion from the previous year and approximately $5.0 billion from 2006 (The Perryman Group 2009).

The horizontal drilling techniques and hydraulic fracturing methods developed, tested and refined in the Barnett Shale are presently being implemented in rural areas, as well as in and around rural, suburban, and urban communities situated in

gas shale basins across the United States. A review of the extant energy boomtown and/or energy-related development literature, however, revealed surprisingly little sociological research directed toward understanding the potentially positive aspects and negative consequences associated with *unconventional* energy development in the Barnett Shale or in other geographical areas where this form of energy development is—or is quickly becoming—an integral part of local society (Anderson and Theodori 2009; Gulliford 1989; Theodori 2008).

The purpose of this paper is to advance the social scientific literature on the unconventional energy industry. Specifically, public perception of potentially problematic issues associated with natural gas development in two Barnett Shale counties with differing levels of established energy development is investigated. In doing so, the hypothesis that individuals residing in places with diverse levels of energy development exhibit dissimilar perceptions of potentially problematic issues is tested.

ANALYTICAL APPROACH

An extensive research literature exists on energy boomtowns and/or energy-related development in conventional reservoirs (both onshore and offshore), particularly from data collected in rural communities throughout the western United States and southern Louisiana communities (Albrecht 1978; Coelho 2006; Cortese and Jones 1977; Forsyth, Luthra, and Bankston 2007; Freudenburg and Gramling 1993, 1994, 1998; Gramling 1996; Gramling and Freudenburg 1996; Molotch, Freudenburg, and Paulsen 2000; Murdock and Leistritz 1979; Weber and Howell 1982; Wilkinson et al. 1982). One primary objective of much of the extant energy boomtown literature has been to empirically document the objective consequences—positive and negative—associated with rapid energy-related growth at the local level. Less attention has been given to the subjective interpretations of energy development (cf. Greider and Krannich 1985; Webb, Krannich, and Clemente 1980).

Rooting to earlier work by Thomas and Znaniecki (1927) and Hastorf, Schnieder, and Polefka (1970), Webb, Krannich, and Clemente (1980: 86), in their study of the socioeconomic impacts as perceived by local leaders in communities that had experienced the nearby development of large-scale electric generating facilities, avowed "To the extent that perceptions comprise the fundamental basis of social reality … perceptual measures of impact may represent a key approach to assessing the consequences of development projects." Working from a similar theoretical perspective, Greider and Krannich (1985) elaborated on the importance

of including subjective interpretations of possible social problems in rapid-growth, boomtown communities. As they asserted, "It seems clear that analysis which focuses solely or even predominately upon objective conditions within a community is likely to miss that which is most important in understanding social reality in that community" (p. 82).

Although social reality tends to be "soft" as it is being produced, it can ultimately become "hard" in its effects (Berger and Luckmann 1966). This paper draws upon Webb et al. (1980) and Greider and Krannich (1985) to examine the public's perception of potentially problematic issues associated with unconventional natural gas development. Knowledge and understanding of local residents' subjective interpretations of such issues will prove beneficial to community leaders, government and regulatory agencies, environmental organizations, and other stakeholders, as well as the oil and gas industry in their decision-making processes.

STUDY SITES

The study-sites included Wise and Johnson Counties, Texas. These counties were purposely chosen to reflect differing levels of established energy development.[1] As of 2005, the year when the present research was conceptualized, the vast majority of natural gas production in the Barnett Shale reservoir had occurred in the Newark East field, which spans portions of Wise, Denton, and Tarrant Counties (Hayden and Pursell 2005). From these three counties, Wise County, where much of the initial development was performed after the first well completion in 1981, was selected to represent a site with relatively mature development. Conversely, Johnson County, the county referred to at the time as an emerging "sweet spot" (Hayden and Pursell 2005: 33), was chosen to represent a site where large-scale exploration and production activities were just beginning.

As of September 2001, there were 2,584 regular producing gas wells in Wise County and only two regular producing gas wells in Johnson County (Railroad Commission of Texas 2001). Four years later, in September 2005, the number of regular producing gas wells in Wise County increased to 3,447, while the number of regular producing gas wells in Johnson County jumped to 144 (Railroad Commission of Texas 2005). Between September of 2005 and February 2009, regular producing gas wells in Wise County increased by roughly 12% (n = 3,860).

[1] In addition to energy development, major sources of economic activity in Wise County include agribusiness, recreation, sand and gravel, and hunting leases. Major sources of economic activity in Johnson County include agribusiness, railroad shops, manufacturing, distribution, and lake activities (Texas Almanac 2004).

During the same time period, Johnson County witnessed an unprecedented increase of approximately 1,216% (n = 1,895) (Railroad Commission of Texas 2009a).

Gas and oil well production data in the two counties from January 2001 through December 2005, as well as between January 2009 and June 2009, are reported in Table 1. Included in the table are figures for the amount of gas well natural gas (i.e., wells without completions for the production of oil), condensate (i.e., natural gas liquid recovered from gas wells from lease separators or field facilities), casinghead gas (i.e., natural gas produced along with crude oil from oil wells), and oil. As shown in Table 1, production of natural gas from gas wells in Wise County between 2001 and 2005 increased by approximately 59% (from 107,790,926 thousand cubic feet (mcf) to 171,854,918 mcf). Concomitantly, gas well gas production in Johnson County during that same time period increased by almost 313,000% (from 20,971 mcf to 65,649,807 mcf). Between January 1, 2009 and June 30, 2009, gas wells in Wise County produced 103,482,228 mcf of natural gas, while those in Johnson County produced 249,473,518 mcf. During the first six months of 2009, gas wells in Johnson County produced more than three times the amount of natural gas produced between 2001 and 2005.

Both counties are situated within the Dallas-Fort Worth-Arlington Metropolitan Statistical Area (MSA) and contain numerous rural communities. Wise County is located on the northwestern edge of the MSA and covers 922.8 square miles (land area = 904.6 square miles) (Texas Almanac 2004). The population of Wise County in 2000 was 48,793; the 2005 estimated county population was 55,794 (see Table 2). Wise County's largest town and county seat of government is Decatur. Decatur's 2000 population was 5,201; its 2005 population estimate was 5,946. Other incorporated places in Wise County include: Alvord, Aurora, Boyd, Bridgeport, Chico, Lake Bridgeport, Newark, New Fairview, Paradise, Rhome, and Runaway Bay.

Johnson County, located on the southwestern edge of the MSA, is 734.5 square miles (land area = 729.4 square miles) (Texas Almanac 2004). The population of Johnson County in 2000 was 126,811; the 2005 estimated county population was 144,030 (see Table 2). Cleburne is the county seat of government and the largest municipality wholly located within the boundaries of Johnson County. Cleburne's population in 2000 was 26,005, while the 2005 estimate was 29,006. Other incorporated places in Johnson County include: Alvarado, Briaroaks, Burleson, Cross Timber, Godley, Grandview, Joshua, Keene, Rio Vista, and Venus. Crowley (2000 population = 7,467; 2005 population estimate = 9,673) and Mansfield (2000

TABLE 1. PRODUCTION DATA FROM GAS AND OIL WELLS IN WISE AND JOHNSON COUNTY: 2001 THROUGH 2005 AND JANUARY, 2009 THROUGH JUNE 2009

COUNTY	TIME PERIOD	GAS WELL GAS (MCF)	CONDENSATE (BBL)	CASINGHEAD (MCF)	OIL (BBL)
WISE	2001	107,790,926	290,786	6,214,921	419,064
	2002	129,271,227	505,921	5,946,546	377,528
	2003	164,909,730	595,195	5,684,199	375,936
	2004	175,096,223	593,192	5,492,683	350,650
	2005	171,854,918	646,991	5,754,185	398,328
	Total 2001 through 2005	748,923,024	2,632,085	29,092,534	1,921,506
	January 2009 through June 2009	103,482,228	452,620	3,157,186	219,398
JOHNSON	2001	20,971	0	0	0
	2002	27,881	0	0	0
	2003	1,292,783	0	0	0
	2004	14,897,805	6,595	0	0
	2005	65,649,807	16,583	0	0
	Total 2001through 2005	81,889,247	23,178	0	0
	January 2009 through June 2009	249,473,518	33,503	0	0

Source: Railroad Commission of Texas 2009b.

TABLE 2. 2000 POPULATION AND 2005 POPULATION ESTIMATES FOR WISE COUNTY, JOHNSON COUNTY, AND MUNICIPALITIES LOCATED WITHIN EACH COUNTY

COUNTY[a] AND MUNICIPALITY [b]	2000 POPULATION	2005 POPULATION ESTIMATE
WISE COUNTY	48,793	55,794
Alvord	1,007	1,347
Aurora	853	991
Boyd	1,099	1,279
Bridgeport	4,309	5,749
Chico	947	1,052
Decatur	5,201	5,946
Lake Bridgeport	372	417
Newark[c]	887	1,036
New Fairview	877	1,005
Paradise	459	507
Rhome	551	852
Runaway Bay	1,104	1,308
JOHNSON COUNTY	126,811	144,030
Alvarado	3,288	3,941
Briaroaks	493	526
Burleson[c]	20,976	29,391
Cleburne	26,005	29,006
Cross Timber	277	299
Godley	879	975
Grandview	1,358	1,543
Joshua	4,528	5,047
Keene	5,003	6,079
Rio Vista	656	715
Venus	910	2,210

NOTES: [a]Source: U.S. Census Bureau 2008a; [b]Source: U.S. Census Bureau 2008b; [c]Extends partly into Tarrant County.

population = 28,031; 2005 population estimate = 37,880), both recognized primarily as Tarrant County municipalities, extend partly into Johnson County. Cresson, which was incorporated in 2001, is recognized primarily as a Hood County municipality and extends partly into Johnson County. Cresson's population estimate for 2005 was 683 (U.S. Census Bureau 2008b).

DATA AND MEASUREMENT

Data were collected in a general population survey from a random sample of individuals in the two counties. In March 2006, interviews were conducted with six key informants in Wise County and 18 key informants in Johnson County to help identify timely and salient local social, economic, and environmental issues related to energy development (Anderson and Theodori 2009). The data gathered in the key informant interviews assisted in the development of a household survey questionnaire. Using a modified total design method (Dillman 1978), the household questionnaire data were gathered using mail survey techniques. During the late spring and early summer of 2006, this survey questionnaire was delivered via U.S. Postal Service to 1,533 randomly selected households in the two counties (749 households in Johnson County; 784 households in Wise County).[2]

To obtain a representative sample of individuals within residences, a response was requested from the adult in the household who most recently celebrated his/her birthday. The survey instrument, organized as a self-completion booklet, contained 42 questions and required approximately 60 minutes to complete. After the initial survey mail out, a post card reminder, and two follow-up survey mailings, a 39 percent response rate was achieved. This resulted in 600 completed questionnaires between the two sites (301 questionnaires in Johnson County; 299 questionnaires in Wise County). Comparisons of selected sociodemographic and economic characteristics between the sample and Census data are included in Appendix A.

Dependent Variables

Perceived problematic issues associated with natural gas development rather than objective conditions were the dependent variables of interest in this paper. Respondents were presented with a list of 30 items which may or may not have

[2] The survey questionnaire was initially mailed to 800 randomly selected households in each county. Fifty one questionnaires were returned as undeliverable from Johnson County; 16 came back from Wise County. None of the 67 undeliverable household addresses were replaced with new ones. Therefore, these 67 households were not factored into the final sample size. The sampling frames from which the samples were drawn consisted of county tax rolls.

been perceived to be problematic in their county.[3] Regardless if the respondent viewed the issue as problematic, he/she was asked to indicate whether the issue was "getting worse," "getting better," or "staying the same" with the continued development of natural gas. Responses were coded as -1 (issue is getting worse), 0 (issue is staying the same), and 1 (issue is getting better).

Independent Variable

To assess the public's perception of potentially problematic issues associated with natural gas development in the study sites with differing levels of established energy development, county of residence was dummy coded (0 = Johnson County; 1 = Wise County) to indicate where the respondent resided. The use of this measure enabled multivariate testing of variation between respondents from the two counties on the 30 perceptual statements.

Control Variables

Building upon previous research (Theodori 2008, 2009), four variables – length of residence in the county, mineral rights ownership, personal/familial ties to the natural gas industry, and perception of the natural gas industry—were included as control factors. Length of residence in the county was measured in years. Mineral rights ownership (0 = does not own mineral rights; 1 = owns mineral rights) and personal/familial ties to the natural gas industry (0 = respondent and/or family members not employed either part-time or full-time in an occupation related to the natural gas industry; 1 = respondent and/or family members employed either part-time or full-time in an occupation related to the natural gas industry) were both dummy coded. Perception of the natural gas industry was assessed using a list of ten statements. Respondents were asked to indicate their level of agreement/disagreement with each of the following items: (a) in the long run, I'm sure that people in this area will be better off if our natural gas resources are developed; (b) natural gas industry operators in this area are too politically powerful; (c) not enough information concerning the development of natural gas is being made available to the general public; (d) even when carefully controlled,

[3] In March 2006, prior to the development and administration of the household questionnaire, key informant interviews were conducted in both counties to gain qualitative insights and help identify the timely and salient local social, economic, political, and environmental issues. The key informants were asked about potentially problematic issues associated with natural gas development. The 30 items included in the questionnaire emerged during the interviews with the key informants in both sites.

natural gas development is likely to upset the quality of life in a local area; (e) too little attention is being paid to the social costs of natural gas development; (f) the natural gas companies have no compassion for our natural environment; (g) natural gas operators MUST adopt and use more environmentally friendly drilling practices; (h) natural gas companies will do only what's required by law; (i) natural gas operators are drilling and producing too close to homes and businesses; and, (j) all in all, the benefits of natural gas development for this area are greater than the costs. Response categories included (1) strongly agree, (2) agree, (3) disagree, and (4) strongly disagree. After reverse coding items "b" through "i," a composite perceptual score was calculated by averaging the responses for the individual items. High scores reflected more negative views of the natural gas industry; low scores indicated more positive notions. A principal components factor analysis with oblique rotation revealed that these perceptual measures were unidimensional and explained 54 percent of the variance. Cronbach's alpha for this public perception scale was 0.90.

ANALYSIS

The 30 issues were ranked in ascending order by overall mean score (see Table 3). At the aggregate level, 24 of the 30 issues had negative mean values, indicating the respondent perceived the issue as getting worse (albeit in varying degrees) with the continued development of natural gas. Most, if not all, of these 24 issues can be classified as social and/or environmental concerns. The issue of 'increased truck traffic' had the highest negative mean value followed by the 'amount of freshwater used.' Conversely, six of the 30 issues had positive mean values, suggesting respondents perceived these issues as getting better with natural gas development. Included here in ascending order were: poverty, local police protection, medical and health care facilities, quality of local schools, fire protection services, and availability of good jobs. These six issues can be viewed as economic and/or service-related concerns.

Also shown in Table 3 are the Johnson and Wise County respondents' adjusted mean scores for each perceptual problematic issue. As was the case in the aggregate, the 'increased truck traffic' issue had the highest mean negative value and 'availability of good jobs' had the highest mean positive value for both Johnson and Wise County residents. Statistical significance of the observed perceptual differences between the respondents from the two counties was tested using

TABLE 3. PERCEIVED PROBLEMATIC ISSUES ASSOCIATED WITH NATURAL GAS DEVELOPMENT (SAMPLE SIZES IN PARENTHESES).

PERCEIVED PROBLEMATIC ISSUE	OVERALL MEAN	ADJUSTED MEAN VALUES BY COUNTY[a]	
		Wise Co.	Johnson Co.
Increased truck traffic.	-0.73	-0.73 (193)	-0.73 (176)
Amount of freshwater used by gas producers.	-0.56	-0.55 (191)	-0.56 (170)
High tax rates.	-0.45	-0.48 (199)	-0.41 (184)
Depletion of aquifers.	-0.44	-0.50 (187)	-0.38 (175)
Noise pollution.	-0.42	-0.41 (202)	-0.44 (185)
Water pollution***	-0.39	-0.49 (197)	-0.27 (181)
Traffic accidents.	-0.39	-0.42 (195)	-0.36 (177)
Loss of privacy.	-0.38	-0.42 (193)	-0.32 (172)
Environmental quality.	-0.36	-0.38 (191)	-0.35 (175)
Land use conflicts.	-0.35	-0.38 (188)	-0.32 (173)
Conditions of roads and streets*	-0.33	-0.25 (203)	-0.42 (188)
Air pollution.	-0.33	-0.30 (196)	-0.37 (182)
Odors/fumes from drilling equipment.	-0.30	-0.25 (193)	-0.35 (173)
Light from gas drilling operations.	-0.28	-0.24 (190)	-0.33 (174)
Population growth*	-0.26	-0.18 (188)	-0.35 (174)
Use of illegal drugs.	-0.25	-0.29 (194)	-0.21 (181)
Crime.	-0.20	-0.16 (199)	-0.25 (186)
Fire hazards.	-0.20	-0.20 (192)	-0.20 (178)
Gas well explosions.	-0.13	-0.10 (186)	-0.17 (170)
Respect for law and order.	-0.12	-0.10 (200)	-0.14 (188)
Disagreements among local residents.	-0.08	-0.08 (180)	-0.09 (178)
Absence of zoning regulations.	-0.07	-0.05 (195)	-0.09 (184)
Effectiveness of county government.	-0.04	-0.07 (197)	-0.01 (188)
Effectiveness of city government.	-0.04	-0.03 (198)	-0.05 (186)
Poverty**	0.05	0.14 (194)	-0.04 (184)
Local police protection.	0.08	0.12 (201)	0.03 (188)
Medical and health care services***	0.12	0.26 (201)	-0.02 (185)
Quality of local schools**	0.12	0.20 (201)	0.02 (186)
Fire protection services*	0.14	0.21 (192)	0.08 (179)
Availability of good jobs***	0.36	0.47 (195)	0.24 (189)

NOTES: [a]Mean values were adjusted for the covariate values; *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

analysis of covariance (ANCOVA).[4] In terms of overall negative mean values, residents of Wise County—the county where the natural gas industry was more mature—were significantly more likely than residents of Johnson County—the county where the natural gas industry was less established—to perceive the issue of 'water pollution' as getting worse because of natural gas development. Johnson County residents, however, were more likely than their Wise County counterparts to view the issues of 'conditions of roads and streets' and 'population growth' as getting worse. Concomitantly, with respect to the issues with overall positive mean values, Wise County residents were significantly more likely than Johnson County residents to view the following as getting better: poverty, medical and health care services, quality of local schools, fire protection services, and availability of good jobs. In general, moderate support was found for the hypothesis that individuals residing in places with diverse levels of energy development exhibit dissimilar perceptions of potentially problematic issues.

DISCUSSION AND CONCLUDING COMMENTS

The findings reported in this paper suggest a rather broad range of perceived negative and positive issues associated with natural gas development. When asked about potentially problematic issues associated with natural gas development, survey respondents generally considered social and/or environmental issues as "getting worse" due to development. Overall, the problematic issue perceived to be worsening the most in both counties was 'increased truck traffic.' This finding, which parallels a critical concern uncovered during interviews with key informants in both counties (Anderson and Theodori 2009), is a real and relatively important consequence of increased energy development. Semi-trailer trucks, eighteen wheelers, and/or other big rig transport trucks are used to deliver drilling equipment, materials, and supplies to the drill site. The same types of trucks are also used to transport large quantities of freshwater (the second-most problematic issue perceived to be associated with natural gas development) to the drill sites for hydraulic fracturing and, concomitantly, haul produced and flowback waters,[5] as well as drill cuttings and other waste materials, from the drill site to disposal sites. In a recent report detailing the truck traffic impact associated with the development

[4] The four control variables were included in the analyses as covariates.

[5] Produced water refers to water present in an underground hydrocarbon-bearing formation that is brought to the surface with crude oil or natural gas. Flowback water refers to the water that returns to the surface after it has been injected into a well to fracture formations.

of oil and gas wells in the Uinta Basin of northeastern Utah, Daniel Kuhn of the Utah Department of Transportation estimated the construction of every new oil or gas well required between 365 and 1,730 truckloads of equipment, materials, and supplies (Utah Department of Transportation 2007). Increased truck traffic volumes produce accelerated roadway deterioration and pose health and safety concerns, especially on narrow, steep, winding, and/or unpaved roads commonly found in rural areas.

Like increased truck traffic volumes, the amount of freshwater used by gas producers—the second-most potentially problematic concern identified by the respondents in both counties—is also a very real and relatively important consequence of unconventional energy development and one that continues to generate increased controversy (Capozza 2009). In this study, over one-half of the respondents in Wise and Johnson counties viewed the amount of freshwater used by gas producers as getting worse due to the continued development of natural gas. Freshwater is a primary ingredient used in the process of hydraulic fracturing. Hydraulic fracturing is a long-standing, yet increasingly controversial, practice in the energy industry and one of particular importance to unconventional energy development (Wiseman 2009). Wells are fractured by flushing large quantities of "frac fluid"—a mixture of freshwater, sand, and small amounts of friction reducers (e.g., partially hydrolyzed polyacrylamides and ethylenediaminetetraacetic acid)[6]—into them at extremely high pressure levels to create cracks, or "fractures," in the rock formations. This allows the natural gas to flow more freely through the shale formations and, in turn, increases recovery.

It has been estimated that more than nine in ten wells drilled in unconventional shale reservoirs around the county must be fractured to become commercially viable (Steinway and Jackson 2009). With wells being drilled to deeper depths, current frac jobs are utilizing larger volumes of water than used in the past. Frac jobs commonly use 1.2 million to 3.5 million gallons of water per gas well (Bené et al. 2007). In some cases, water use may exceed 5.0 million gallons per frac (Anderson and Theodori 2009). Water for well frac operations is in the Barnett Shale comes from both groundwater and surface water sources. In a recent assessment of groundwater use in the Trinity and Woodbine aquifers, Bené et al. (2007) estimated that total water demand for gas well development in the Barnett Shale in 2005 was

[6]Information on the friction reducers was obtained via personal communication with David B. Burnett, Director of the Global Petroleum Research Institute at Texas A&M University, July 27, 2009.

roughly 7,200 acre-feet (or 2.35 billion gallons). Of this total, about 4,300 acre-feet (60%) was supplied by groundwater from the two aquifers. Groundwater use in 2005 for gas well development in the Barnett Shale accounted for approximately 3% of total groundwater use. The authors asserted that by 2025 groundwater use for gas well development may reach 7 to 13% of the total groundwater use.

Conversely, economic and/or service-related issues such as poverty, local police protection, quality of local schools, fire protection services, medical and health care services, and availability of good jobs were all viewed as "getting better" because of the development of natural gas. Energy exploration and production activities in the Barnett Shale are generating vast sums of tax revenues for State and local taxing jurisdictions. In a study of the economic and fiscal impacts of one energy corporation operating in a nine-county region of the Barnett Shale, Weinstein and Clower (2006) estimated in 2005 Devon Energy Corporation paid roughly $62 million in severance taxes to the State of Texas and approximately $45 million in ad valorem taxes to local taxing entities. Of the $45 million that went into local tax coffers that year, counties and county agencies, such as hospital and community college districts, received about $8 million; municipalities received roughly $1.1 million; area school districts received more than $35 million; and other local taxing authorities received approximately $94,000 (Weinstein and Clower 2006). It is important to understand these 2005 estimated State and local tax revenues were drawn from only one company. While Devon Energy Corporation remains the top producer in the Barnett Shale (*Oil & Gas Financial Journal* 2009), there are numerous exploration and production companies operating there which substantially multiply these economic and fiscal impacts.

The Perryman Group (2008) estimated that Barnett Shale-related activity resulted in the payment of roughly $212.1 million in severance taxes to the State of Texas in 2007, which was up from $165.4 million in 2006. Tax receipts to local entities (i.e., counties, municipalities, and school districts) exceeded $378.7 million in 2007 (The Perryman Group 2008). According to The Perryman Group (2008), counties received approximately $82.9 million, municipalities collected roughly $119.6 million, and school districts garnered an estimated $176.3 million. Tax revenue totals for 2007 for Wise and Johnson counties were estimated at $72.5 million and $64.5 million, respectively (The Perryman Group 2008). The total amount for Wise County included an estimated $15.4 million to the county, $24.3 million to the county's municipalities, and $32.8 million to the county's school districts. For Johnson County, the estimated amounts were $16.5 million to the county, $12.4 million to the municipalities, and $35.6 million to the school districts.

In essence, the results of this study reveal a paradox among the general population. On one hand, it appears the members of the general public typically dislike the potentially problematic social and/or environmental issues perceived to accompany natural gas development. However, on the other hand, local citizens generally appreciate and view favorably the economic and/or service-related benefits that normally accompany such development. Coincidently, as revealed by the results of the statistical analyses, this paradox was more pronounced in Wise County, the site where the natural gas industry is more mature. Residents of Wise County were significantly more likely than residents of Johnson County to view five of six economic and/or service-related issues (i.e., poverty, quality of local schools, fire protection services, medical and health care services, and availability of good jobs) more positively.[7]

Based upon the results of this study, a primary recommendation posed to the energy industry, community leaders, government and regulatory agencies, environmental organizations, and other stakeholders is that open and full communication is paramount. The energy industry must inform local residents about the potentially positive aspects and negative consequences of energy development in and around their communities. At the same time, community leaders, government and regulatory agencies, environmental organizations, and other stakeholders must effectively communicate their hopes, fears, and/or anxieties associated with unconventional gas development to each other and, in turn, to industry. Open and honest communication will reduce the spread of rumors and inaccuracies about perceived negative consequences of current activities and proposed developments at the local level. Furthermore, county and municipal leaders must communicate the concerns of their constituents to industry and work with them to minimize the negative "objective" aspects of the unconventional gas recovery process. Examples of successful partnerships are evident in the Barnett Shale (The Perryman Group 2007), as well as in communities in and around the Piceance Basin in Colorado (Norris 2009; Utesch 2009). Counties and municipalities are effectively negotiating road maintenance and repair agreements with

[7] Previous analyses of the key informant interview data collected in both counties (Anderson and Theodori 2009) revealed a pattern opposite to that of the general public with respect to the service and/or economic benefits associated with energy development. Like the general population, key informants in both counties recognized the service and/or economic benefits of energy development. However, Johnson County key informants were more optimistic about such benefits than Wise County informants.

exploration and production companies; many companies are proactively taking steps to reduce water use, as well as lighting and noise levels, during drilling operations.

Moreover, the energy industry must do a better job of educating the general public by promoting its low-impact technologies and other environmentally friendly drilling systems which have substantially reduced adverse impacts in the social and environmental arenas (Haut et al. 2009). However, industry must recognize that it alone will not change public (mis)perceptions of problems associated with unconventional natural gas development. Oil and natural gas producers and service companies must partner and work with government and regulatory agencies, environmental organizations, and other stakeholders if they are to correct misconceptions and gain the public's trust.

Finally, the extent to which the perceptions of problems associated with unconventional natural gas development correspond to objective conditions is an empirical issue worthy of future investigation. As exploration and production activities quickly commence in gas shale basins in the U.S. (e.g., Fayetteville Shale, Haynesville Shale, Marcellus Shale, New Albany Shale) and across the globe, the perceptual issues examined in this paper may serve as a foundation around which to design future studies to examine the objective social and environmental effects of unconventional energy development.

REFERENCES

Albrecht, Stan L. 1978. "Socio-Cultural Factors and Energy Resource Development in Rural Areas in the West." *Journal of Environmental Management* 7:73–90.

Ambrose, William A., Eric C. Potter, and Romulo Briceno. 2008. "An 'Unconventional' Future for Natural Gas in the United States." *Geotimes: Earth, Energy and Environment News* (February). Retrieved May 27, 2008 (http://www.geotimes.org/feb08/article.html?id=feature_gas.html).

Anderson, Brooklynn J. and Gene L. Theodori. 2009. "Local Leaders' Perceptions of Energy Development in the Barnett Shale." *Southern Rural Sociology* 24: 113–29. Retrieved September 12, 2009 (http://www.ag.auburn.edu/auxiliary/srsa/pages/Articles/SRS%202009%2024%201%20113-129.pdf).

Bené, James, Bob Harden, Stephanie W. Griffin, and Jean-Phillipe Nicot. 2007. *Northern Trinity/Woodbine Aquifer Groundwater Availability Model Assessment of Groundwater Use in the Northern Trinity Aquifer Due to Urban Growth and Barnett Shale Development.* Retrieved September 19, 2009 (http://www.twdb.state.tx.us/RWPG/rpgm_rpts/0604830613_BarnetShale.pdf).

Berger, Peter L. and Thomas Luckmann. 1966. *The Social Construction of Reality.* Garden City, NY: Doubleday.

Blalock, Hubert M. 1972. *Social Statistics.* New York: McGraw-Hill.

Bowker, Kent A. 2003. "Recent Developments of the Barnett Shale Play, Fort Worth Basin." *West Texas Geological Society Bulletin* 42:4–11.

_____. 2007. "Barnett Shale Gas Production, Fort Worth Basin: Issues and Discussion." *American Association of Petroleum Geologists Bulletin* 91:523–33.

Capozza, Richard. 2009. "Marcellus Shale: A Modern-Day Gold Rush." *Oil & Gas Financial Journal* 6:32–6.

Coelho, Karen. 2006. "The Footprint of the Offshore Oil Industry on Community Institutions." *Research in Economic Anthropology* 24:123–62.

Cortese, Charles F. and Bernie Jones. 1977. "The Sociological Analysis of Boom Towns." *Western Sociological Review* 8:76–90.

Dillman, Don A. 1978. *Mail and Telephone Surveys: The Total Design Method.* New York: John Wiley and Sons.

EIA (Energy Information Administration). 2008a. *Annual Energy Outlook 2008* (Early Release). Retrieved May 22, 2008 (http://www.eia.doe.gov/oiaf/aeo/production.html).

_____. 2008b. *Is U.S. Natural Gas Production Increasing?* Retrieved October 25, 2008 (http://tonto.eia.doe.gov/energy_in_brief/natural_gas_production.cfm).

_____. 2009. *Annual Energy Outlook 2009 with Projections to 2030.* Retrieved June 13, 2009 (http://www.eia.doe.gov/oiaf/aeo/gas.html).

Forsyth, Craig J., Asha D. Luthra, and William B. Bankston. 2007. "Framing Perceptions of Oil Development and Social Disruption." *Social Science Journal* 44:287–99.

Freudenburg, William R. and Robert Gramling. 1993. "Socioenvironmental Factors and Development Policy: Understanding Opposition and Support for Offshore Oil." *Sociological Forum* 8:341–64.

_____. 1994. *Oil in Troubled Waters: Perceptions, Politics, and the Battle Over Offshore Drilling.* Albany, NY: State University of New York Press.

_____. 1998. "Linked to What? Economic Linkages in an Extractive Economy." *Society and Natural Resources* 11:569–86.

Gramling, Robert. 1996. *Oil on the Edge: Offshore Development, Conflict, Gridlock.* Albany, NY: State University of New York Press.

Gramling, Robert. and William R. Freudenburg. 1996. "Crude, Coppertone®, and the Coast: Developmental Channelization and Constraint of Alternative Development Opportunities." *Society and Natural Resources* 9:483–506.

Greider, Thomas R. and Richard S Krannich. 1985. "Perceptions of Problems in Rapid Growth and Stable Communities: A Comparative Analysis." *Journal of the Community Development Society* 16:80–96.

Gulliford, Andrew. 1989. *Boomtown Blues: Colorado Oil Shale, 1885-1985.* Niwot, CO: University Press of Colorado.

Hastorf, Albert H., David J. Schneider, and Judith Polefka. 1970. *Person Perception.* Reading, MA: Addison-Wesley.

Haut, Richard C., David Burnett, Tom Williams, and Gene Theodori. 2009. "By Adopting Low-Impact Technologies, Industry Can Change Perceptions, Open Off-Limits Acreage." *Drilling Contractor* (March/April): 90, 92–3.

Hayden, Jeff and Dave Pursell. 2005. *The Barnett Shale: Visitors Guide to the Hottest Gas Play in the US.* Houston: Pickering Energy Partners, Inc.

Kuuskraa, Vello A. and Scott H. Stevens. 1995. "How Unconventional Gas Prospers Without Tax Incentives." *Oil and Gas Journal* 93(December 11):76–81.

Kuuskraa, Vello A., George Koperna, James W. Schmoker, and John C. Quinn. 1998. "Barnett Shale Rising Star in Fort Worth Basin." *Oil and Gas Journal* 96(May 25):67–76.

Kuuskraa, Vello A., Michael Godec, and Scott R. Reeves. 2007. "Outlook Sees Resource Growth During Next Decade." *Oil and Gas Journal* 105(November 19):47.

Molotch, Harvey, William Freudenburg, and Krista E. Paulsen. 2000. "History Repeats Itself, But How? City Character, Urban Tradition, and the Accomplishment of Place." *American Sociological Review* 65:791–823.

Montgomery, Scott L., Daniel M. Jarvie, Kent A. Bowker, and Richard M. Pollastro. 2005. "Mississippian Barnett Shale, Fort Worth Basin, North Central Texas: Gas-shale Play with Multi-trillion Cubic Foot Potential." *American Association of Petroleum Geologists Bulletin* 89:155–75.

Murdock, Steve H. and F. Larry Leistritz. 1979. *Energy Development in the Western United States: Impact in Rural Areas.* New York: Praeger Publishers.

Norris, Sean. 2009. "BMPs in a Changing Operational Philosophy." Presented at Best Practices for Community and Environmental Protection Workshop, October 14, Rifle, CO.

Oil & Gas Financial Journal. 2009. "Devon Energy Ranks No. 1 in Barnett Shale." *Oil & Gas Financial Journal* 6:24.

Pollastro, Richard M. 2007. "Total Petroleum System Assessment of Undiscovered Resources in the Giant Barnett Shale Continuous (Unconventional) Gas Accumulation, Fort Worth Basin, Texas." *American Association of Petroleum Geologists Bulletin* 91:551–78.

Railroad Commission of Texas. 2001. *Gas Well Counts by County as of September 2001.* Retrieved September 12, 2009 (http://www.rrc.state.tx.us/data/wells/wellcount/gaswlct0901.pdf).

_____. 2005. *Gas Well Counts by County as of September 2005.* Retrieved September 12, 2009 (http://www.rrc.state.tx.us/data/wells/wellcount/gaswlct0905.pdf).

_____. 2009a. *Gas Well Counts by County as of February 2009.* Retrieved September 12, 2009 (http://www.rrc.state.tx.us/data/wells/wellcount/gaswellct0209.pdf).

_____. 2009b. *Oil & Gas Production Data Query.* Retrieved September 12, 2009 (http://webapps.rrc.state.tx.us/PDQ/generalReportAction.do).

Smith, Jack Z. 2009a. "Deposits of Natural Gas are at Record Level." *Fort Worth Star-Telegram*, June 18. Retrieved June 18, 2009 (http://www.star-telegram.com/business/story/1442327.html).

_____. 2009b. "Barnett Shale is Top U.S. Natural Gas Producer, Chesapeake CEO Says." *Fort Worth Star-Telegram*, June 19. Retrieved June 19, 2009 (http://www.star-telegram.com/business/story/1444043.html).

Steinway, Daniel M. and Thomas C. Jackson. 2009. "Hydraulic Fracturing: The Current State of Play." *Oil & Gas Financial Journal* 6:4–7.

Stowers, Don. 2009. "Unconventional Gas Outlook to 2020." *Oil & Gas Financial Journal* 6:37–8.

Texas Almanac. 2004. *Texas Almanac 2004-2005.* Dallas, TX: The Dallas Morning News.

The Perryman Group. 2007. *Bounty from Below: The Impact of Developing Natural Gas Resources Associated with the Barnett Shale on Business Activity in Fort Worth and the Surrounding 14-County Area.* Retrieved August 12, 2009 (http://www.barnettshaleexpo.com/docs/Barnett_Shale_Impact_Study.pdf).

_____. 2008. *Drilling for Dollars: An Assessment of the Ongoing and Expanding Economic Impact of Activity in the Barnett Shale on Fort Worth and the Surrounding Area.* Retrieved August 12, 2009 (http://www.barnettshaleexpo.com/docs/2008_Report.pdf).

_____. 2009. *An Enduring Resource: A Perspective on the Past, Present, and Future Contribution of the Barnett Shale to the Economy of Fort Worth and the Surrounding Area.* Retrieved August 12, 2009 (http://www.barnettshaleexpo.com/docs/2009_eco_report.pdf).

Theodori, Gene L. 2008. "Public Perception of the Natural Gas Industry: Insights from Two Barnett Shale Counties" SPE 115917. Presented at 2008 Society of Petroleum Engineers Annual Technical Conference and Exhibition, September 24, Denver, CO.

_____. 2009. "Public Opinion on Exploration and Production of Oil and Natural Gas in Environmentally Sensitive Areas." Presented at the 16th International Petroleum & BioFuels Environmental Conference, November 3, Houston, TX.

Thomas, William I. and Florian Znaniecki. 1927. *The Polish Peasant in Europe and America.* New York: Knopf.

U.S. Census Bureau. 2000a. *Wise County, Texas - DP - 1. Profile of General Demographic Characteristics: 2000.* Retrieved November 18, 2009 (http://factfinder.census.gov/servlet/QTTable?_bm=n&_lang=en&qr_name=DEC_2000_SF1_U_DP1&ds_name=DEC_2000_SF1_U&geo_id=05000US48497).

_____. 2000b. *Johnson County, Texas - DP - 1. Profile of General Demographic Characteristics: 2000.* Retrieved November 18, 2009 (http://factfinder.census.gov/servlet/QTTable?_bm=n&_lang=en&qr_name=DEC_2000_SF1_U_DP1&ds_name=DEC_2000_SF1_U&geo_id=05000US48251).

_____. 2008a. *Table 1: Annual Estimates of the Population for Counties of Texas: April 1, 2000 to July 1, 2007 (CO-EST2007-01-48).* Retrieved August 12, 2009 (www.census.gov/popest/counties/tables/CO-EST2007-01-48.xls).

_____. 2008b. *Table 4: Annual Estimates of the Population for Incorporated Places in Texas, Listed Alphabetically: April 1, 2000 to July 1, 2007 (SUB-EST2007-04-48).* Retrieved August 12, 2009 (www.census.gov/popest/cities/tables/SUB-EST2007-04-48.xls).

Utah Department of Transportation. 2007. *Oil & Gas Truck Traffic Impacts on U.S. 40 Corridor, Utah.* Retrieved August 12, 2009 (http://www.udot.utah.gov/us40study/docs/Final_oil-gas_rpt.pdf).

Utesch, Peggy. 2009. "Rifle, Silt, New Castle Community Development Plan: A Collaborative Planning Approach to Natural Gas Development." Presented at Best Practices for Community and Environmental Protection Workshop, October 14, Rifle, CO.

Webb, Stephen, Richard Krannich, and Frank Clemente. 1980. "Power Plants in Rural Area Communities: Their Size, Type and Perceived Impacts." *Journal of the Community Development Society* 11:81–95.

Weber, Bruce A. and Robert E. Howell. 1982. *Coping with Rapid Growth in Rural Communities*. Boulder, CO: Westview.

Weinstein, Bernard L. and Terry L. Clower. 2004. *The Economic and Fiscal Impacts of Devon Energy in Denton, Tarrant, and Wise Counties*. Retrieved August 12, 2009 (http://www.unt.edu/cedr/devonenergy.pdf).

_____. 2006. *The Economic and Fiscal Impacts of Devon Energy Corporation in the Barnett Shale of North Texas: An Update*. Retrieved August 12, 2009 (http://www.unt.edu/cedr/devonenergy2006.pdf).

Wilkinson, Kenneth P., James G. Thompson, Robert R. Reynolds, Jr., and Lawrence M. Ostresh. 1982. "Local Social Disruption and Western Energy Development: A Critical Review." *Pacific Sociological Review* 25:275–96.

Wiseman, Hannah. 2009. "Untested Waters: The Rise of Hydraulic Fracturing in Oil and Gas Production and the Need to Revisit Regulation." 20 *Fordham Environmental Law Review* 115.

APPENDIX A. SELECTED SOCIODEMOGRAPHIC AND ECONOMIC CHARACTERISTICS OF THE SAMPLE AND U.S. CENSUS DATA

	WISE COUNTY		JOHNSON COUNTY	
SELECTED CHARACTERISTICS	U.S. CENSUS DATA[a]	SAMPLE DATA	U.S. CENSUS DATA[b]	SAMPLE DATA
Percent 18 to 20 years of age.	3.7	0.0	4.2	0.4
Percent 21 to 64 years of age.	57.4	66.9	57.0	71.9
Percent 65 years and older.....	10.6	33.1	10.0	27.7
Percent female.....	49.6	37.0	50.1	43.2
Percent white.....	91.0	95.4	90.0	81.4
Percent 25 years of age or older—high school graduate (or equivalent) or higher.....	76.1	92.2	77.6	91.8
Percent 25 years of age or older—bachelor's degree or higher.	13.0	26.6	13.8	27.0
Median household income.....	$41,933	$61,590[c]	$44,621	$58,125[c]

NOTES: [a]Source: U.S. Census Bureau 2000a; [b]Source: U.S. Census Bureau 2000b; [c]Median values were computed using the formula for the computation of the median from grouped data (see Blalock 1972: 66–68).