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Divided Rights, Expanded Conflict:

The Impact of Split Estates in Natural Gas Production

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Abstract: A survey was conducted of West Virginian land owners with completed, shale gas wells located on their property. The research objective was to determine if the separation of mineral from surface rights impacted satisfaction and problems with natural gas drilling. Split estate owners were found to have a statistically greater probability of reporting problems with drilling. Complaints by a neighbor and a residence located on the property were the only variables that consistently impacted satisfaction and reported problems throughout all three econometric models. Our results provide motivation for policies to strengthen surface owner rights.

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Introduction

Property is defined by Black's Law Dictionary as anything that can be owned and consists of a bundle of rights. Under the common law developed in England, fee simple title to land conferred ownership "from the center of the earth to an altitude above the land which is necessary for the enjoyment of the land" (Huffman 1982). The assignment of property rights have been touted for its ability to reduce conflict by internalization of externalities associated with common or open access resources (Ellickson 1993, Demsetz 1967). However, property ownership also confers to the owner the ability to sever one right from the bundle of other rights. In the U.S. and a few other countries, land ownership included mineral rights which can be transferred to another owner separately from the rest of bundle of land rights. This separation of mineral from surface ownership of land is called split estates.

Under common law, mineral right ownership is recognized as the dominant estate, such that it is assumed that both the original surface and mineral right owners at the time of severance intended for the minerals to be developed. Thus, mineral right holders have the right to perform activities that are "fairly necessary" on the land surface such as these activities that would have been contemplated by the original parties of the severance agreement in order to extract minerals, even over the objections of the current surface owner.

Nationwide, the federal government has retained mineral right ownership on about 58 million acres across the western U.S. when surface rights were sold or exchanged under the Carey Act, the Stock Raising Homestead Act of 1916 and the Taylor Grazing Act of 1934. One example is the Powder River Basin in Wyoming (Straube and Holland 2003). Separation of surface and mineral rights also is fairly common in the Appalachian region (Appalachian Land

Ownership Task Force 1983). Mineral right severance has emerged as an issue in West Virginia due to the expanded interest in drilling created by a rapid increase in natural gas prices during the first decade of 2000 along with the implementation of horizontal drilling and fracturing technology to extract natural gas and hydrocarbon liquids from shale formations deep underground.

The literature on split estates and surface owner problems with drilling for fossil fuels is very scarce. There is literature that examines impacts of community residents and shale gas drilling. Examples include Brasier et al. (2011) and Anderson and Theodori (2009). The only split estate literature related to natural gas drilling is from the western U.S. Straube and Holland (2003) identify the sources of conflict in split estate ownership and proposed a resolution conflict model. Their application was for coalbed methane in Wyoming. Also in Wyoming, Fitzgerald (2010) found that divided ownership leases have lower bids in federal auctions than leases with only one owner due to expectations of higher transaction costs. Huffman (1982) argues using Coasian-like hypothetical examples that split estates are efficient in allocation of resources based on the dominate estate rule and relates this concept to surface mining of coal.

This research utilized a survey of West Virginia surface right owners to examine problems or issues with shale gas drilling. Owners were divided into two groups: (1) those landowners who own both surface and mineral rights (fee simple estates); and (2) those landowners who own only the surface rights (split estates). The objective of this research was to test whether split estate ownership of property rights leads to a greater perception of problems or issues with shale gas drilling by surface owners and therefore a higher level of

dissatisfaction with the outcome of natural gas extraction. The research hypothesis is that split estate ownership of property rights leads to a greater perception of problems or issues with shale gas drilling by surface owners.

Study Area

Extraction of unconventional natural gas, such as from shale formations, has resulted in a "golden age of gas" (International Energy Agency 2012). One such formation, Marcellus Shale, covers around a 50,000 square mile region of West Virginia, Pennsylvania, Maryland, Ohio and New York. This shale is a layer of sedimentary rock 4,000 to 8,000 feet underground which contains organic-rich deposits formed in an oxygen-deficient environment over 300 million years ago during the Devonian Era. There is as an estimated 141 trillion cubic feet of recoverable shale gas (U.S. Energy Information Administration (EIA) 2012).

In order to efficiently extract these energy resources, a process called horizontal fracturing is performed. A vertical well is drilled to the shale formation then drilled horizontally at a 90 degree angle through this formation up to one mile. After the drilling is completed, millions of gallons of fluids are pumped down the well under high pressure in order to fracture the shale formation so that natural gas and hydrocarbon liquids can be released to the surface. Through this process, multiple wells can be located on one drill pad with the ability to extract energy resources from nearly one square mile of land. The downside is that horizontal fracturing involves more drilling machinery, trucks traffic, water and chemical use, and disturbed land area than conventional vertical drilling.

The exploitation of shale gas in the U.S. has expanded both natural gas production and reserves. Overall, production of natural gas in U.S. has increased 17% between 2009 and 2011,

while proven reserves increased 12% (2009 to 2010). The number of producing gas wells in the U.S. also increased 4.3% from 2009 to 2011 (U.S. EIA 2013c). A similar trend has been evident in the Marcellus shale play. Between 2009 and 2011, natural gas production in Pennsylvania quadrupled (with 5% decrease in the number of wells), while West Virginia production increased 49% (with a 12% increase in the number of wells) (U.S. EIA 2013c).

The disproportional relationship between the number of production gas wells and natural gas production within the Marcellus shale, especially in Pennsylvania, has been attributed to the expansion of horizontal drilling technology, hydraulic fracturing, and improved well completion techniques which improves the efficiency of drilling activities (drilling time) as well as increase in gas production (U.S. EIA 2013a). Between 2011 and 2012, average daily natural gas production in Pennsylvania increased by 69% with about a third of increase stemming from horizontally drilled wells (U.S. EIA 2013b).

The economic benefits from exploiting Marcellus shale have been enormous. In Pennsylvania, Kelsey et al. (2011) estimated that over 23,000 jobs and $3.1 billion in economic activity were generated in 2009 from Marcellus Shale development. In West Virginia, Higginbotham et al. (2010) report that the Marcellus shale development had provided 2009 economic impacts of $2.35 billion of output and accounted for the generation of 7,600 jobs. In 2009, the natural gas industry paid $65.9 million in West Virginia severance taxes and approximately $88.4 million in property taxes (Higginbotham et al. 2010).

While the economic gains from Marcellus shale may be enormous, surface owners are often excluded. In West Virginia, mineral rights were frequently severed from surface rights decades to hundreds of years ago. These rights may include all minerals, just coal, or only oil

and gas. They can even be limited to specific formations. Many of these rights were sold or traded by landowners or left to separate heirs (Appalachian Land Ownership Task Force 1983). However, speculators, known as "Robber Barons", would separate rights by filing broad form deeds to sever ownership of land from the current occupants on wide swaths of land. Once filed, they would persuade the occupant farmers to give up mineral and/or timber rights in order to settle the property ownership dispute that they created (Hufford 1999, Rasmussen 1994).

While surface owner rights vary by state, legislation has established some rights in West Virginia. Surface owner rights include (for horizontal wells): a 30 day comment period on the drilling permit application; notification periods for seismic testing, surveying, and drilling; drill cuttings and pit waste cannot be buried on-site without owner consent; compensation for surface damages; $2,500 to compensate for property taxes on surface lands disturbed by construction and operation of the well pad; and set back limitations for wells from occupied structures (600 ft.), existing water wells (250 ft.), and surface waters (100 ft.).

Survey Data Collection

An initial list of over 1400 completed shale gas well permits was obtained from the West Virginia Geologic and Economic Survey in June 2012 (http://www.wvgs.wvnet.edu/). This list contained the names of the drilling company, the surface owner(s), and mineral right owner(s). Using this list, split estates were identified along with owners of both surface and mineral rights. Eliminated from consideration were drilling operator owned surface right wells and institutional surface owners (governments, corporations, or non-profit organizations (churches, Boy Scouts, etc.). This left a population list of 935 wells with surface owners that were

primarily sole or jointly owned by individuals or families. 650 wells were split estates and 285 wells were fee simple ownership (including all or a portion of both surface and mineral rights).

From this list of 935 wells, a sample of 481 surface owners each of who own property with at least one completed well was obtained from the Office of Oil and Gas in the West Virginia Department of Environmental Protection. This list represented 680 wells. 72% of each category (split estate and fee simple ownership) were obtained in the sample. Names and mailing addresses were obtained from completed shale gas well permits application forms.

A survey instrument was developed based upon a review of popular literature on reported problems or issues by landowners with shale gas drilling, particularly horizontal hydraulic fracturing into Marcellus Shale. Questions included type of drilling conducted; drilling related developments on the property; type of agreement signed; how the land was utilized prior to drilling; identified problems resulting from drilling divided up into environmental, financial, and health, safety & quality of life; level of satisfaction with the overall outcome of the drilling process; quality of life questions; and respondent demographics. This survey was reviewed and commented on by David McMahon and Julie Archer of the West Virginia Surface Owners' Rights Organization and by Jill Kriesky at the University of Pittsburgh, Graduate School of Public Health. Four individuals with gas wells on their properties also reviewed the survey as a pre-test.

The survey sample was sent invitations to participate in the survey in December 2012. Respondents could then mail back a request for a paper survey or go on-line to complete the survey. A reminder postcard was sent out in January. Then in February, a paper survey was sent out to all non-respondents. In total, 33 surveys were completed on-line, 101 paper

surveys were returned, and 20 respondent refusals and/or indicated no well was drilled on their property. The survey response rate was 43.1% after subtraction of 125 non-deliverable addresses and deceased surface owners. 61.5% of sample respondents were split estates with 90% reporting to be the sole owner of surface rights. The remaining 38.5% were fee simple estates, of which about 1/3 were sole owners of both, about 1/3 were sole owners of the surface and one of many mineral right holders, and the remainder were either owners of gas rights only, owned both but the mineral rights were alright leased by a prior owner, or one of many surface and mineral right owners.

Models and Methods

Our goal was to examine the impact of split estates on surface owner perceptions of drilling outcomes and their level of satisfaction with the outcome of drilling. Ideally, who owns the surface versus the mineral rights should not change the drilling process or the manner upon which this process is completed by the drilling company. However, there are unique features of each individual land owner and drilling situation which must be accounted for when determining the potential impacts on a surface owner's perceptions. These features include: the size of the property relative to the number of wells drilled, the type of well drilled, how the land was used prior to drilling, what other types of development for extraction occurred on the property (gas lines, ponds, compressor stations, etc.), the types of regulations in place for the drilling, the level of compensation received by the land owner (both monetary and non-monetary), whether or not an agreement[1] was signed with the driller, and what complaints the

[1] Agreements were mainly leasing of mineral rights for fee simple estates. For split estates, examples of agreements included surface use, right of way access, and/or a statement of no objection to drilling.

neighbors had about the drilling. All of these features were viewed as potential explanatory variables for surface owners' perceptions of drilling.

Three models were developed to assess the impact of split estates on: (I) whether a surface owner identified a non-zero number of problems or issues associated with drilling, (II) the number of problems or issues among the non-zero respondents; and (III) dissatisfaction versus satisfaction of a surface owner with the outcome of drilling.

For Models I and II, respondents were given a series of questions where they could check off boxes to identify problems or issues dealing with environmental, financial, health, safety, and quality of life concerns associated with drilling or fracturing processes. These data were examined as two separate models since a substantial portion of respondents (42.6%) indicated there were no problems or issues. The dependent variable in Model I was a zero/one variable. Zero indicated no problems were identified and one was a non-zero number of problems were identified. The dependent variable for Model II consisted of a count of checked responses across 24 categories of possible problems or issues, including three other categories where respondents were given the opportunity to list other problems.

For Model III, the dependent variable was based on respondents' answers to the question below:

> "There are many impacts that occur as result of leasing and drilling – environmental, financial, health, safety, quality of life, etc. Overall, in thinking about all of these impacts (both good and bad), how would you rate your level of satisfaction with all the outcomes from the drilling and fracturing processes that were conducted on your property? (Please check only one)".

Responses were confined to five categories ranging from very satisfied to very dissatisfied. A zero/one variable was created where zero included very satisfied, somewhat satisfied, and

neutral responses. Respondents who gave a somewhat or very dissatisfied response were coded as one. Neutral responses were placed into the zero classification based on a discriminant analysis where neutral responses were twice as likely to be classified as satisfied compared to dissatisfied.

The independent variables included in both models are presented in Table 1. They included categorization of the many unique features of each property owner and their drilling situation which could potentially impact landowner satisfaction and perceptions of problems or issues with drilling. The variable YEAR was included to reflect the impact of regulations stemming from December 2011 legislation on Natural Gas Horizontal Well Control Act. We also included demographic variables of respondent age, education level, and gender in all three models in order to assess their impacts on satisfaction and perceptions.

With limited dependent variables, regression coefficients in Models I and III were estimated with a logistic regression. For Model II, the dependent variable was a non-zero count of the number of surface owner identified problems. A Poisson regression was considered, but the dependent variable suffered from over-dispersion even after separating out observations with zero problems from those where at least one problem was identified (a non-zero count). Over-dispersion occurs in a count data when the conditional variance exceeds the conditional mean, thereby violating a Poisson regression assumption (UCLA Statistical Consulting Group 2013). When count data suffers from over-dispersion, two alternatives for correction are available: quasi-maximum likelihood estimation and negative binomial regression (Wooldridge 2011, Cameron and Travedi 2010, Long and Freese 2006,). A negative binomial regression was selected to estimate coefficients for Model III.

The negative binomial regression, a generalized Poisson regression model allowed for observed heterogeneity by adding an extra parameter (α) to the Poisson regression model (Long and Freese 2006, UCLA Statistical Consulting Group 2013). The parameter α represented the unobserved heterogeneity among observations in the data (Long and Freese 2006). With a Poisson regression, α is assumed to be equal to zero. To test this assumption in the negative binomial regression model, a likelihood test ratio was performed. All estimations were conducted with STATA econometric software (StataCorp 2011).

Results

Survey

As described above, most of sample population and survey respondents were split estate owners. Among the entire sample, there were slightly more dissatisfied land owners than satisfied ones (Table 2). When satisfaction responses were broken down by both ownership and well type, ownership showed dramatic differences between split and fee simple properties, with split estate owners overwhelming dissatisfied whereas fee simple owners were overwhelming satisfied (Table 2). Responses based on well type showed satisfaction levels were higher for vertical wells than for horizontal wells. A slightly higher percentage of surface owners with non-horizontal wells were satisfied compared to dissatisfied.

In the survey, respondents were asked to report from their own experiences with drilling and fracturing any problems or issues that arose. Problems and issues were categorized based upon environmental, financial, and health, safety plus quality of life. Here, split estates and horizontal fracture wells averaged over twice as many problems as fee simple and vertical wells (Table 3). Land surface damages were generally the most common problem reported,

although fee simple owners most commonly reported inadequate compensation as a problem. About ¾ of surface owners with horizontal wells reported at least one problem/issue and over half of these respondents noted a problem with truck traffic. Other commonly noted problems with horizontal wells included: land surface damages (46.7%), property value declined (43.3%), lack of cooperation by drilling company (41.4%), road damages (37.9%), and not enough money was included in the lease for compensation (36.7%).

Ample opportunities in the survey were provided for respondents to explain their situation and reasons why they were satisfied or dissatisfied with natural gas drilling. Those respondents who reported good experiences with drilling were commonly informed about the process by the drilling company, company representatives communicated well with the landowner, and were "polite and nice". Other positive comments included those such as: "built decent roads through my property", "they were very professional & prompt in completion", "the company was very easy to work with and respected my position as a surface owner', "I feel they did all that we agreed to, put well site back with lime and fert. and seeded, kept roads in good shape", and "informed us when drilling occurred, gave us tours of the process". Most of these positive comments came from fee simple owners.

Respondents who reported problems or issues typically provided much more detailed descriptions than those without problems or issues. For example, one respondent provided two additional pages of detailed descriptions of problems that drilling had caused on the property. Split estate owners often noted their lack of rights in dealing with drilling companies and how they were treated with disrespect by drilling company representatives. As one respondent noted, "No matter how much money you receive it is not enough. We love the

country because of the peace and quiet that we have here but when the drilling company was here we had everything but peace and quiet. As a surface owner we really have no rights.". Typical of the comments was: "we were not consulted about location of pad or road, surveyed well site without notice, unsafe work site during drilling, poor topsoil preservation, pollution to streams, excessive acreage damaged, poor reclamation (slope spillage), ridiculously low offer of damage compensation. ($1500 for 8 acres of destruction)"

Econometric

All three models were statistically significant (Table 4). Models I and III were re-estimated dropping demographic variables with statistically insignificant coefficients. Each of these four logistic regression models could not reject a Hosmer-Lemeshow χ^2 statistic for model goodness-of-fit. Due to a much lower number of observations, variables with z statistics greater than 1.0 were retained in a re-estimated Model II. For Model II, the null hypothesis that α is equal to zero was rejected at 1% significance level, thus a negative binomial regression was appropriate compared to a Poisson regression.

The main independent variables of interest, SPLIT and HORIZONTAL, did have statistically significant, positive coefficients explaining both PROBLEM and #PROBLEMS (Table 4). SPLIT impacted PROBLEM while HORIZONTAL did not. HORIZONTAL impacted #PROBLEMS while SPLIT had a low level of statistically significant influence. Neither variable had a statistically significant impact on DISSATISFACTION.

Average marginal effects were computed across the number of observations utilized in each model (Table 5). For zero/one variables like SPLIT, the average of SPLIT=1 was 0.224 higher than SPLIT=0 in Model Ib. Thus, split estate ownership increased the probability of a

respondent reporting a problem with drilling by 22.4% - the third largest impact behind NEIGHBOR and INADCOMP (Table 5). The HORIZONTAL variable had the largest average marginal effect of any independent variable on #PROBLEMS, increasing reported problems by 2.8 in Model IIb (Table 5).

NEIGHBOR and RESIDENCE were the only variables with statistically significant, positive coefficients throughout all three models (Table 4). When a respondent reported that a neighbor complained about the drilling, there was a 43.2% greater probability of a reported problem by the surface owner and a 24.4% greater probability of surface owner dissatisfaction with drilling (Table 5). The impact of a residence on the property had the second largest impact on the number of reported problems, increasing it on average by 2.4 in Model IIb.

Model III on DISSATISFACTION was mainly explained by NEIGHBOR, RESIDENCE, and variables reflecting surface owner compensation. When a respondent reported inadequate compensation (INADCOMP), the probability of dissatisfaction increased by an average of 41.7%, by far the largest impact of any variable (Table 5). Conversely, respondents who received non-monetary compensation had, on average, a 19.7% lower probability of being dissatisfied. The INADCOMP variable also increased the probability of a surface owner reporting a problem with drilling by 38.5%, the second largest variable impact in Model Ib.

Surface owner compensation impacts dissatisfaction and problem reporting. It was difficult to completely separate the issue of compensation from split estates given the weak negotiating position of surface owners in West Virginia. In the survey, split estate owner respondents had a slightly higher percentage that checked inadequate compensation as a problem than fee simple owners (27% to 18%). The largest difference was in a survey question

on what benefits the surface owner perceived from drilling. A total of 45% of split estate owners had a “none” response compared to only 2% of fee simple owners. Thus, the perception of inadequate compensation was more common among split estate owners.

Variables of lesser importance in explaining reported problems and dissatisfaction included NOAG, POND, WELLS, and YEAR. The variable YEAR did not have a statistically significant coefficient in any model whereas NOAG and WELLS were only significant at 10% levels in Model III. The POND variable had a positive, statistically significant impact in Model I. The storage of water in ponds led to a 20.2% greater probability of problems reported by surface owners in Model Ib than other methods utilized to store water storage (storage tanks, trucks, etc.). With the exception of AGE in Model II, demographic variables of AGE, GENDER, and COLLEGE were not influential in explaining reported problems and dissatisfaction.

Conclusions and Policy Implications

This research examined whether spilt estates impacted surface owner perceptions of problems or issues with shale gas drilling along with their satisfaction from the drilling outcome. A summary of survey results provided evidence that split estates led to more reported problems and lead to higher level of dissatisfaction with drilling than fee simple estates. The presence of a horizontally drilled well on the property showed similar impacts.

Regression analyses were conducted for three models: surface owner reported at least one problem (yes or no), the number of problems reported, and dissatisfaction versus satisfaction. The econometric results showed that a split estate owner was more likely to report a problem while a horizontal well increased the number of problems reported. Surface owner dissatisfaction was not impacted significantly by either split estates or horizontal wells.

It was mainly explained by neighbor complaints, residence on the property, and surface owner compensation.

The combination of survey and econometric results does indicate a need to expand surface owner rights in West Virginia, particularly when there is a residence on the property where wells are drilled. Quite often the separation of mineral from surface rights occurred decades to generations ago. With changing technology making shale gas resources available that previously were not accessible, split estate owners are faced with an unfortunate situation where their property basically "enslaved" by an industrial process of drilling and fracturing for the sole benefit of mineral right holders. The wealth created in society by shale gas extraction should not exploited by imposing excessive extraction burdens on surface owners without mineral rights.

Other states (Colorado and New Mexico) have responded to split estate issues with legislation to expand surface owner rights, termed "surface owners' bill of rights". For example in New Mexico, the Surface Owners Protection Act of 2007 includes provisions of: a 30 day notice prior to drilling, a written agreement must exist between the surface owner and driller or drillers must pay for the use of the land surface, and drillers must provide a description of the proposed operations such that the owner can evaluate the effects on the property.

A current policy proposal by the West Virginia Surface Owner Rights Organization (http://www.wvsoro.org/index.html) advocates a process to reunify surface and mineral rights by notification and creation of an opportunity for surface owners to purchase back mineral rights upon non-payment of property taxes. In addition, there is a legal case currently before the West Virginia Supreme Court that would expand surface owner rights. This case addresses

whether or not a surface owner in Marion County, WV can be burdened with the production of oil and/or gas not underlying the surface owner, i.e. can the mineral right holder extract gas from neighboring property without a surface owner's permission? The outcome of this case could impact surface owner rights in the case of horizontal well drilling.

Overall, the survey response rate was acceptable at over 40%. Respondents included a higher proportion of fee simple estates than the survey sample, so that group was not under-represented in responses. Plus, feedback from non-respondents indicated that split estate owners may have been less likely to respond for a variety of factors – pending litigation, the survey caused the respondent to re-live the stress caused by the drilling, or they were very discouraged by the entire situation. Also, the survey responses contained shale gas drilled wells between 2004 and 2012. There were an ample number of both vertical and horizontal drilled wells represented in the sample. However, as a research limitation, only 6.2% of wells were either completed in 2012 or drilling was still on-going. Thus, relatively few wells in our data set were covered by horizontal drilling regulations put in place by the December 2011 legislation. The primary impact on surface owners from this legislation was to increase setback requirements for horizontal drilling wells. How these increased setbacks have impacted surface owner perceptions and satisfaction with drilling is unknown.

Future research could extend this survey to cover horizontal well permits where the increased setback standards apply. Also, survey coverage could be increased to those states with surface owners' bill of rights. Both of these strategies would enable researchers to examine whether or not perceptions and dissatisfaction with drilling outcomes differ when surface owner rights are expanded.

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Table 1: Variable Definitions

Variable	Description	Coding	Mean
AGE	Age of respondent	years	64.57
COLLEGE	Respondent education level	1= college education, 0=otherwise	0.357
DISSATISFACTION	Respondent rating of level of satisfaction with all the outcomes from the drilling and fracturing processes"	1= Very or somewhat dissatisfied, 0=somewhat or very satisfied and neutral	0.444
GENDER	Gender of respondent	1=female, 0=male	0.195
HORIZONTAL	Type of drilling conducted on property	1=horizontal drilled well, 0=otherwise	0.263
INADCOMP	Respondent identified financial compensation as an issue that arose with drilling	1=yes 0=no	0.238
NEIGHBOR	Response to statement "Have any of your neighbors ever complained to you about any part of the drilling or fracturing processes for the well (s) drilled on your property?"	1=yes 0=no	0.214
NOAG	Agreement signed concerning natural gas wells on your property	1= no agreement 0= signed agreement	0.178
NONMONCOMP	Non-monetary compensation (either improved roads or free gas) received by surface owner	1=yes 0=no	0.536
POND	Pond for water or fracturing wastes was constructed on property	1= yes, 0=no	0.54
PROBLEM	Respondent reported problems related to drilling	1= reported at least one problem , 0= no problems	0.563
#PROBLEMS	Number of problems reported by respondents with at least one problem	Count of problems reported	6.14
RESIDENCE	Property included a residence prior to construction of the well pad and drilling"	1=yes 0=no	0.531
SPLIT	Property rights held by respondent	1= Split estate , 0=Fee simple	0.615
WELLS	Acres per well	Surface acres of property divided by the number of wells drilled	82.65
YEAR	Year drilling and fracturing of well(s) was completed	1= 2012 and not yet completed, 0=otherwise	0.063

Table 2. Responses to survey question about satisfaction with leasing and drilling on respondent's property.

	Satisfied (Somewhat and Very)	Dissatisfied (Somewhat and Very)
Entire Sample (n=124)	41.9%	44.4%
Ownership Type		
Split (n=75)	28.0%	60.0%
Fee Simple (n=48)	64.6%	20.9%
Well Type [a]		
Horizontal (n=30)	33.3%	53.4%
No Horizontal Well (n=83)	43.4%	42.2%

[a] Well type included only respondents with a horizontal fracture well on their property versus no horizontal well with only conventional or vertical fractured wells.

Note: Percentages do not add up to 100% by row as the neutral response percentage is not reported.

Table 3. Responses to questions about problems or issues with drilling and fracturing on respondent's property.

	Respondents who Reported at Least One Problem/Issue	Average Number of Reported Problems/Issues	Most Common Problem/Issue Reported (% of Respondents)
Entire Sample (n=129)	57.4%	4	Land surface damages (34.9%)
Ownership Type			
Split (n=78)	69.2%	5	Land surface damages (52.0%)
Fee Simple (n=49)	38.8%	2	Not enough money was included in the lease (18.0%)
Well Type [a]			
Horizontal (n=30)	73.3%	7	Truck traffic (51.7%)
No Horizontal Well (n=88)	46.5%	3	Land surface damages (30.6%)

[a] Well type included only respondents with a horizontal fracture well on their property versus no horizontal well with only conventional or vertical fractured wells.

Table 4. Regression results for logistic regression (Models I and III) and negative binomial regression (Model II).

	Model Ia	Model Ib	Model IIa	Model IIb	Model IIIa	Model IIIb
	Dependent Variable: PROBLEM		Dependent Variable: #PROBLEMS		Dependent Variable: DISSATISFACTION	
Independent Variables	Coefficient (Std. Error)	Coefficient (Std. Error)	Coefficient (Std. Error)	Coefficient (Std. Error)	Coefficient (Std. Error)	Coefficient (Std. Error)
CONSTANT	-0.157	-4.209[b]	1.814[b]	2.147[a]	-0.369	-1.166
	(2.631)	(1.656)	(0.726)	(0.533)	(2.073)	(0.986)
SPLIT	1.944[b]	2.193[b]	0.366	0.326[c]	1.047	0.956
	(0.927)	(0.896)	(0.260)	(0.194)	(0.749)	(0.687)
HORIZONTAL	-0.294	0.331	0.505[b]	0.421[b]	-1.236	-1.065
	(1.023)	(0.843)	(0.228)	(0.173)	(0.924)	(0.858)
NEIGHBOR	4.308[a]	4.621[b]	0.477[b]	0.317[c]	1.635[c]	1.708[b]
	(1.573)	(1.566)	(0.217)	(0.174)	(0.872)	(0.842)
RESIDENCE	1.869[b]	1.976[b]	0.325	0.401[b]	1.300[b]	1.336[b]
	(0.894)	(0.831)	(0.206)	(0.185)	(0.653)	(0.629)
NONMONCOMP	-0.674	-0.260	-0.064		-1.349[c]	-1.354[b]
	(0.960)	(0.798)	(0.228)		(0.726)	(0.681)
INADCOMP	3.803[a]	3.848[a]	0.159		2.738[a]	2.858[a]
	(1.306)	(1.261)	(0.220)		(0.888)	(0.843)
POND	2.288[b]	2.018[b]	0.063		0.232	0.071
	(0.927)	(0.814)	(0.216)		(0.704)	(0.660)
NOAG	0.843	0.349	0.122		1.750	1.885[c]
	(1.361)	(1.216)	(0.274)		(1.126)	(1.057)
WELLS	-0.003	0.0002	0.001		-0.010[c]	-0.008
	(0.006)	(0.004)	(0.002)		(0.006)	(0.005)
YEAR	-1.172	-3.453	-0.151		0.542	0.157
	(2.912)	(2.202)	(0.393)		(1.672)	(1.579)
COLLEGE	-0.542		0.039		0.409	
	(0.863)		(0.211)		(0.694)	
GENDER	-0.489		0.148		-0.478	
	(1.112)		(0.270)		(0.853)	
AGE	-0.047		-0.018[b]	-0.019[b]	-0.011	
	(0.031)		(0.008)	(0.007)	(0.025)	
# obs.	91	94	52	58	91	93
LR χ^2	71.33[a]	68.90[a]	24.10[b]	23.35[a]	54.68[a]	54.53[a]
Pseudo R^2	0.574	0.537	0.082	0.0721	0.437	0.427
α			0.189	0.199		
			(0.071)	(0.685)		
LR $\bar{\chi}^2$(null: α=0)			20.43[a]	26.03[a]		

[a,b,c] Statistically significant at 1%, 5%, and 10% levels, respectively.

Table 5. Average marginal effect of independent variables in each model.

	Model Ia	Model Ib	Model IIa	Model IIb	Model IIIa	Model IIIb
	Dependent Variable: PROBLEM		Dependent Variable: #PROBLEMS		Dependent Variable: DISSATISFACTION	
Independent Variable	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
SPLIT	0.187	0.224	2.162	1.922	0.139	0.127
HORIZONTAL	-0.027	0.034	3.426	2.825	-0.136	-0.122
NEIGHBOR	0.395	0.432	3.196	2.074	0.230	0.244
RESIDENCE	0.172	0.198	1.966	2.358	0.166	0.173
NONMONCOMP	-0.065	-0.027	-0.412	-	-0.195	-0.197
INADCOMP	0.365	0.385	1.053	-	0.396	0.417
POND	0.216	0.202	0.404	-	0.029	0.009
NOAG	0.079	0.036	0.813	-	0.235	0.256
WELLS	0.000	0.000	0.008	-	-0.001	-0.001
YEAR	-0.105	-0.302	-0.926	-	0.068	0.020
COLLEGE	-0.049	-	0.256	-	0.050	-
GENDER	-0.044	-	1.010	-	-0.058	-
AGE	-0.004	-	-0.119	-0.118	-0.001	-