

The North Carolina *Public Opinions on Fracking Survey*: Developing an Instrument for the  
Assessment of Beliefs about Fracking Outcomes

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## Abstract

GRISLE, SONJA YVETTE. The North Carolina *Public Opinions on Fracking Survey*: Developing an Instrument for the Assessment of Beliefs about Fracking Outcomes

Recent media attention has focused on the risks and benefits that hydraulic fracturing poses to society, the environment, and human health. These specific risks and benefits provide focal areas for political officials, researchers, and industry workers to improve public awareness and understanding. This study details the development of a survey instrument to collect data on the public's beliefs about the potential outcomes of fracking in North Carolina. The goal was to understand what the public perceives as risk and benefit, identify knowledge gaps, and ascertain if residents of counties targeted for future drilling have differences in opinion as compared to residents of counties where drilling is unlikely to occur. Described here are the development, pilot testing, administration details, and some results for the *Public Opinions on Fracking Survey* conducted with a random sample of registered voters from 20 counties in North Carolina. The key survey Likert-type facets on risks and benefits were psychometrically sound with Cronbach's alphas of  $\geq 0.9$ , indicating an excellent internal consistency for instrument reliability. Facet means for benefits reflect that control and study county respondents similarly ranked benefits. More substantial differences were noted in the facet means between the two groups for risks for those living near drilling sites and potential risks associated with adverse impact to the environment. The survey results showed most respondents highly rank water-related risks associated with hydraulic fracturing and identified the most widely recognized benefit was a financial benefit for gas companies. In addition, most respondents agreed that more research is needed on fracking to better understand the potential risks. The survey is a useful tool in capturing the public's beliefs about fracking risks and benefits and in exploring these beliefs to address fears and misinformation among the general public. Moreover, the survey has the potential to be used to capture perceptions in areas other than North Carolina. While the study results were collected in North Carolina, they can also, with caution, be applied to other areas for useful data collection on this and similar topics.

## **Acknowledgements**

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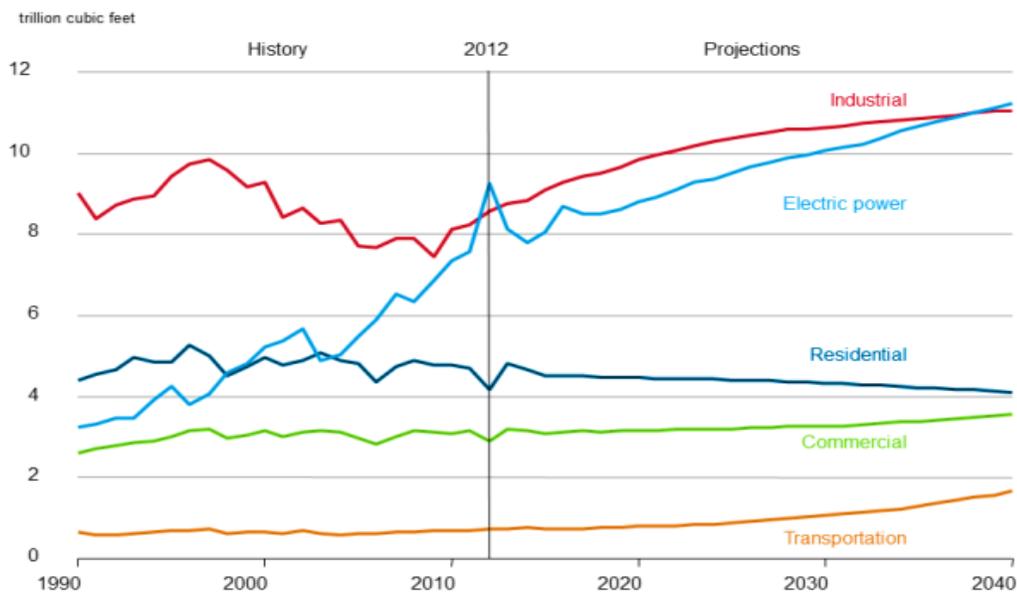
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# 1. INTRODUCTION

## 1.1 Context for Shale Gas Development

About 83% of U.S. energy demand was met by domestic production in 2012 (EIA 2013). Imported petroleum provided the rest. Major fossil fuels (e.g., coal, oil/gasoline, natural gas) have dominated U.S. energy for the past century. Energy production, however, has changed in recent years, particularly with respect to natural gas production (EIA 2013). In 2012, natural gas production was higher than in any previous year due to efficient and cost-effective drilling techniques (EIA 2013). Also in 2012, U.S. crude oil production was the highest since 1995 due to the utilization of horizontal drilling and hydraulic fracturing. According to the U.S. Energy Administration (EIA), total U.S. energy production in 2012 was 31% natural gas, 26% coal, 21% petroleum, 11% renewable energy, and 10% nuclear electric power (EIA 2013). Natural gas consumption in the U.S. is projected to grow from 25.6 trillion cubic feet (Tcf) in 2012 to 31.6 Tcf by 2040 according to the Annual Energy Outlook reference case (Figure 1) (EIA 2014).

**Figure 1.** Natural Gas Consumption by Sector, 1990-2040



Increases in nearly all sectors are expected except in residential end-use, where natural gas use for space heating decreases as people move to warmer areas and appliances are improved to be more energy efficient. The industrial sector is expected to see increases by 2.5 Tcf, accounting for approximately 26% of the total increase in natural gas consumption (EIA 2014).

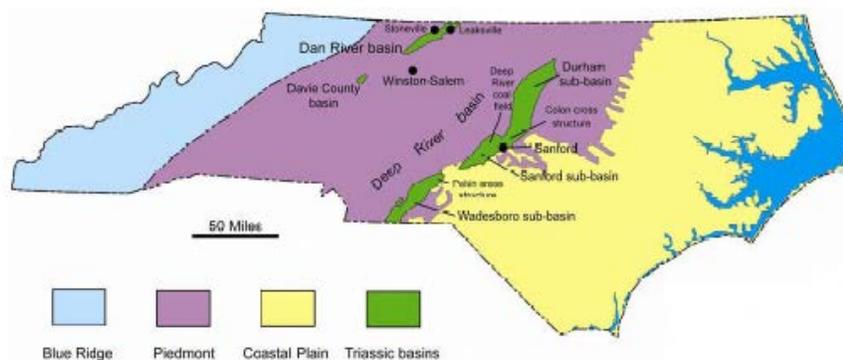
Swift development of oil and natural gas resources to meet growing energy demands across North America has sparked debates between supporters and opponents of unconventional horizontal drilling processes. The potential economic benefits and human health and environmental risks associated with unconventional hydraulic fracturing processes, commonly called fracking, are at the core of the shale gas development debate. Shale gas development is considered unconventional because of the low permeability of the rock formations. The natural shale gas is located in the pores, vertical fractures contained in the rock. Gas is not extracted efficiently by conventional vertical wellbores because the fracture and the wellbore are on the same axis. Because the rock does not allow gas to pass through easily, it is fractured with water, chemicals, and other additives under high pressure to increase the permeability. The contents of the hydraulic fracturing fluids added to water previously were not known on a wide scale. Companies argued disclosure threatened their business model and as such the chemical composition(s) were considered proprietary (Watson 2012). However, the additives raised concerns about the potential impact on drinking water sources. Chemicals are now disclosed to a greater extent due to changes in government regulation; however concerns still exist about the potential impact of these fluids (Watson 2012). Approximately forty chemical additives can constitute fracking fluid. The combination varies by operator and depends on which are best for certain geological characteristics. According to The U.S. House of Representatives Committee on Energy and Commerce, oil and gas service companies used

fracking fluids containing 29 chemicals that are listed as hazardous air pollutants under the Clean Air Act or are known to be carcinogenic and regulated by the Safe Drinking Water Act due to the risks posed to human health (Waxman, Markey, and DeGette 2011). Used between 2005 and 2009, the 29 chemicals were in over 650 different commercially available fracking products (Waxman *et al.* 2011). Studies have provided evidence of environmental public health risks associated with shale gas development, namely contributions of pollutants to ambient air linked to increases in risk of morbidity and mortality (Shonkoff, Hays, and Finkel 2014). Other studies suggest water contamination risks can occur through multiple environmental pathways, particularly during wastewater transport and disposal, and structural integrity issues of gas wells (Shonkoff, Hays, and Finkel 2014).

### 1.2 Fracking in North Carolina

The debate on fracking in North Carolina has grown more critical as key decisions have been made to impact the state's future in the natural gas drilling arena. North Carolina state geologists identified potential producible natural gas resources in the Deep River and Dan River Basins (Figure 2) (Adair, Pearson, Monast, Vengosh, and Jackson 2012).

**Figure 2.** Mesozoic Basins in North Carolina (Reid and Milici 2008)



Test results from several wells in Lee County have revealed the presence of natural gas (Adair *et al.* 2012). The North Carolina Geological Survey estimated the natural gas potential of 59,000 acres below Lee, Moore, and Sanford counties in 2011 (Adair *et al.* 2012). Companies

have already leased thousands of acres to drill in Chatham, Moore, and Lee Counties (Seawell 2011). In June 2014, the North Carolina General Assembly passed a bill to allow permits for fracking as early as May 2015. For two years North Carolina has been protected from fracking by a temporary moratorium to allow for the completion of rules that would have aimed to mitigate fracking risks. As explained by Elizabeth Ouzts, State Director of Environment North Carolina, a statewide, citizen-based environmental advocacy organization, those rules are still incomplete, but they will be effective next year (Environment North Carolina 2014). Opponents have expressed concerns that current state government is rushing the process. They want some assurance risks will be mitigated. They argue the rules don't address air pollution from fracking or adequately address toxic wastewater storage (Environment North Carolina 2014). Being uncertain about the various risks, many hope for more focus on wind and solar energy sources instead of natural gas exploration in the state (Environment North Carolina 2014). At the October 2012 Environmental Health Summit, the Research Triangle Environmental Health Collaborative (EHC) made policy and other recommendations to protect the health of North Carolinians and the environment if/when shale gas exploration takes place in the state. The summit included participants from the oil and gas industry, nonprofits, government organizations, and academia who focused on exposure pathways, health impacts, and social impacts related to fracking. The EHC recommended North Carolina conduct a comprehensive Health Impact Assessment (HIA) in the Centers for Disease Control and Preventions National Environmental Public Health Tracking Network to avoid and monitor health problems (EHC 2013). Other important recommendations were to create a Community Needs and Assets Assessment (CNAA) to identify potential jobs for locals, have citizen stakeholder forums and reporting mechanisms, carefully plan transportation, and have the state facilitate studies on medical and demographic data and exposure pathways (EHC 2013). The group recommended

the state require and fund an organization in the N.C. State Center for Health Statistics to establish baseline health data analysis of areas where fracking could occur (EHC 2013).

### *1.3 Benefits and Risks*

Natural gas offers advantages as it is cleaner-burning than coal or oil (EIA 1998).

Natural gas combustion produces lower levels of carbon dioxide and sulfur dioxide than coal or oil. (EIA 2014). This type of energy production in the US also offers the potential for increased domestic production and could, potentially, decrease the dependence on foreign oil imports, although experts do not necessarily agree on absolute contributions. Despite the benefits, there are potential environmental concerns associated with the shale gas production. The transportation, storage, and use of significant quantities of water are important factors in gas development, which raises several concerns.

Fracturing wells requires large amounts of water. Drilling and hydraulic fracturing of a single well can require millions of gallons of water. The volume of water used varies by rock formation, depth and well length, and the number of times it is fractured. Water for drilling and fracking could be drawn from local surface waters, rivers, or lakes (Schwartz 2011). Some use groundwater or municipal water supplies while others use recycled wastewater from their previous operations. If drilling occurs during drought or low stream flow, the withdrawals can create shortages. Significant use of water for gas production impacts the availability of water for other uses and aquatic habitats (KPMG Global Energy Institute 2012). Toxic wastewater disposal from the fracking process poses potential water-related contamination risks (Swennen 2013). According to Thomas Swartz, Senior Vice President at the Marsh Environmental Practice, "As the industry matures, risk management techniques will improve, but as with any operation, even the best-managed facilities can have releases" (Swartz 2011). Improperly managed hydraulic fracturing fluid can be released by spills, leaks, faulty well construction, or other pathways (Swennen 2013). Fracturing produces large amounts of wastewater containing

dissolved chemicals and other contaminants that could require complex or costly treatment before disposal or reuse (Swartz 2011).

Historically, North Carolina has been considered to be fairly rich in water resources; however there are numerous and increasing demands on those resources (EPA 2010). In recent years North Carolina has experienced water shortages due to rapid population growth, drought, and aquifer degradation (EPA 2010). Current growth and water use trends will make it increasingly difficult to meet water needs in the future. One of the fastest-growing states in the nation, North Carolina experienced population growth of nearly 17% between 2000 and 2009. By 2030 more than 12.2 million people will reside in North Carolina (Stuart 2006). This population increase will increase demand for water and undeveloped forest and wetland areas, environments important for ensuring the quantity and quality of the water supply. The state's potential shale gas resources are located within the region experiencing growth, the area between Raleigh and Charlotte (Adair *et al.* 2012).

#### *1.4 Communication*

Emotionally and politically charged, the conversations around fracking, taking place in news media, at town meetings, in webinars, and through other outlets, are providing a wide array of communication avenues about risks and benefits. There are numerous videos, documentaries, and testimonials from residents and political leaders of states where fracking is already occurring. In addition, there are the less publicized messages coming from academia and the oil and gas industry, including research studies on water contamination, energy independence statistics, complex assessments of drilling and engineering protocols, and case studies. Unfortunately, these messages are extremely mixed, leaving the general public with the task of distinguishing fact from fiction and fear-mongering from genuine public safety advisories. While information on practically any subject is readily available via the internet and other media, understanding the topics involved in the fracking debate requires a deliberate and

sustained effort by someone who has the time and ability to synthesize the evolving complex information available. To those in the population who are not scientific or engineering experts in the field, for example lay people, the information can be challenging to process. A few examples of public messages on fracking benefits and risks are presented below. The sources include text from web banners, as well as quotations from articles, documentaries, and commercials. These are presented to simply demonstrate the diversity of messages being communicated about the potential outcomes related to oil and gas development and fracking. The display in no way aims to identify any specific source as reliable or otherwise.

The North Carolina Environmental Partnership, a partnership comprised of various groups, including the Natural Resources Defense Council, the Southern Environmental Law Center, the North Carolina Conservation Network, Waterkeeper® Alliance, the Haw River Assembly, the Neuse Riverkeeper® Foundation, Waterkeepers® Carolina, and the Yadkin Riverkeeper®, recently communicated the following message in a commercial,

"The Fracking Crew: State Senators Chad Barefoot, Wesley Meredith and Ronald Rabin...they all voted to fast-track fracking. Fracking can pollute the air and threaten our drinking water. Fracking uses toxic chemicals, including benzene, silica, formaldehyde, chemicals that can cause cancer and birth defects, but the fracking crew voted to put our families at risk. Tell Barefoot, Meredith, and Rabin to stop reckless fracking in North Carolina." (North Carolina Environmental Partnership 2014)

The United States Environmental Protection Agency (EPA) website claims,

"Natural gas plays a key role in our nation's clean energy future. The U.S. has vast reserves of natural gas that are commercially viable as a result of advances in horizontal drilling and hydraulic fracturing technologies enabling greater access to gas in shale formations. Responsible development of America's shale gas resources offers important economic, energy security, and environmental benefits" (EPA 2014).

A Marcellus Shale coalition commercial states,

"The sun rises over our green, rolling hills. Beneath them lies one of the largest natural gas fields on earth. Developing natural gas secures our energy future. Natural gas is produced by friends and neighbors who are there to lend a helping hand, generating one of the cleanest sources of energy available, clean abundant American energy is a

resource that will power our future” ( Marcelluscoalition.org).

In a documentary, *“Black Gold Boom: How Oil Changed North Dakota,”* produced by independent producer Todd Melby and the Association of Independents in Radio, Inc., there is a short video clip featuring women who are afraid of the new aggressive male oil workers in their county in North Dakota. The following quote is displayed before their testimonies begin.

“In 2009, before the oil boom violent crime was rare in McKenzie County, N.D. There were not reported rapes, murders or assaults. In 2011, McKenzie County reported three rapes and 12 aggravated assaults” (Melby 2012).

The messages clearly illustrate the various ways risks and benefits are being communicated to the public.

North Carolina is at an interesting point in its plan to drill. There is a potential advantage in being in a position to observe and learn from other states where fracking is already occurring, such as Pennsylvania and North Dakota. This is important to understand the most likely potential risks and to determine the best mitigation efforts, essentially placing the state in a position to establish a plan to handle all that comes with the oil and gas development activities and growth. With an understanding of likely outcomes, more accurate messages could be communicated to the public. A major source of fear in North Carolina is the rush to drill, a concern for proceeding with little public notice and study (Henderson 2014). There are a variety of issues being reported by towns in states where natural gas is being developed. They range from flammable drinking water due to methane contamination (Adair *et al.* 2012) to increases in criminal activity (Food and Water 2013). Irrespective of these issues, the plans to drill are moving forward in North Carolina, as evidenced by the May 29, 2014 state lawmakers’ vote to approve Senate Bill 786, The Energy Modernization Act, while rules are still in development. Governor Pat McCrory signed the bill into law on June 4, 2014 (NCGA 2014). The bill requires the Mining and Energy Commission in North Carolina to complete fracking rules by January 1, removing the initial July 2015 deadline for beginning permit releases and

allowing the issuing of permits 61 days after the rules are approved. People are concerned that this allows permits to be issued even if the rules are inadequate (Henderson 2014).

Polls have been conducted to ask people if they support fracking in the state. The Natural Resources Defense Council, a non-profit international environmental advocacy group, conducted a telephone poll in 2013. The poll found that in the Triangle (Raleigh, Durham, and Chapel Hill), 59% of respondents oppose fracking; in the Charlotte metro area, 53% oppose; in the Triad (Winston-Salem, Greensboro, High Point), 48% oppose; and in easternmost and westernmost NC, 55% oppose fracking (NRDC 2013). Considering the diversity of information available about fracking and the challenges North Carolina already faces with respect to growth and water resources, it is important to explore and attempt to understand what fuels support and opposition. Therefore, the questions guiding this study were the following: *What are people's beliefs about the risks and benefits related to fracking, particularly the potential human health, environmental, and social outcomes? How do beliefs differ for residents in counties targeted for future fracking sites in comparison to those in other counties? How aware is the public about fracking in general? Where does the general public obtain reliable information about fracking?*

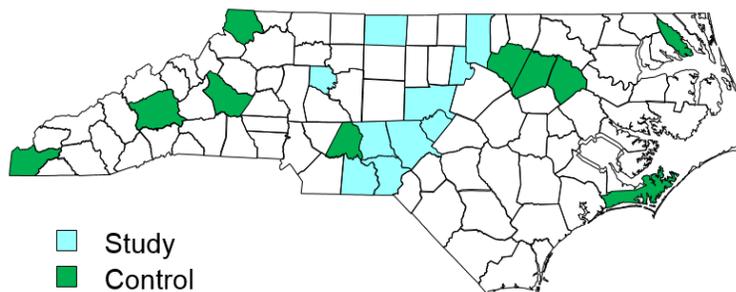
In fulfillment of the professional project requirement of the Masters of Environmental Assessment degree program at North Carolina State University, a survey instrument was developed to study these types of questions. This paper details the development and delivery of the survey instrument, which was designed to capture the public's perceptions of specific risks and benefits associated with fracking. This instrument and information obtained could be used to help improve risk communication, identify knowledge gaps, and establish a template for further study in a large sample.

## **2. METHODS**

### *2.1 Sample Selection*

Twenty North Carolina counties were selected for the study, ten of which are counties where fracking is likely to occur in the future based on the proximity to shale basins and current gas leases and ten control counties (Figure 3). According to estimates published by the U.S. Geological Survey (USGS), the amount of undiscovered accumulations of natural gas resources in the East Coast Mesozoic basins totals 3,860 billion cubic feet, approximately 135 million barrels (Reid and Milici 2008). Included in this estimate are the Deep River, Dan River-Danville, and Richmond basins of North Carolina's Piedmont region and Virginia, the Taylorsville basin of Virginia and Maryland, and the Newark basin in New Jersey (Reid and Milici 2008).

**Figure 3.** North Carolina County Selections Map

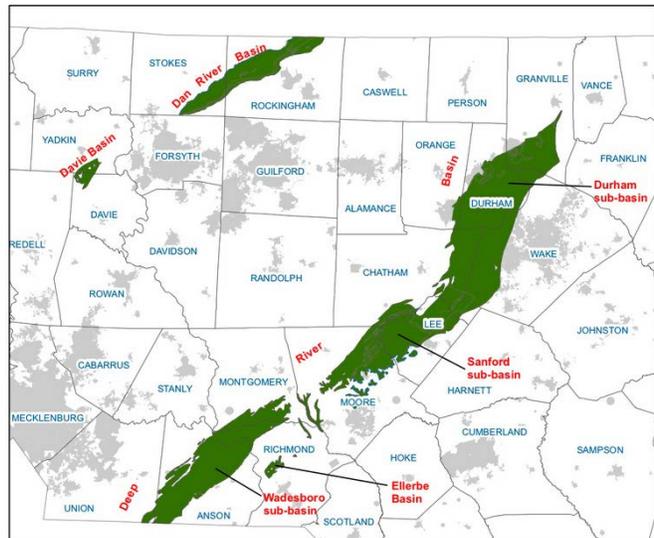


The two shale basins in North Carolina presumed to be capable of producing sufficient natural gas, the Dan and Deep River Basins, host Granville, Anson, Chatham, Davie, Durham, Lee, Montgomery, Moore, Richmond, Rockingham, Orange, Stokes, Wake, and Yadkin counties (Figure 4). These Triassic basins that may contain hydrocarbons were formed approximately 230 million years ago (Milici et al. 2012). Ten of the 14 counties in the basins were selected for this research study (Table 1). Ten controls were matched to the selected counties by published data on income and population from the U.S. Census Bureau.

**Table 1.** County Selections

Control County	Study County
Cherokee	Anson
Ashe	Montgomery
Pasquotank	Davie
Edgecombe	Richmond
Stanly	Lee
Franklin	Granville
Carteret	Chatham
Nash	Moore
Burke	Rockingham
Buncombe	Durham

**Figure 4.** Exposed North Carolina Triassic Rift Basins



Using a database of registered voter data from the North Carolina State Board of Elections, active registered voter residents from the selected counties were extracted and assigned consecutive record numbers once they were uploaded into a database. Households were randomly selected for survey participation. Four hundred households in total, twenty per county, were randomly selected from the pool of active registered voters by using a random number generator to select the specific records. Survey participants were randomly selected from the household by survey instruction; to allow varied representation, the adult in the household with the next birthday was instructed to complete the survey. Each survey was coded with a unique ID number to confirm county affiliation in case the county question item was nonresponse.

### *2.2 Instrument Development*

The survey contains 22 main questions with categorical items comprising 85 total data points. There majority of questions included Likert-type items (Appendix A). A five-point scale was used for questions on potential outcomes and fracking governance support; Strongly Agree, Somewhat Agree, Neutral, Somewhat Disagree, and Strongly Disagree. When scoring, the

response “Strongly Disagree” corresponded to a score of 1, “Somewhat Disagree” corresponded to 2, “Neutral” corresponded to 3, “Somewhat Agree” corresponded to 4, and “Strongly Agree” corresponded to 5. Scales were also used and similarly scored for questions on fracking awareness and beliefs about the future of fracking: Completely True, Somewhat True, Neither True nor False, Somewhat False, Completely False; and Very Likely, Somewhat Likely, Neutral, Somewhat Unlikely, and Very Unlikely respectively.

The survey questions gathered information on fracking information sources, time spent using news media, fracking awareness, governance support, negative and positive associations with fracking terminology, and potential fracking outcomes, including specific environmental and human health risks and various economic benefits. Of particular interest were perceptions of benefits, risks for residents near drilling sites, and environmental risks, which comprised three facets detailed in questions 18, 19, and 20 (see Appendix A. Information from prior studies, national polls, a North Carolina summit, other states’ publicized experiences with fracking risks and benefits, newspaper articles, and other publications were used to identify specific items for the survey questions. The facet items were grouped by category on the paper survey. Also included in the survey are demographics and socioeconomic items to capture age, ethnicity, gender, level of education, number of years in North Carolina, county of residence, employment status, income, political affiliation, and political views. The inventory was only available in English.

To assess survey content, correctly categorize facets, ensure answer choices were balanced, and improve the survey readability, the survey underwent survey methodology and content and industry expert review. Expert review by Catherine LePrevost, PhD, Waverly Kallestad, PhD, an oil and gas industry expert, and four survey methodology experts from Duke University, The Odum Institute at The University of North Carolina, and Arizona State University provided feedback that led to survey changes. This improved the instrument’s

readability, length, and consistency; reduced bias and ambiguity; offered more neutral wording (i.e., 'potential outcomes' replaced the use of 'risks' and 'benefits'); appropriately expanded answer choices; and corrected errors. The final draft was then pilot tested with three volunteers representing educational backgrounds equivalent to levels of less than high school, high school diploma, and some college. Included was one person who spoke English as a second language. Volunteers were asked to complete the survey, highlight or circle any words they could not define or did not fully understand, provide an average completion time, and discuss their survey completion experience in general. Feedback from the pilot test resulted in additional changes, including the addition of a "Don't Know" option to question 5 ("Fracking is exempt from common laws and rules that protect the environment") and the addition of a "None/Not Applicable" option to question 6 ("I turn to the following for information on fracking in North Carolina"). A more basic definition for gas leases and fracking was also provided. The average survey completion time was 25 minutes.

### *2.3 Survey Administration*

Paper copies of the *Public Opinions on Fracking Survey* were mailed through the United States Postal Service (USPS) to the 400 selected households. Mailed surveys were sent with cover letters and self-addressed stamped envelopes. Information was provided in the cover letter on the survey purpose, the incentive, how the data would be used, completion instructions, and confidentiality details. Five electronic gift cards for \$25 were offered as an incentive for completing the *Public Opinions on Fracking Survey*. Respondents could enter a drawing for a gift card by sending a blank email to an email address created for the project. The selected winners were randomly chosen and gift cards were sent electronically.

The *Public Opinions on Fracking Survey* data collection period began on April 11, 2014 and continued through August 1, 2014. In July, respondents were given the opportunity to submit their survey responses online. The online version of the survey was developed using

the North Carolina State University College of Agriculture and Life Sciences survey builder. Reminder postcards were sent as a single follow-up attempt during the survey period to thank the respondents for their participation and inform them about the new online submission option. The cards were sent to the selected participants through the USPS with the link to the online version of the survey and a quick response code. Respondents were instructed to enter the pre-printed unique survey ID code from the paper survey into the online version to prevent duplicate entries. Reminders have been widely used to improve mail survey response rates. Single follow-up attempts can increase overall response rates significantly; however, the increases are higher with multiple follow-ups (Kanuk and Berenson 1975). Since this project was primarily student-funded, multiple attempts were not economically feasible. Respondents were given deadlines that allowed sufficient time to complete the survey, including additional time allowed following the reminder card receipt.

Responses were scored, and facet means for benefits, environmental risks, and human health risks items for the sample overall, as well as control and study groups, were measured. The Cronbach's alpha values, measuring internal consistency and instrument reliability, for the three facets were determined. For survey submissions missing fewer than 15% of item responses, the respondent's average score for the missing item's corresponding facet was used as the response. If respondents did not complete at least 85% of the items, the respondent was excluded from the facet calculations. This resulted in the removal of 3 respondents for the facets corresponding to benefits and environmental risks and 2 respondents from the facet for risks to residents living near drilling sites.

#### *2.4 Respondent Description*

Of the 400 randomly selected, 51 respondents returned the completed paper survey and 7 respondents made online submissions for an overall response rate of 14.5%. Residents of all counties except Lee responded. Some surveys were returned undeliverable. Only one

Lee county survey was returned and this was due to a vacant address. Eighteen total surveys were returned due to vacant addresses and instruction to RTS (return to sender). The sample was 52% female (n = 27). There were six item nonresponses for gender. The majority of the respondents were White/European American 83% (n=45) individuals, similar to the demographic composition of the entire state (71.7%) and nation (77.7%) (U.S. Census 2014). As shown in Table 2, Black/African American and Hispanic/Latino people were underrepresented in the sample. There were four item nonresponses for ethnicity.

**Table 2.** Survey Ethnicity Comparison

<b>Ethnicity</b>	<b>SURVEY</b>	<b>NC<sup>1</sup></b>	<b>USA<sup>1</sup></b>
White/European American	83%	71.7%	77.7%
Black/African American	7%	22%	13.2%
Multi-Ethnic	6%	2%	2%
American Indian/Alaska Native	2%	1.6%	1.2%
Hispanic/Latino	2%	8.9%	17.1%

<sup>1</sup>(U.S. Census Bureau 2014)

Education levels ranged from some high school to postgraduate study. Of the 56 respondents who answered the question, 2% reported some high school, 14% were high school graduates, 23% had some college or trade school, 30% were college graduates, and 30% completed post-graduate study. There were two item nonresponses for education. Among the 54 respondents who answered political affiliation, 50% were Democrat, 31% Unaffiliated/Independent, and 19% Republican. Of the 52 individuals who reported political views, the majority identified with moderate political views (31%), and those identifying as very liberal were in the minority (8%). Respondents ranged from age 31-87 years. The average respondent age was 60 years. The average in the U.S. population is 37.3 years according to 2012 U.S. Census data (U.S. Census 2014). Most respondents reported a full-time employment status 47% (n=26) or were retired (38%). There were three item nonresponses for employment status. Of the 42 respondents who reported income, 24% reported earning

\$20,000 - <\$40,000 and 29%, the majority, reported earning \$100,000 or more for the 2013 tax year.

### 3. RESULTS AND DISCUSSION

#### 3.1 Reliability and Validity

The Cronbach's alpha internal consistency estimate is a reliability measurement that is sensitive to content sampling error (Reynolds 2009). It was used to assess the content homogeneity of the survey instrument facets of potential benefits, risks to residents living near drilling sites, and environmental risks. Findings from the main facets in this study indicated excellent internal consistency. The Cronbach's alpha values for the individual facets ranged from 0.912 to 0.966 (Table 3), indicating excellent internal consistency. Expert review of the survey facets provided evidence of content validity.

**Table 3.** Public Opinions on Fracking Facets with Cronbach's Alpha and Mean Values

Facet	Cronbach's Alpha	Facet Mean	Control Mean	Study Mean
Potential fracking outcomes: Benefits	0.912	3.15	3.184	3.12
Potential fracking outcomes: Risks for residents near drilling sites	0.966	3.93	3.84	4.01
Potential fracking outcomes: Environmental Risks	0.975	3.81	3.77	3.84

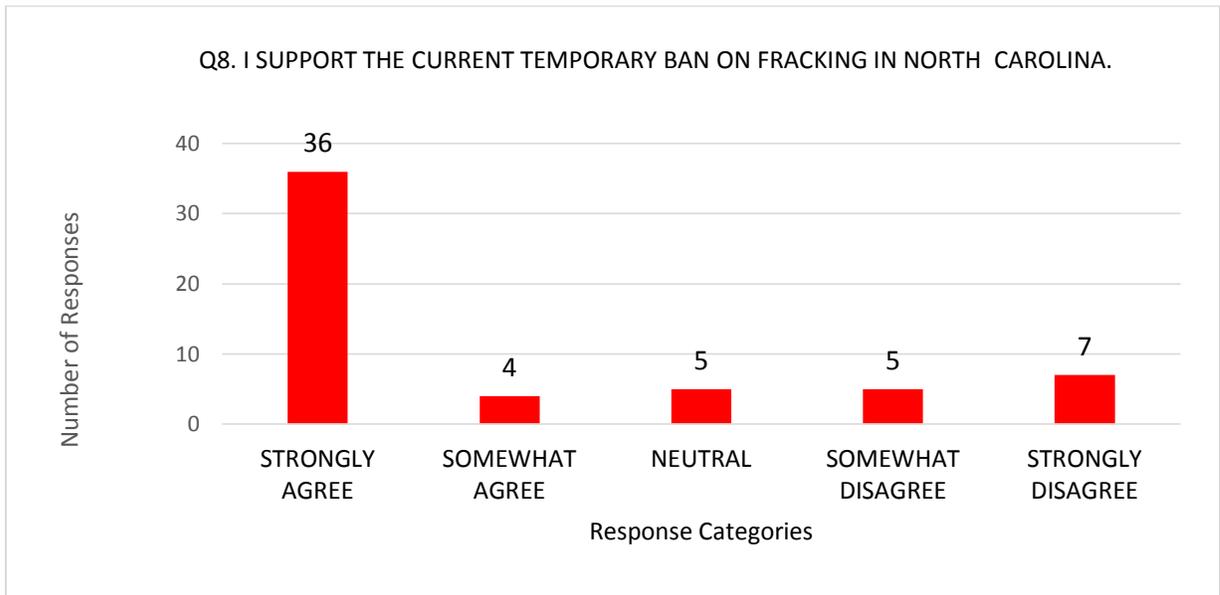
For potential benefits, the control and study facet means are similar, suggesting the respondents similarly perceived fracking benefits. More substantial differences among the two groups are demonstrated in the other two facets. The study counties ranked risks for residents near drilling sites and environmental risks more highly.

#### 3.2 Governance

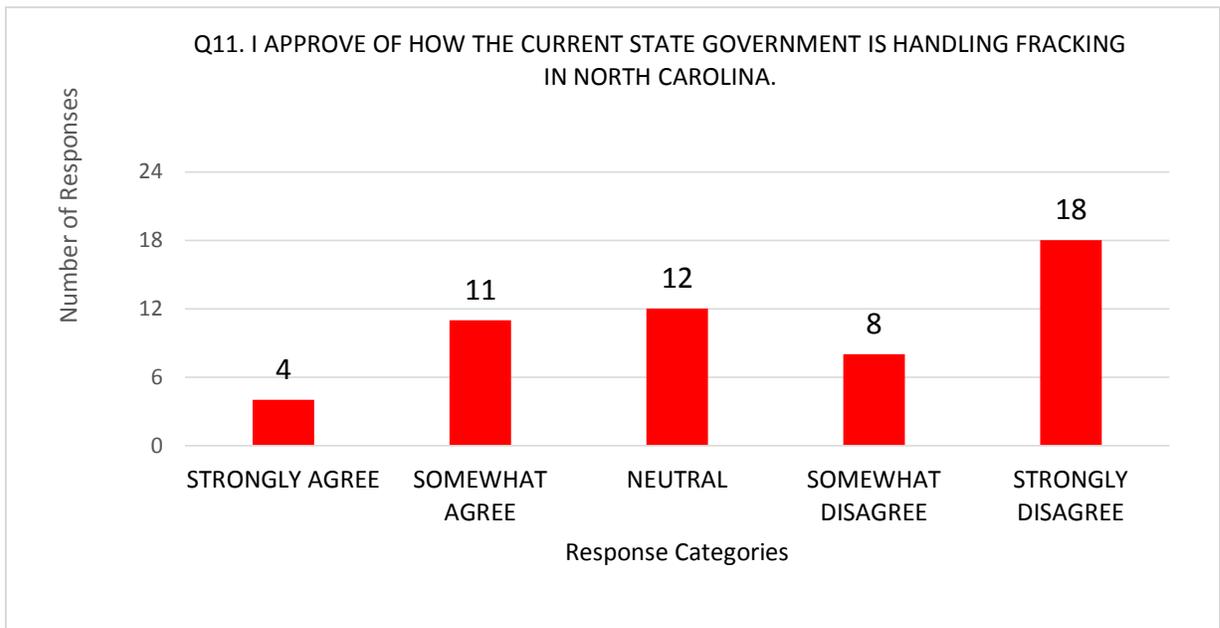
Four statements were used to examine how strongly the public supports or opposes fracking in North Carolina. Results from three of these governance questions are presented below. The majority of the respondents (n=36) strongly agreed to the statement in question 8,

“I support the current temporary ban on fracking in North Carolina” (Figure 5). Most respondents strongly disagreed (n=18) to the statement in number 11, “I approve of how the current state government is handling fracking in North Carolina” (Figure 6).

**Figure 5.** Question 8 Overall Response Distribution

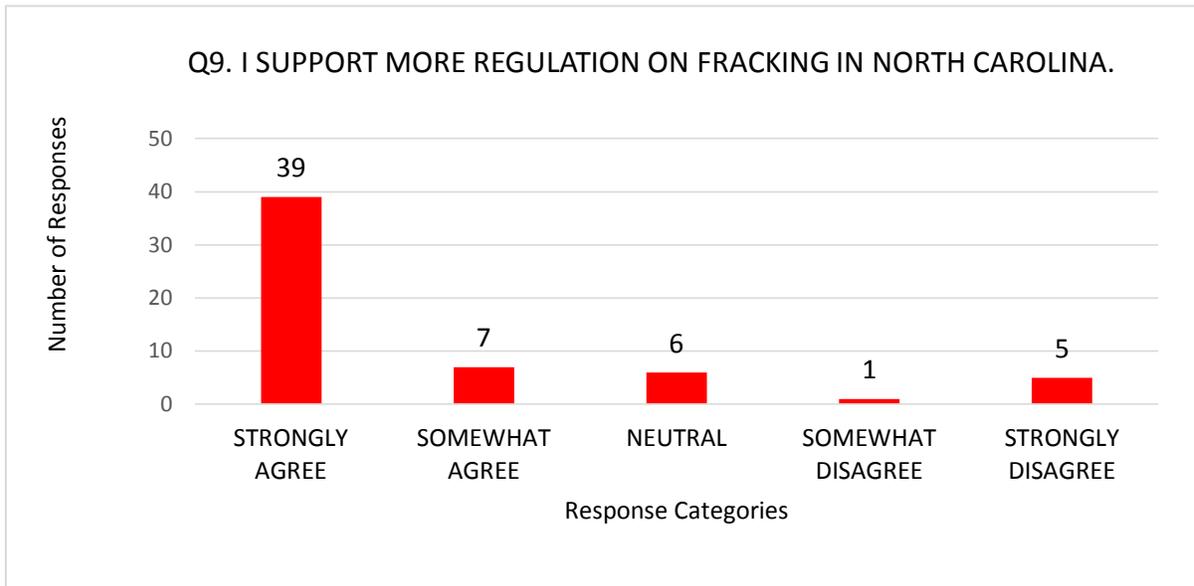


**Figure 6.** Question 11 Overall Response Distribution



Similarly, most support more regulation on fracking in North Carolina (n=39) (Figure 7).

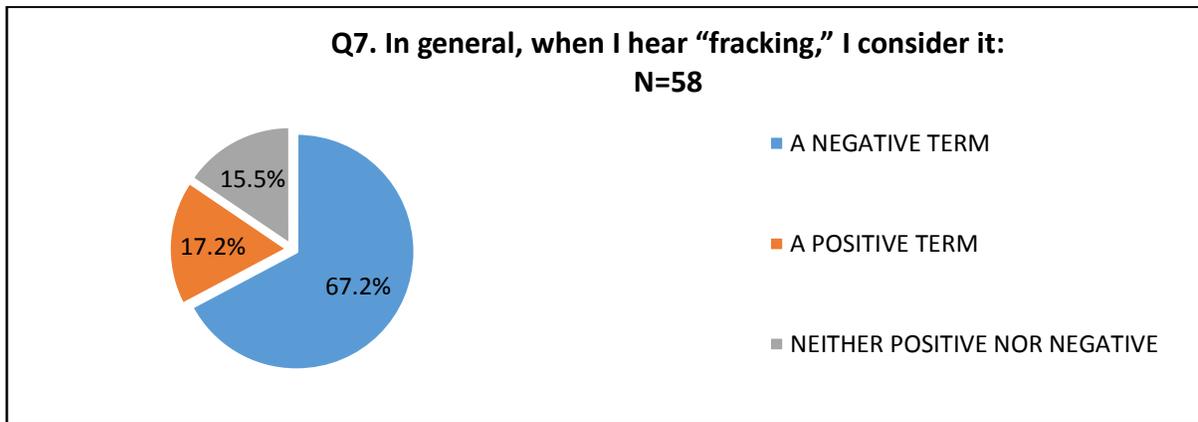
**Figure 7.** Question 9 Overall Response Distribution



### 3.3 Perceptions

Given the varied media attention around fracking debates in North Carolina, it was interesting to explore the public's perception of the terminology. The survey captured the public's perception of the term "fracking" in three different questions, 7, 12, and 13 (see Appendix A). Of the 58 respondents who answered question 7, 67.2% said they consider fracking a negative term and 17.2% considered it a positive term (Figure 8). In exploring the media's influence on perceptions in the future, one could ask respondents if they consider the majority of the messages they hear about fracking in the media as negative or positive to gain more insight on their perceptions.

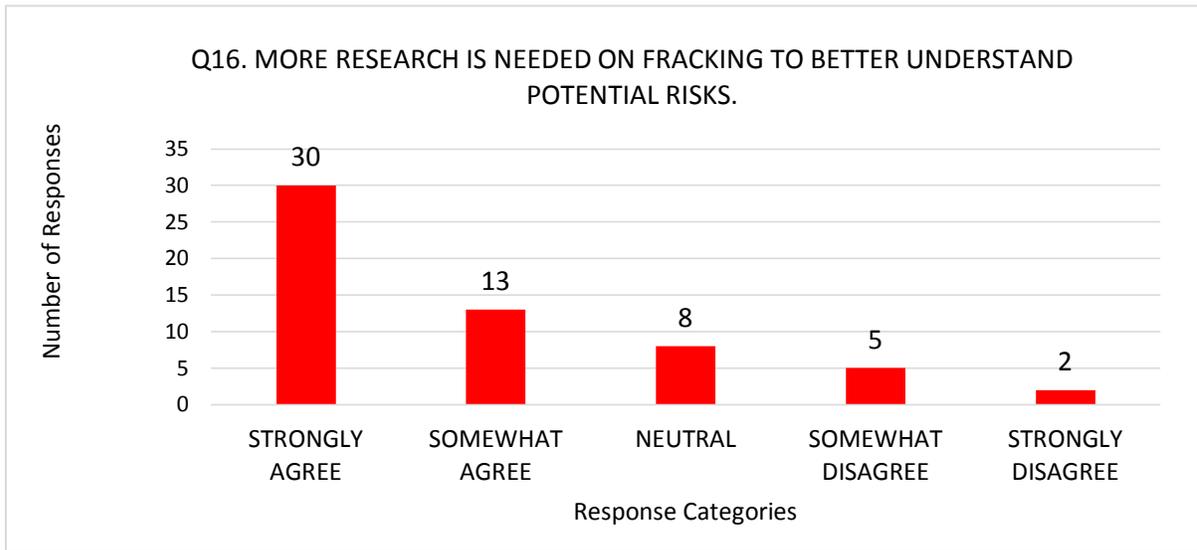
**Figure 8.** Question 7 Overall Response Distribution



### 3.4 Risks and Benefits

Of the 58 respondents who answered question 16 (More research is needed on fracking to better understand potential risks.), the majority agreed that more research is needed on fracking to better understand potential risks; 30 people strongly agreed and 13 somewhat agreed (Figure 9). While multiple studies have suggested shale gas development activities produce air pollutants at concentrations associated with increased risk of morbidity and mortality, there are data gaps, including emissions and atmospheric concentration measurements in different geographic locations and epidemiological studies (Shonkoff *et al.* 2014). Ambient air emission estimates should be measured inside and outdoors to better identify the types and degree of exposure to populations (Shonkoff *et al.* 2014). An important information gap is the lack of epidemiological studies as there is a need to evaluate the association between risk factors and health outcomes for people living near shale gas development activities compared to those living in areas without the activities (Shonkoff *et al.* 2014). To examine the public's opinion on the need for more research to better understand fracking risks in the future, it could be helpful to ascertain the respondent's awareness of existing research on potential risks and their opinions about the adequacy of available data.

**Figure 9.** Question 16 Overall Response Distribution

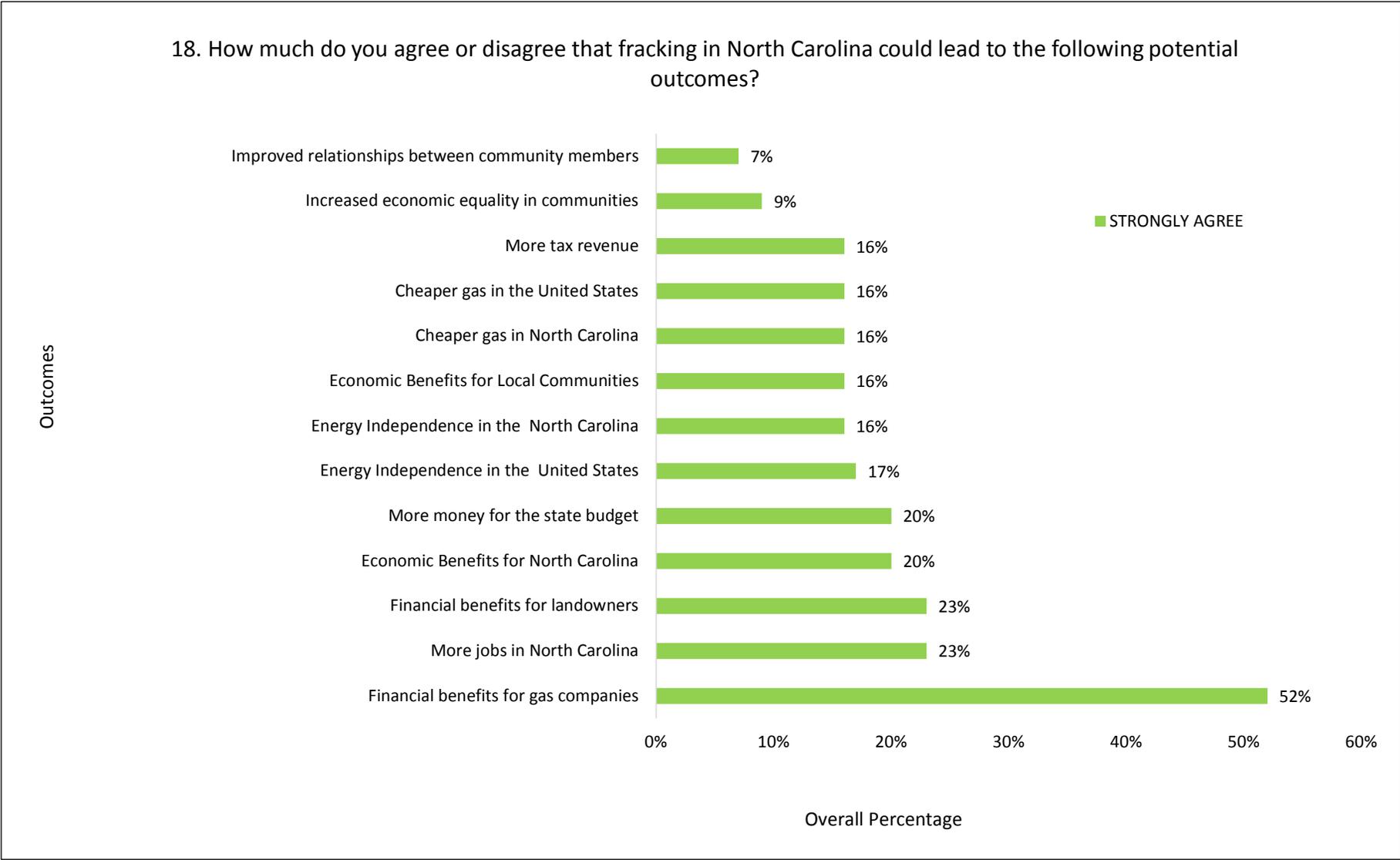


In this instrument, some items were designed with similar wording to capture perceptions of benefits to the state versus to the nation as a whole. For example, there are items related to cheaper gas and energy independence in the state and in the United States. The potential for natural gas production in North Carolina is small compared to other states (Adair *et al.* 2012). Some believe North Carolina’s oil and natural gas energy production from fracking will not significantly contribute to the overall economic condition of the country so some argue it’s not worth the risks to engage in fracking. The similar facets were meant to explore these beliefs. The public’s beliefs about these types of potential benefits were captured in the question 18 series. Respondents similarly ranked benefits for the U.S. and the state. Among the 55 total respondents for the benefits facet, 16% strongly agreed “cheaper gas in the U.S.” and “cheaper gas in North Carolina” were potential fracking benefits. Similarly, 17% strongly agreed with “energy independence in the U.S.” as a potential benefit and 16% strongly agreed with “energy independence in North Carolina” as a potential benefit (Figure 10). The most strongly agreed with statement was “financial benefits for gas companies” (52%) and the

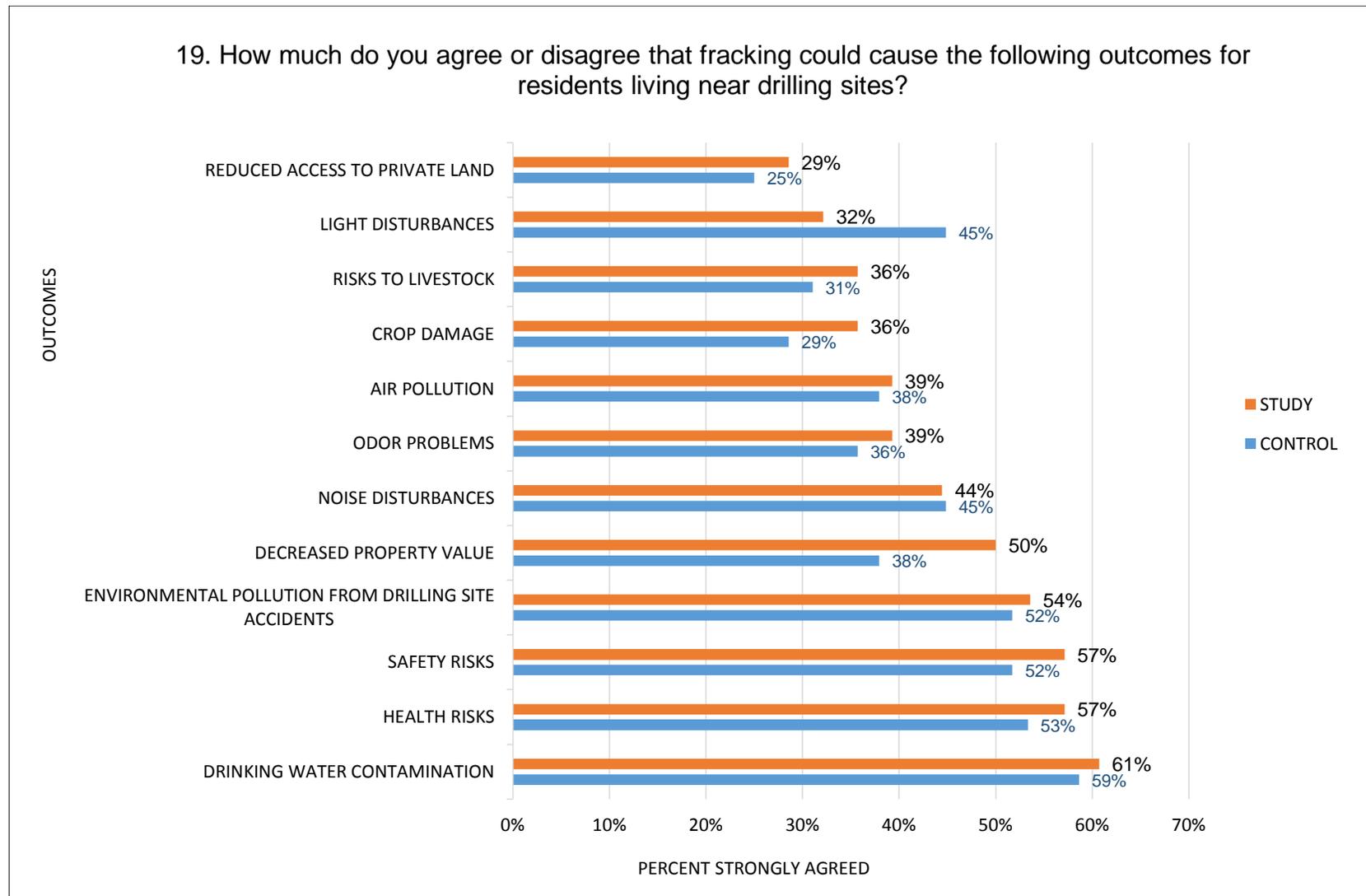
least strongly agreed with statement that indicated a benefit was “improved relationships between community members” (7%) (Figure 10).

According to the North Carolina Energy Coalition, a group which provides the public with facts on the oil and natural gas industry in North Carolina to foster open communication on all topics related to energy production, the natural gas industry is already responsible for 146,000 jobs in the state and contributes \$12.4 billion to North Carolina’s economy (NC Energy Coalition, 2014). The addition of safe shale energy development in the state can create more jobs, help the local economy, and yield more tax revenue. By 2030, further development of energy reserves could add over 45,000 jobs and more than \$3 billion in total government revenue (NC Energy Coalition, 2014). North Carolina’s June unemployment rate was 6.4% and the U.S. unemployment rate dropped by 0.2 percentage point to 6.1 percent in June. (NC Dept. of Commerce, 2014). In states where shale gas development is underway, the unemployment rates are lower; Pennsylvania’s June rate was 5.6, Montana’s was 4.5, and North Dakota’s was 2.7, the lowest in the country (US Dept. of Labor, 2014). The natural gas industry contributes over \$1 trillion of total value to the U.S. economy, 7.1% of GDP (NC Energy Coalition, 2014). Production of natural gas was responsible for more than a million jobs in the country in 2010 (NC Energy Coalition, 2014). The job and economic growth from shale gas development is expected to have a significant impact on state economies and the national economies (NC Energy Coalition, 2014).

Figure 10. Question 18 Overall Response Distribution

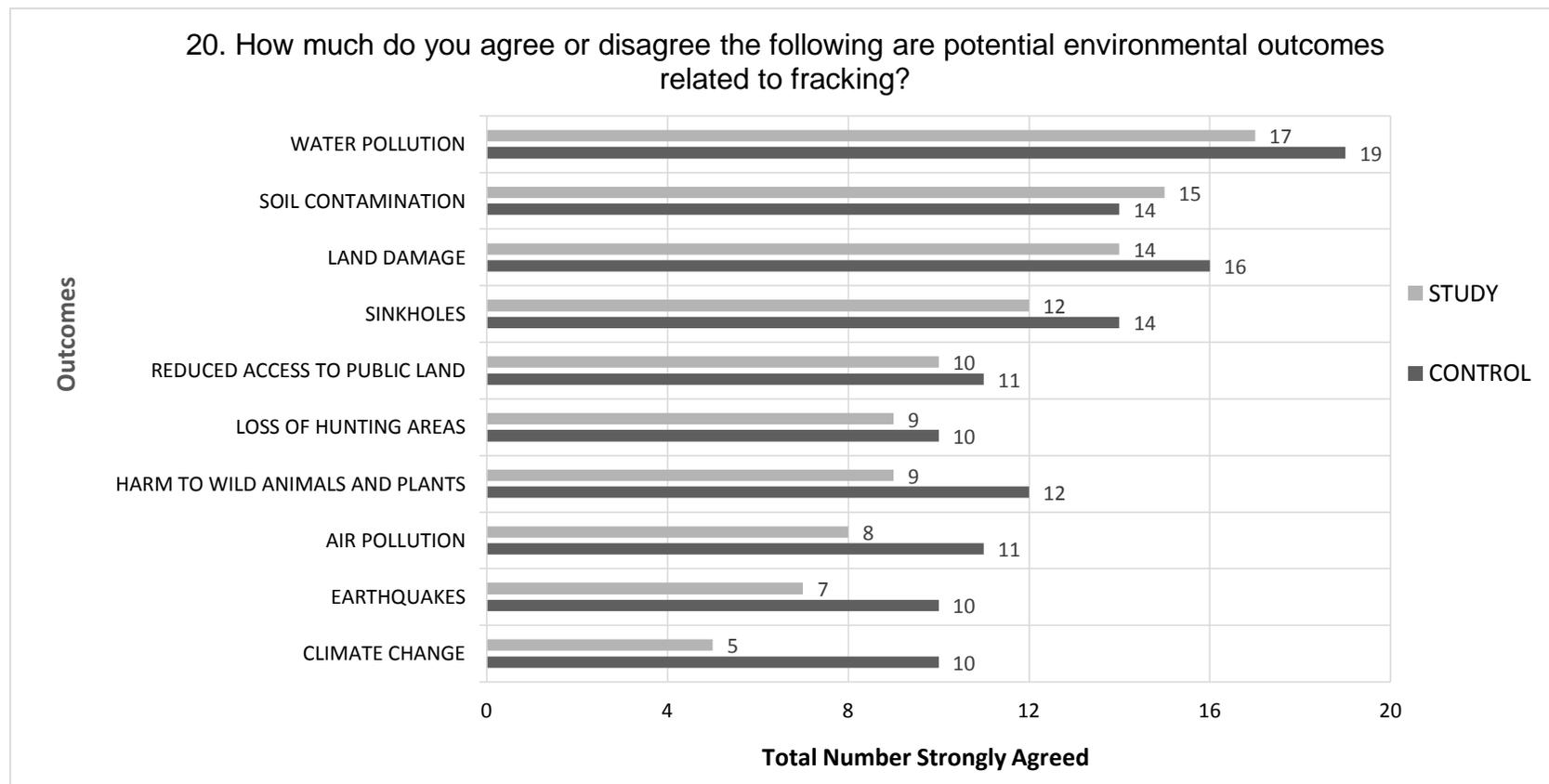


**Figure 11.** Question 19 Response Distribution by County Status



For the environmental risks facet, the risk with the largest percentage of respondents indicating they strongly agreed corresponded to water pollution. This was the case for respondents of both control (n=19) and study counties (n=17). As shown in Figure 12, controls reported they strongly agreed in the lowest numbers for the loss of hunting areas (n=10), earthquakes (n=10), and climate change (n=10) and respondents from study counties reported they strongly agreed in the lowest numbers for climate change (n=5).

**Figure 12.** Question 20 Response Distribution by County Status

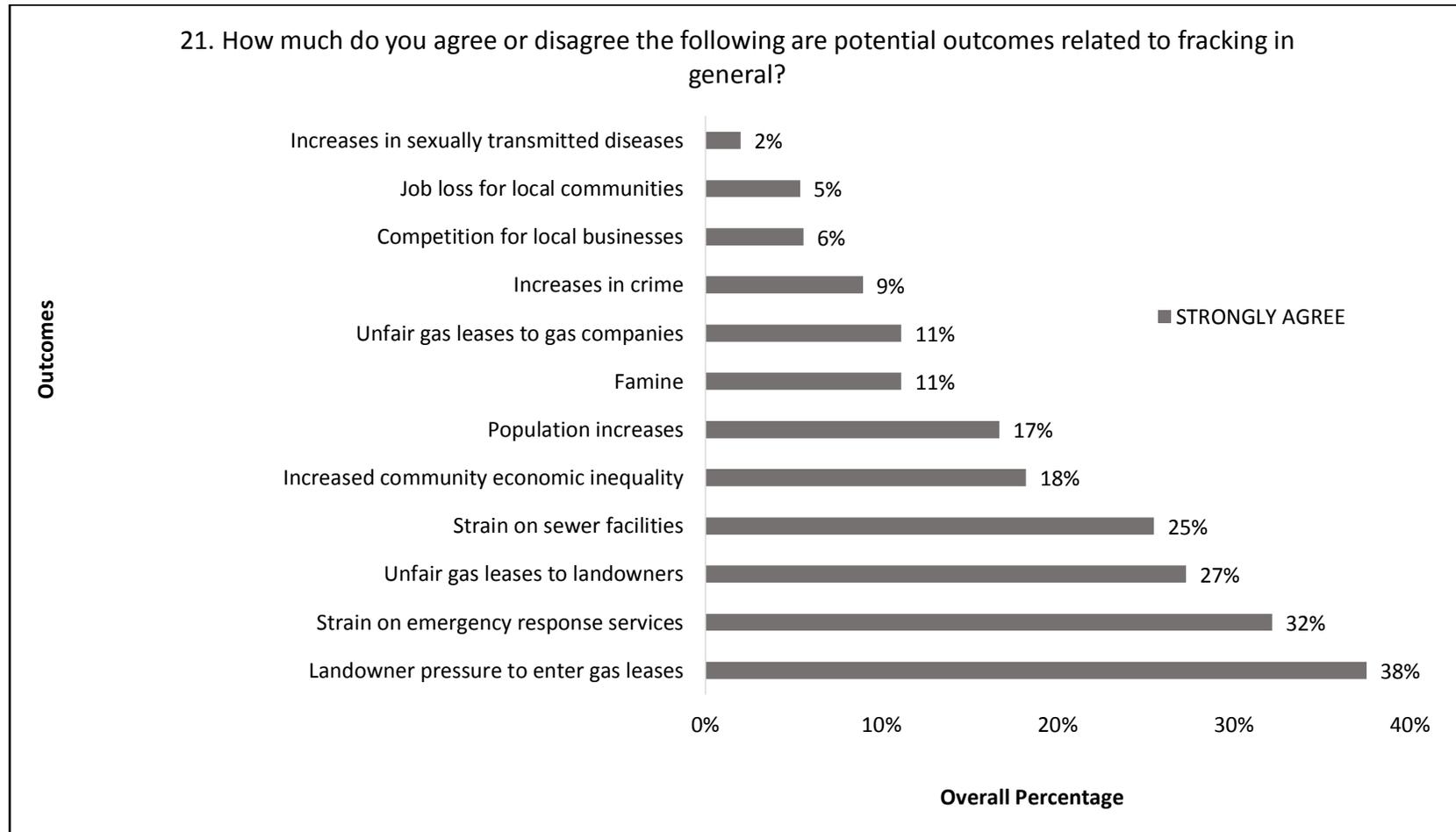


Three items in this survey addressed leases, unfair gas leases to gas companies and landowners, and landowner pressure to enter gas leases. Respondents were provided a basic definition of gas leases for the question 21 series, “These are agreements that outline the basic terms, such as royalties to be paid, length of time, and description of lands to be used for development and other activities.” Of the 55 respondents who answered item 21k (Appendix A), 27% of respondents strongly agreed that unfair gas leases to landowners was a potential outcome related to fracking in general. Among the 54 respondents who answered item 21l, 11% of respondents strongly agreed that unfair gas leases to gas companies was a potential outcome. Of the 56 respondents who answered item 21m, 38% of respondents strongly agreed that landowner pressure to enter gas leases was a potential outcome related to fracking in general (Figure 13).

Because many of North Carolina’s homeowners have no prior experience with oil and gas development activities and may be unable to evaluate the financial and environmental risks associated with shale gas leases and because few lawyers in the state have experience with the industry to provide adequate legal guidance, the Research Triangle Environmental Health Collaborative at the 2012 Environmental Health Summit made several recommendations and identified the need to clarify industry and landowner liabilities, establish property owner insurance mechanisms, provide funding for low-cost baseline water and air testing in state laboratories, and provide education about mineral leases (EHC 2013). Understanding the public’s perception of risks related to gas leases is important to better address knowledge gaps and establish the most effective ways to provide the education necessary for landowners to make informed decisions when entering gas leases. Three items in this survey addressed leases, unfair gas leases to gas companies and landowners and landowner pressure to enter gas leases. Respondents were provided a basic definition of gas

leases for the question 21 series, “These are agreements that outline the basic terms, such as royalties to be paid, length of time, and description of lands to be used for development and other activities.” Of the 55 respondents who answered item 21k (Appendix A), 27% of respondents strongly agreed that unfair gas leases to landowners was a potential outcome related to fracking in general. Among the 54 respondents who answered item 21l, 11% of respondents strongly agreed that unfair gas leases to gas companies was a potential outcome. Of the 56 respondents who answered item 21m, most respondents strongly agreed that landowner pressure to enter gas leases was a potential outcome related to fracking in general (38%) (Figure 13).

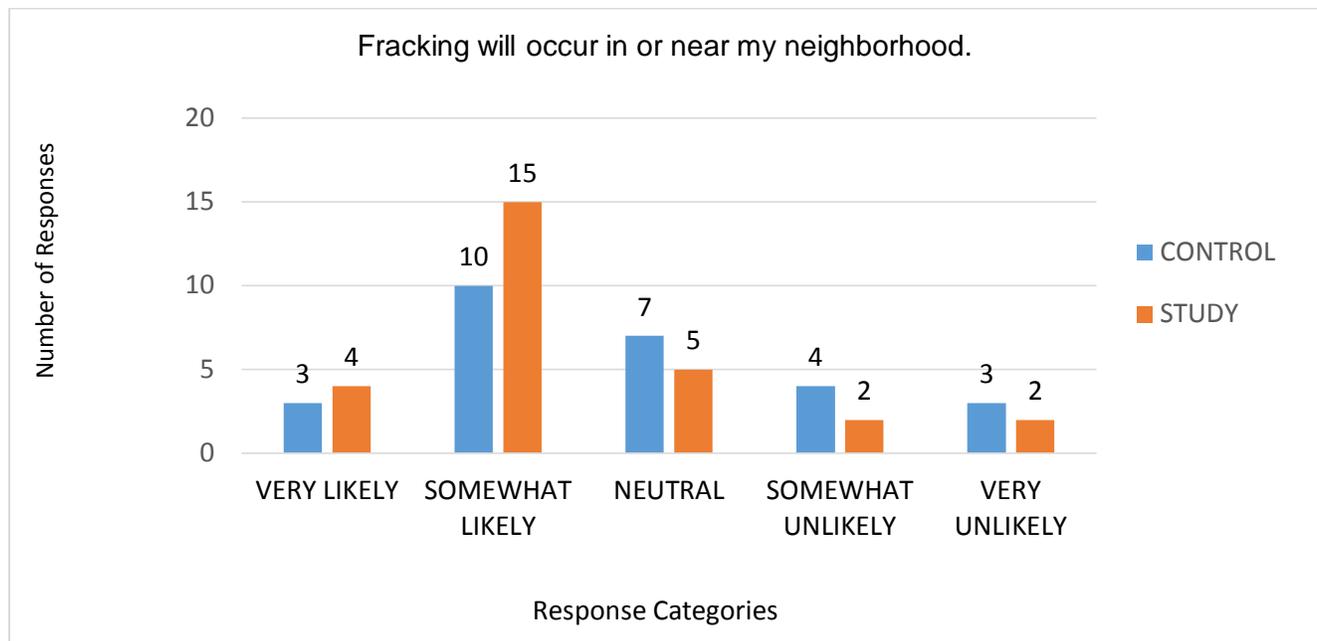
**Figure 13.** Question 21 Overall Response Distribution



### 3.5 The Future

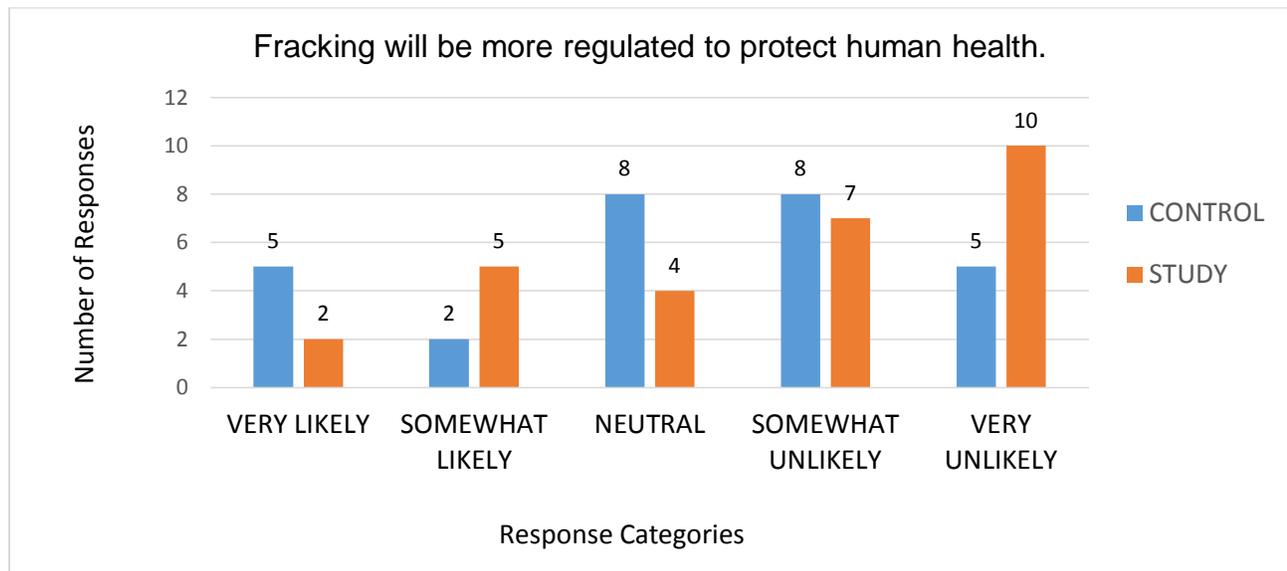
North Carolina is in the process of making important decisions about fracking regulations that will impact the future of shale gas development in the state, therefore it was important to attempt to capture the public's beliefs about the future of the state. Respondents were asked to report the likelihood of 9 occurrences happening within the next 10 years (Appendix A). Of the 55 respondents who answered item 22b, 15 people from study counties reported it was somewhat likely that fracking would occur in or near their neighborhood and 4 respondents said it was very likely to occur, slightly higher than control counties where 10 said it was somewhat likely and 3 reported it was very likely (Figure 14). A difference was expected because the study counties are those areas that have been identified for future fracking sites.

**Figure 14.** Question 22b. Response Distribution by County Status



Among the 56 respondents, 10 respondents from study counties reported it was very unlikely that fracking will be more regulated to protect human health in the next 10 years and only 2 said it was very likely (Figure 15). Most control respondents said they were neutral or that it was somewhat likely fracking will be more regulated to protect human health in the next 10 years.

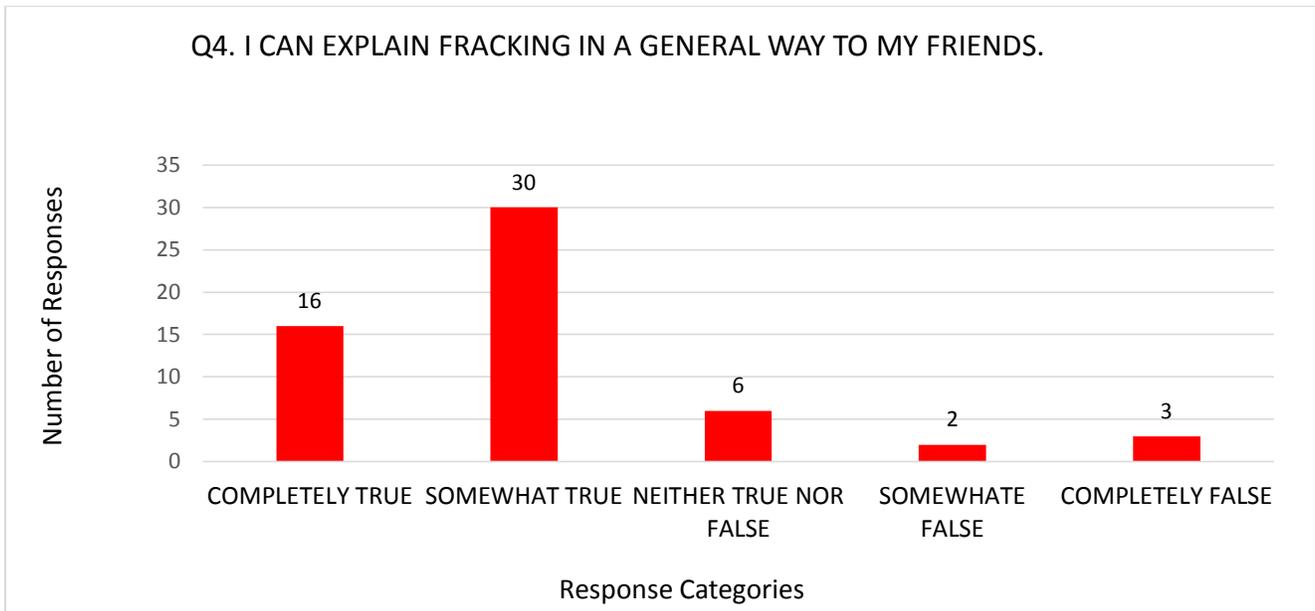
**Figure 15.** Question 22e. Response Distribution by County Status



### 3.6 Awareness

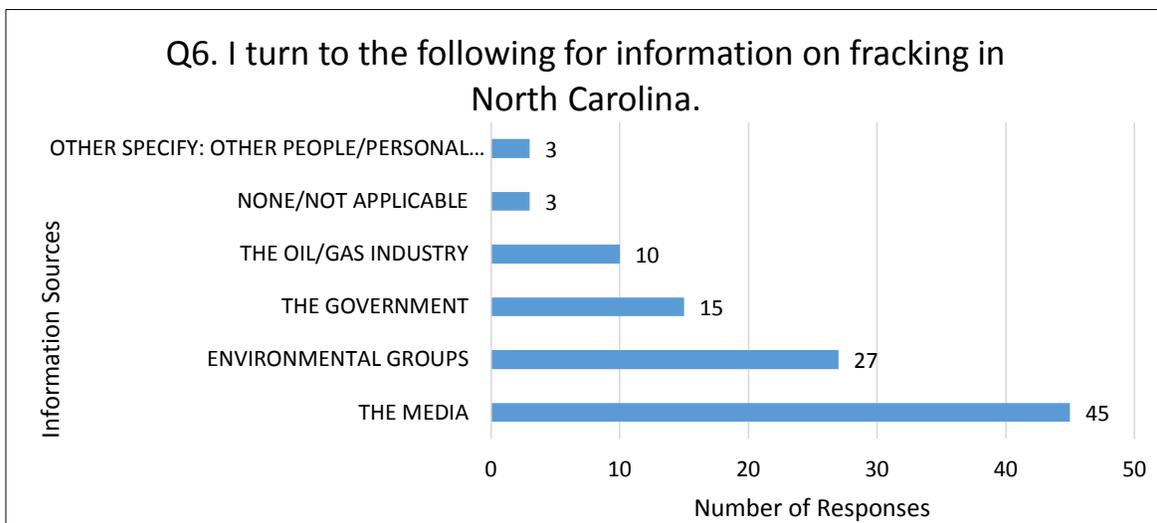
The *Public Opinions on Fracking Survey* included a few different questions to evaluate respondent awareness of fracking. In question 4 respondents were asked to report their ability to explain fracking in a general way. The majority, 30 respondents, reported it was somewhat true that they could do so and 16 reported that it was completely true (Figure 16). Other polls have been conducted at the national level to gather data on the public’s perception of fracking, some of which specifically capture awareness. The National Energy Opinion poll reported only 21% of respondents had “significant knowledge” about hydraulic fracturing and a poll by the Pew Research Center for the People and the Press discovered 26% of Americans heard a lot about the issue, 37% heard a little, and 37% heard nothing at all (Boudet *et al.* 2013). Given the media’s attention on fracking in North Carolina, this was an interesting aspect to explore.

**Figure 16.** Question 4 Overall Response Distribution



Respondents were asked to identify the sources they turn to for information on fracking in North Carolina. The majority, 45 respondents, reported the media, followed by environmental groups, 27 (Figure 17). Respondents were also given the option to specify sources in the “other” category. Three respondents reported “other people” or “personal experience” as sources.

**Figure 17.** Question 6 Overall Response Distribution



Efforts to educate the public, provide information on regulation changes, and increase awareness about issues related to fracking or any other issue requires a communication avenue. In order to reach the majority of the population, government officials, educators, researchers, and others need to know the best method to use to reach the public.

### *3.7 Conclusion*

In this study, the *Public Opinions on Fracking Survey* was developed, pilot tested and administered to a random sample of residents in select counties in North Carolina where fracking is likely and unlikely to occur in the future. Various messages publicized as “benefits and risks” in the media, poll data from other states, research publications, webinars, personal interest, and expert feedback informed the selection of inventory items. The survey was found to be reliable and valid.

Importantly, the instrument revealed some knowledge gaps in the surveyed population related to fracking. More than half of the respondents reported not knowing if fracking is exempt from common laws and rules that protect the environment. Where respondents were asked to agree or disagree that increases in sexually transmitted diseases could be a potential outcome related to fracking, 44% (n=24) respondents were neutral and 42% strongly disagreed. This risk has not resulted in as much attention as drinking water contamination, however, it is real. One of the components addressed in the EHC’s HIA was psychological and other stressors. The EHC suggested the HIA address all factors that could impact human health in communities, not only the exposure to chemicals. Such factors include increases in traffic, light and noise pollution, and increases in the prevalence of sexually transmitted infections (EHC 2013). Some states, such as North Dakota, Pennsylvania, and Montana, currently participating in fracking are experiencing the social problems associated with fracking in relation to more prostitution, rape, and sexual assault. With oil and gas workers coming into towns for employment, there is an increase in illegal drug sale and usage, as well as

prostitution (Breiner 2013). The Food & Water Watch organization, a non-profit that advocates for policies for healthy food and affordable drinking water, produced a report on a case study of the social problems caused by fracking in Pennsylvania. They found the influx of work force for shale exploration in Pennsylvania since 2005 has brought increased sexually transmitted infections and more arrests for violations of social disorder (Food & Water Watch 2013). According to the report, disorderly conduct arrests increased by 17.1% and the average increase in chlamydia and gonorrhoea cases was 62% higher in rural counties that are heavily fracked than in those that are not (Food & Water Watch 2013). This year, National Geographic published an article on the growing pains a Montana town is facing, "Bakken Oil Boom Brings Growing Pains to Small Montana Town An influx of workers leaves housing scarce-and the jail full." In the section, "Crime on the Rise," the author describes FBI warnings of drug cartels targeting the area for the large paychecks of the mostly young men who work there now. Felony drug arrests have increased and assault arrests have nearly doubled from 2008 to 2012 (Eaton 2014).

The knowledge gap revealed in the survey results are not surprising, as most of the national discussions about fracking primarily focus on environmental risks and specific human health risks related to drinking water contamination and exposure to toxicants. As expected, respondents ranked water-related risks highest. Where respondents were asked to agree or disagree that water pollution could be a potential environmental outcome related to fracking, of the 57 who answered the question, 63% (n=36) strongly agreed. Where respondents were asked to agree or disagree that drinking water contamination could be a potential outcome for residents living near drilling sites, of the 58 who answered the question, 60% (n=34) strongly agreed. Findings about knowledge gaps about risks could be used to better communicate with the public about social implications and stimulate more in-depth conversations in the fracking debate.

Given the respondent demographics in this study and number of responses, a recommended next step is administering the survey to a larger, more diverse sample, specifically aiming for more adults younger than 31 years old. Among the respondents, 31 was the minimum age. The online survey option will likely be the best method to capture this younger population. Additional counties in or near the Triassic basins should be surveyed in the future, including a reattempt to capture a sample from Lee County. Lee County is the center of where most of the state's natural gas reserves are believed to be located (Henderson 2014).

Once fracking has started in this state, it will be interesting to ask the public to weigh the risks and benefits experienced at that time. This has already been explored in other states where fracking is occurring. For example, a 2011 survey of Pennsylvania residents reported 41% saw more benefits than problems, 33% reported problems exceeded benefits, 26% saw problems and benefits as equal, 50% expected more benefits than problems in the future, 32% expected more problems than benefits in the future, and 17% expected equal problems and benefits in the future (Rabe and Borick 2011).

Now that certain facet items have been explored singularly, such as those in 18, some items may be eliminated to create a shorter survey instrument with more unique data points. A shorter survey could improve the response rate, as questionnaires perceived as long can deter respondents (Burgess 2001). Although the survey was sent according to standard survey administration guidelines to improve survey responses and expedite responses, the response rate was low. Mailed questionnaires offer advantages such as being low cost, geographically flexible, more valid, and without interviewer bias; however a major disadvantage is their low response rate and problems with response and nonresponse bias (Kanuk and Berenson 1975). Guidelines on acceptable survey return rates vary and are shaped by multiple factors including the type of case or subject and the data collection method; however, most support

obtaining a high rate to reduce nonresponse bias and justify sample representation (Hager *et al.* 2003). Respondents from colleges appear to be more responsive to web surveys, while some other respondents such as those from the general public tend to prefer traditional mail surveys (Shih and Fan 2008). Studies have found response rates ranging from 26-95% for those conducted among businesses (Hager *et al.* 2003). Studies used in a meta-analysis for comparing web and mail survey response rates had response rates ranging from 10-89% for paper surveys and 7-88% for web survey surveys (Shih and Fan 2008). Although the overall response rate for this survey was 14.5%, lower than an ideal response rate for other, well-funded surveys or those with larger sampling, such as the Wygant and Lindorf (1999) collegiate survey that received a 50% web response rate and a 32% paper survey response rate (n=2,569), these data are useful as a first step for understanding overall perception of the risks and benefits of fracking in North Carolina.

The survey developed and administered for this project can be used as a template for future research. This will likely be needed as people's beliefs shift with other changes and experiences in North Carolina and as fracking is explored in other states. For example, many North Carolinians are expressing concerns based on fear of what could happen. Once drilling starts and people experience certain outcomes, their beliefs could change because of individual experience and the availability of additional evidence. At that time it could be useful to reassess people's beliefs. The information obtained can be used to develop effective communication tools, improve mitigation efforts, inform plans to educate the public where knowledge gaps exist, and clarify messages in the media. Education can help communities transition once the state begins to experience the effects of oil and gas drilling (EHC 2013). Information should be available about all potential impacts of shale gas. The more people know about the potential impacts of shale gas, the better prepared they are to make informed land lease and other decisions (EHC 2013). As the state ventures into the drilling arena,

preparedness for the benefits and risks alike will be the public's collective responsibility. An important initial step is to understand what people believe about risks and benefits. Instruments like the one developed for this project can play an important role in that regard.

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**Appendix A. Public Opinions on Fracking Survey Questions and Answers**

	Completely True	Somewhat True	Neither True nor False	Somewhat False	Completely False
1. I pay close attention to information about possible outcomes related to human health.					
2. I pay close attention to information about possible outcomes related to environmental health.					
3. I am aware of fracking regulations in North Carolina.					
4. I can explain fracking in a general way to my friends.					
<p><b>5. Fracking is exempt from common laws and rules that protect the environment.</b></p> <p><input type="checkbox"/> Yes</p> <p><input type="checkbox"/> No</p> <p><input type="checkbox"/> Don't Know</p> <p><b>6. I turn to the following for information on fracking in North Carolina. Check all that apply.</b></p> <p><input type="checkbox"/> Environmental groups</p> <p><input type="checkbox"/> The government</p> <p><input type="checkbox"/> The oil/gas industry</p> <p><input type="checkbox"/> The media</p> <p><input type="checkbox"/> None/Not Applicable</p> <p><input type="checkbox"/> Other (specify): _____</p> <p><b>7. In general, when I hear "fracking," I consider it:</b></p> <p><input type="checkbox"/> A positive term</p> <p><input type="checkbox"/> A negative term</p> <p><input type="checkbox"/> Neither positive nor negative</p>					

	Strongly Agree	Somewhat Agree	Neutral	Somewhat Disagree	Strongly Disagree
8. I support the current temporary ban on fracking in North Carolina.					
9. I support more regulation on fracking in North Carolina.					
10. I approve of how the former state government handled fracking in North Carolina.					
11. I approve of how the current state government is handling fracking in North Carolina.					
12. In general, when I hear the word “fracking,” I consider it a positive term.					
13. In general, when I hear the word “fracking”, I consider it a negative term.					
14. All forms of energy production have environmental consequences.					
15. There are no proven risks related to fracking.					
16. More research is needed on fracking to better understand potential risks.					
17. Fracking can be done safely in North Carolina.					
<b>18. How much do you agree or disagree that fracking in North Carolina could lead to the following potential outcomes?</b>					
	Strongly Agree	Somewhat Agree	Neutral	Somewhat Disagree	Strongly Disagree
a) Energy independence in the United States					
b) Energy independence in the North Carolina					
c) Economic benefits for North Carolina					
d) Economic benefits for local communities					
e) More jobs in North Carolina					
f) Cheaper gas in North Carolina					
g) Cheaper gas in the United States					
h) More money for the state budget					
i) More tax revenue					

j) Improved relationships between community members					
k) Increased economic equality in communities					
l) Financial benefits for gas companies					
m) Financial benefits for landowners					
<b>19. How much do you agree or disagree that fracking could cause the following outcomes for residents living near drilling sites?</b>					
	Strongly Agree	Somewhat Agree	Neutral	Somewhat Disagree	Strongly Disagree
a) Health risks					
b) Safety risks					
c) Light disturbances					
d) Noise disturbances					
e) Odor problems					
f) Environmental pollution from drilling site accidents					
g) Drinking water contamination					
h) Air pollution					
i) Decreased property value					
j) Reduced access to private land					
k) Crop damage					
l) Risks to livestock					
<b>20. How much do you agree or disagree the following are potential environmental outcomes related to fracking?</b>					
	Strongly Agree	Somewhat Agree	Neutral	Somewhat Disagree	Strongly Disagree
a) Harm to wild animals and plants					
b) Climate change					
c) Earthquakes					
d) Water pollution					
e) Land damage					
f) Sinkholes					
g) Air pollution					

h) Soil contamination					
i) Reduced access to public land					
j) Loss of hunting areas					
<b>21. How much do you agree or disagree the following are potential outcomes related to fracking in general?</b>					
	Strongly Agree	Somewhat Agree	Neutral	Somewhat Disagree	Strongly Disagree
a) Population increases					
b) Competition for local businesses					
c) Famine					
d) Strain on sewer facilities					
e) Increased community economic inequality					
f) Strain on emergency response services					
g) Strain on roads and bridges					
h) Increases in sexually transmitted diseases					
i) Job loss for local communities					
j) Increases in crime					
k) Unfair gas leases to landowners					
l) Unfair gas leases to gas companies					
m) Landowner pressure to enter gas leases					
<b>22. How likely or unlikely do you think each of the following will happen within the next 10 years in North Carolina?</b>					
	Very Likely	Somewhat Likely	Neutral	Somewhat Unlikely	Very Unlikely
a) The temporary ban on fracking will be lifted.					
b) Fracking will occur in or near my neighborhood.					
c) Fracking will be more regulated to protect environmental safety.					
d) Fracking will occur on my property without my permission.					
e) Fracking will be more regulated to protect human health.					
f) Fracking will lead to economic benefits.					

g) Fracking will lead to energy independence.					
h) Fracking will be banned.					
i) The demand for natural gas will decrease.					