

## Section 6 – Potential social impacts

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### A. Potential impacts on housing availability

Natural gas and oil development has had a major impact on the cost and availability of rental housing in states such as Pennsylvania and North Dakota. In areas with a short supply of workers trained in the field of natural gas and oil construction, companies must import crews from other states.<sup>387</sup> These workers, skilled in drilling, hydraulic fracturing or other specialized skills, typically seek rental housing within one hour of their worksites.<sup>388</sup>

#### *Examples from other states*

As drilling activity has increased in certain parts of the United States, rural areas and small towns have, in some cases, been overwhelmed by the demand for worker housing. In some parts of northern Pennsylvania, drilling in the Marcellus has led to shortages in affordable housing. Townships in several Pennsylvania counties (such as Bradford, Lycoming and Tioga counties) have seen spikes in housing costs, as rates for hotel rooms and rental units increase in response to greater housing demand.<sup>389</sup>

The impact of gas production on housing costs and availability likely depends on three key factors: 1) the speed and scale of industry growth in a given community; 2) the existing housing capacity of a community before drilling begins; and 3) the industry's need to import workers skilled in gas production activities. For example, communities with faster industry growth tend to experience greater increases in housing costs, especially if those communities lack adequate housing stock to accommodate an influx of new workers.<sup>390</sup>

Examples of housing shortages associated with oil and gas development have also come from the American Mountain West. In Colorado, Mesa and Garfield counties experienced a spike in housing costs as energy companies developed the oil and gas fields of the Western Slope.<sup>391</sup> Grand Junction, the region's largest city at 58,566 people, has experienced steady increases in the cost of living.<sup>392</sup>

Other examples include Sublette County, Wyo., which has seen a decrease in affordable housing since its nearby oilfields have grown.<sup>393</sup> In South Texas, the Eagle Ford shale play has revitalized small towns and driven up housing prices.<sup>394</sup> These communities, largely rural in character and lacking adequate housing supply, have struggled to maintain affordable living

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<sup>387</sup> Andree interview, 2011; Brasier, 2011; Jacquet, 2009; Patton et al, 2011.

<sup>388</sup> Brasier interview, 2011.

<sup>389</sup> Blevins interview, 2012; Daley, 2011; Junkins, 2011; Laughner, 2012; Maroney, 2011; Mullin and Lonergan, 2010; Reuther, 2011; Stender, 2011; Turner, 2011; Williamson and Kolb, 2011.

<sup>390</sup> Blevins interview, 2012; Williamson and Kolb, 2011.

<sup>391</sup> Headwaters, 2008.

<sup>392</sup> Bullen, 2009.

<sup>393</sup> Jacquet, 2007.

<sup>394</sup> Hiller, 2011; Hiller and Vaughan, 2011; Mildenberg, 2011.

options. A 2011 environmental impact statement prepared by the state of New York also indicates that drilling activity would lead, at least temporarily, to shortages in rental housing.<sup>395</sup>

One extreme example of housing shortages comes from North Dakota's Bakken shale oil region. Housing shortages in and around Williston, the area's commercial hub, have led to residents struggling to afford rising rental rates, workers sleeping in cars and hotels booked solid for years in advance.<sup>396</sup>

Not all oil and gas development leads to housing shortages, however. Production in the Barnett shale region of Texas, centered in and around the Dallas-Fort Worth metropolitan area, does not appear to have greatly impacted the availability or affordability of rental housing. The Barnett shale region differs from areas that have experienced housing shortages and cost increases in two respects: natural gas development makes up a relatively small portion of the region's economic activity and most of the natural gas workforce could be supplied locally.

In the Marcellus region, areas that have experienced modest amounts of drilling have not seen rising housing costs. Counties such as Armstrong and Butler in Pennsylvania's Southwest, where gas production pales in comparison to neighboring Washington County, report only a modest increase in hotel occupancy and room rates.<sup>397</sup>

### ***Distributional impacts***

The effects of increased rental housing costs are felt in varying degrees by different social groups in any impacted community. Rental property owners, naturally, enjoy increased return on their property investments. Landlords in some gas and oil-impacted communities have raised their monthly rates, in some cases displacing former tenants.<sup>398</sup>

Hotel owners and proprietors also benefit from increased occupancy rates. These businesses are often the first to benefit from oil and gas activity, as industry representatives and "land men" arrive to acquire leases and prepare for development. For example, preparations for oil and gas development in eastern Ohio's newly discovered Utica shale has led to a spike in hotel occupancy.<sup>399</sup>

Local residents in rental housing, on the other hand, can experience the negative impacts of increased housing costs. In some areas of Pennsylvania, senior citizens, people with disabilities and other individuals living on a low or fixed income have been priced out of their homes. Some of these individuals and families have been forced to "double" or "triple-up" with other families; move to neighboring counties; or relocate to mobile homes or local campgrounds. In some cases, displaced renters face homelessness.<sup>400</sup>

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<sup>395</sup> NYSDEC, 2011.

<sup>396</sup> Ellis, 2011; North Dakota Housing Finance Agency, 2011; Oldham, 2012; Shactman, 2012; Zarling, 2012.

<sup>397</sup> Coonley interview, 2011; Pennsylvania Department of Environmental Protection, 2012; Pinkerton interview, 2011; Pozzuto interview, 2011.

<sup>398</sup> Blevins interview, 2012; Daley, 2011; Hiller, 2011; Maroney, 2011; Stender, 2011; Smith-Heavenrich, 2011.

<sup>399</sup> Henkel, 2011; Pritchard, 2011.

<sup>400</sup> Blevins interview, 2012; Patton et al, 2011; Reeger, 2012; Skillings, 2010; Williamson and Kolb, 2011.

In a few communities around the United States, housing has simply become unavailable. Although oil and gas companies in North Dakota, Pennsylvania, and Wyoming have sought to alleviate these shortages with temporary housing units (sometimes called “man camps”), demand continues to outstrip supply in some communities.<sup>401</sup>

Property owners in areas where shale gas development occurs may stand to gain from increased property values (see Section 6.B.) and the ability to charge more for their rental properties. Renters, however, will not benefit directly from increased property values associated with shale gas development. Renters may experience negative impacts on quality of life (such as traffic, noise, or negative environmental impacts), without enjoying any economic benefits.

### ***Rental housing stock and affordability in potentially affected North Carolina counties***

Counties with large populations of low- or fixed-income renters could be the most impacted from increased costs of housing if extensive shale gas development were to take place in North Carolina. Individuals or families paying above 30 percent of their monthly income on housing would be particularly susceptible. Figure 6-1 and Figure 6-2 show some relevant characteristics:

**Figure 6-1. Demographics and Economics of Housing in Deep River Basin Counties**

<b>County</b>	<b>Population over Age 65, 2010</b>	<b>Households below Poverty Level, 2005-09</b>	<b>Unemployment Rate, Dec. 2011</b>	<b>Spending &gt;30% of Income on Housing, 2005-09</b>
<b>Anson</b>	14.3%	24.1%	12.1%	53.6%
<b>Chatham</b>	18.3%	11.0%	8.4%	48.6%
<b>Durham</b>	9.8%	16.4%	7.5%	47.8%
<b>Granville</b>	12.4%	14.8%	9.8%	43.5%
<b>Lee</b>	13.7%	14.5%	12.3%	44.6%
<b>Montgomery</b>	15.7%	21.3%	12.0%	43.1%
<b>Moore</b>	22.6%	13.3%	9.0%	46.6%
<b>Orange</b>	9.6%	16.9%	6.1%	59.1%
<b>Richmond</b>	14.3%	30.0%	13.0%	42.8%
<b>Union</b>	9.7%	10.9%	8.9%	48.5%
<b>Wake</b>	8.5%	10.2%	7.7%	45.3%
<b>N.C. average</b>	14.3%	16.2%	9.8%	47.9%

Source: U.S. Census Bureau, U.S. Bureau of Labor Statistics

<sup>401</sup> Blevins interview, 2012; Konigsberg, 2011; Press and Sun Bulletin, 2010; Shactman, 2012.

**Figure 6-2. Demographics and Economics of Housing in the Dan River Basin Counties**

County	Population over Age 65, 2010	Households below Poverty Level, 2005-09	Unemployment Rate, Oct. 2011	Spending >30% of Income on Housing, 2005-09
<b>Davie</b>	16.6%	11.7%	10.4%	43.2%
<b>Rockingham</b>	16.2%	14.9%	11.4%	40.6%
<b>Stokes</b>	16.0%	11.2%	8.4%	40.9%
<b>Yadkin</b>	16.3%	13.4%	9.0%	42.1%
<b>N.C. average</b>	14.3%	16.2%	9.8%	47.9%

Source: U.S. Census Bureau, U.S. Bureau of Labor Statistics

Each column in the above tables indicates a potential risk factor for affordable housing shortages in the event of a surge in demand for rental housing. Retirees, often living on fixed incomes, could struggle more than the working-age population to adjust to higher housing costs. Similarly, households with incomes below the poverty line could struggle to afford any additional housing costs.

A high countywide unemployment rate would be another indicator that the local population may be negatively affected by increased living expenses. On the other hand, natural gas exploration may increase economic activity, lowering unemployment rates and leading to a population more capable of affording increased housing costs.<sup>402</sup>

**Figure 6-3. Housing Characteristics of Counties in the Deep River Basin, 2005-2009**

County	Homeownership Rate	Rental Vacancy Rate	Median Rent (dollars per month)
<b>Anson</b>	69.7%	10.6%	585
<b>Chatham</b>	78.4%	10.0%	728
<b>Durham</b>	55.9%	9.8%	786
<b>Granville</b>	75.3%	3.7%	666
<b>Lee</b>	71.6%	7.7%	611
<b>Montgomery</b>	75.3%	12.6%	492
<b>Moore</b>	76.6%	12.6%	642
<b>Orange</b>	59.5%	10.2%	795
<b>Richmond</b>	70.3%	12.4%	487
<b>Union</b>	79.9%	5.5%	769
<b>Wake</b>	66.6%	8.7%	826
<b>N.C. average</b>	68.1%	9.7%	702

Source: U.S. Census Bureau American Communities Survey, 2005-2009.

<sup>402</sup> Blevins interview, 2012; Considine, 2011; Headwaters, 2011; Hefley, 2011; IHS Global Insight, 2011; Perryman, 2011.



**Figure 6-4. Housing Characteristics of Counties in the Dan River Basin, 2005-2009**

County	Homeownership Rate	Rental Vacancy Rate	Median Rent (Dollars per Month)
Davie	83.8%	9.4%	694
Rockingham	71.4%	11.7%	549
Stokes	81.2%	6.9%	533
Yadkin	78.0%	10.5%	512
<b>N.C. average</b>	68.1%	9.7%	702

Source: U.S. Census Bureau American Communities Survey, 2005-2009.

The two charts above (Figure 6-3 and Figure 6-4) show potential risk factors for affordable housing shortages in the event of a surge in demand for rental housing. Homeownership rates are significant because homeowners would likely experience less impact from increased rental costs. Indeed, homeowners in some gas-heavy areas around the United States have supplemented their income by renting out spare rooms to oil and gas industry workers.<sup>403</sup> On the other hand, residents of counties with low homeownership rates (such as Durham or Orange counties) may be more heavily impacted by increased rental costs.

Low vacancy rates indicate a tight supply of additional rental housing units. If significant gas development occurred, a shortage of affordable housing could be more likely in counties such as Granville, Lee, Stokes or Union Counties, which have relatively low rental vacancy rates. Finally, median rental rates give perspective on how many dollars per month households spend on rental housing.

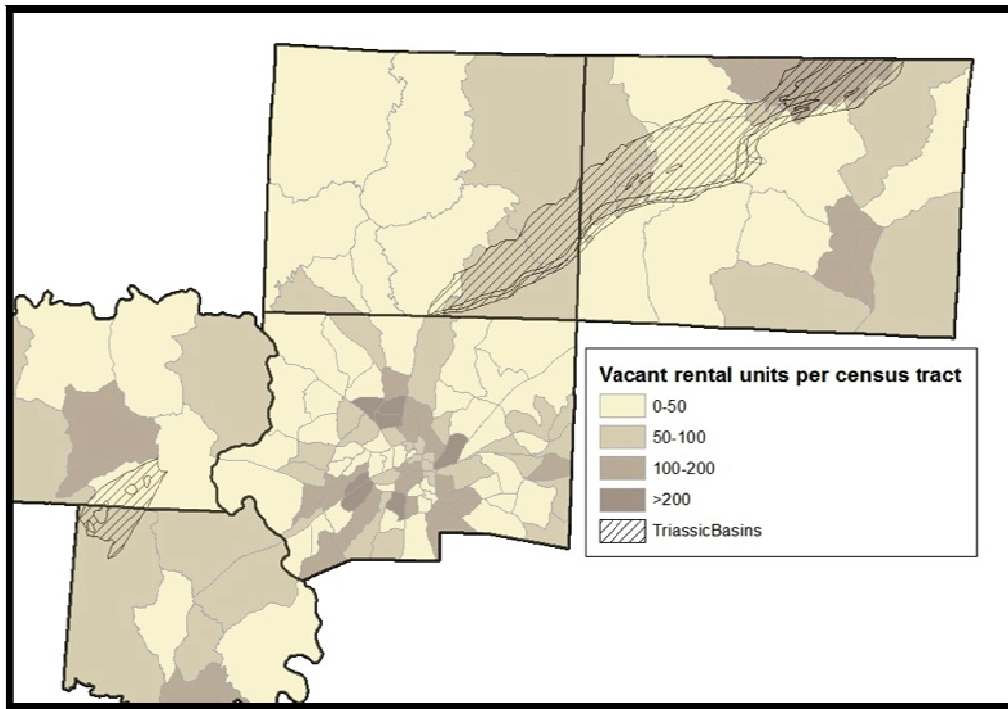
### ***Estimated vacant rental units in the Dan and Deep River basins***

The images below depict the estimated number of rental units available in each census tract of potentially impacted North Carolina counties. If these 2010 estimates closely resemble the amount of currently available rental housing, each region should be able to accommodate thousands of additional tenants.

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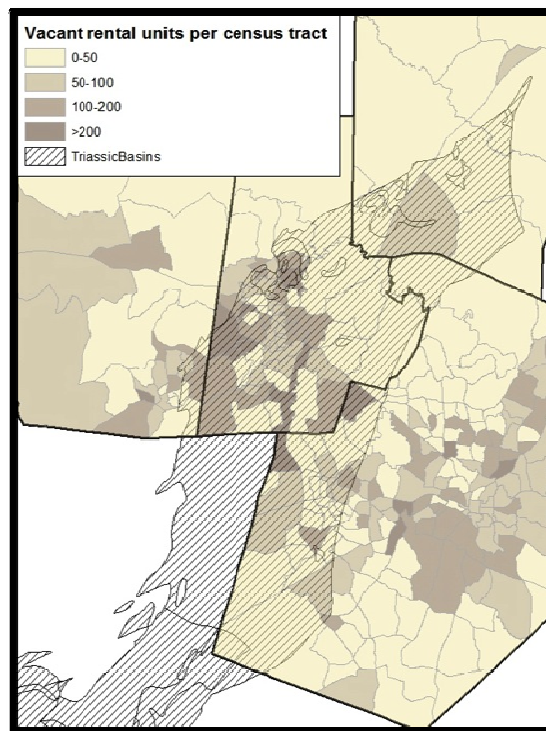
<sup>403</sup> A web search for rental housing in active drilling areas in Pennsylvania, Texas, North Dakota and Colorado turns up many such offers from local homeowners.

**Figure 6-5. Estimated Vacant Rental Units in Dan River Basin, 2010**



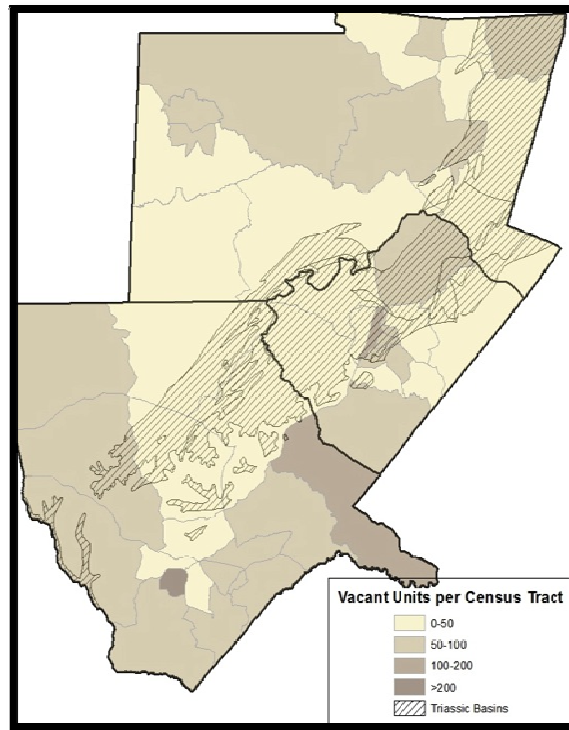
Source: U.S. Census Bureau, NCOneMap geospatial data, N.C. Geological Survey

**Figure 6-6. Estimated Vacant Rental Units in Durham Sub-basin, 2010**



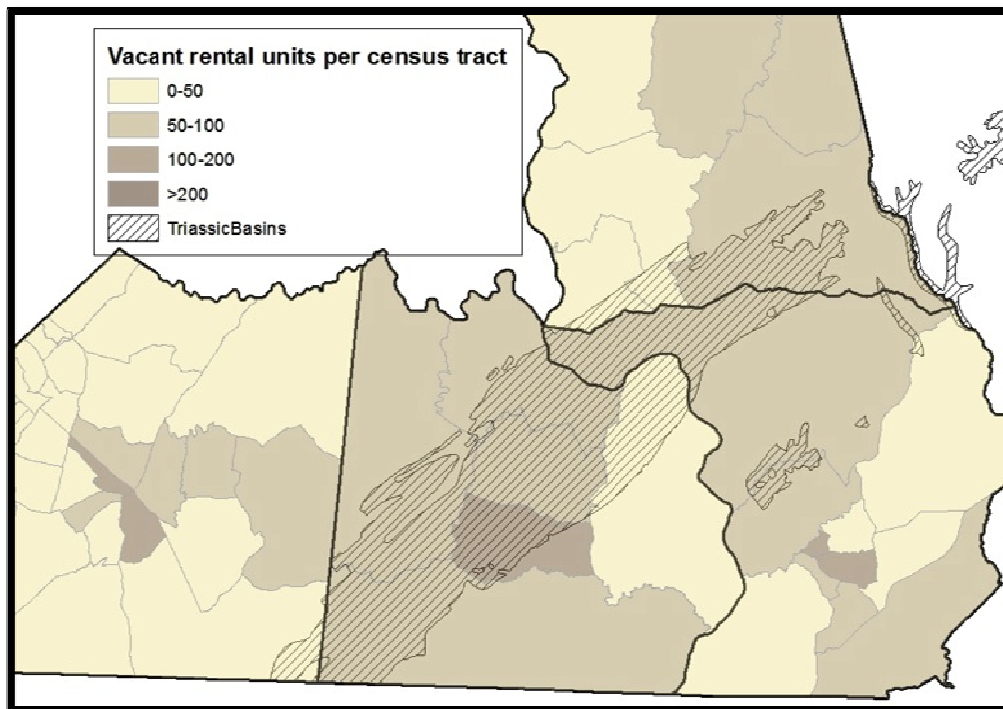
Source: U.S. Census Bureau, NCOneMap geospatial data, N.C. Geological Survey

**Figure 6-7. Estimated Vacant Rental Units in Sanford Sub-basin, 2010**



Source: U.S. Census Bureau, NCOneMap geospatial data, N.C. Geological Survey

**Figure 6-8. Estimated Vacant Rental Units in Wadesboro Sub-basin, 2010**



Source: U.S. Census Bureau, NCOneMap geospatial data, N.C. Geological Survey

### **Housing options**

The early stages of gas exploration and production (constructing well pads, drilling, hydraulic fracturing and completing wells) require significantly greater numbers of workers than maintenance and monitoring of those wells.<sup>404</sup> Any spike in demand for housing related to the natural gas industry may not be sustained in the long term. Construction of permanent housing for workers during a spike in housing demand, such as new hotels or motels, could lead to an oversupply once drilling activity has declined.

Mobile housing units could be one option for housing out-of-state workers. Demand for mobile homes, trailers and campground space has surged in parts of Pennsylvania and a similar effect could occur in North Carolina.<sup>405</sup> If housing shortages become a major issue, natural gas companies may construct “man camps” in areas close to drilling locations.

The Pennsylvania experience indicates that natural gas workers are typically willing to commute up to an hour each way to work on a well site.<sup>406</sup> Because of the large number of metropolitan areas within an hour of North Carolina’s Durham and Sanford sub-basins, workers may be expected to commute from cities including Raleigh, Durham, Chapel Hill or Fayetteville. If drilling occurs in the Dan River shale region, workers may commute from Greensboro, Winston-Salem or other proximate cities. The Wadesboro sub-basin, while within an hour of the greater Charlotte metropolitan area, may be at greater risk for housing shortages because of its isolation.

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<sup>404</sup> Considine, 2011; IHS Global Insight, 2011; Marcellus Shale Education and Training Center, 2010, NYSDEC, 2011.

<sup>405</sup> Andree interview, 2011; Brasier interview, 2012; Coonley interview 2011; Mullin and Lonergan, 2010; Williamson and Kolb, 2011.

<sup>406</sup> Brasier interview, 2011.

**Table 6-1. Commute Times (in minutes) to North Carolina Shale Regions**

<b>From:</b>	<b>To: Sanford (Sanford sub-basin)</b>
Cary	43
Chapel Hill	50
Durham	61
Fayetteville	55
Pinehurst	39
Pittsboro	26
Raleigh	47

<b>From:</b>	<b>To: Durham (Durham sub-basin)</b>
Cary	27
Chapel Hill	24
Greensboro	65
Pittsboro	46
Raleigh	32
Sanford	61

<b>From:</b>	<b>To: Madison (Dan River basin)</b>
Burlington	64
Danville, Va.	56
Eden	23
Greensboro	40
Reidsville	30
Winston-Salem	43

<b>From:</b>	<b>To: Wadesboro (Wadesboro sub-basin)</b>
Asheboro	74
Charlotte	65
Fayetteville	90
Lumberton	76

Source: Google directions

Note: All times were computed using city centers as start and end points.

## B. Potential impacts on property values

Natural gas drilling has the potential to impact property values in a number of different ways. Landowners who have economically recoverable gas resources and control their own mineral rights may benefit from increased property values. Those who do not own the mineral rights under their property, however, are unlikely to see such increases. Since property taxes are directly tied to property valuation, an increase in property values could lead to an increase in property taxes for all landowners who possess mineral rights – including those who choose not to lease the mineral estate.

Proximity to natural gas production, transmission, and storage facilities also could impact property values, although economists and researchers have not reached consensus on the direction of the impact or its extent. In any case, experiences in other states or countries will not necessarily predict the impacts of these facilities on North Carolina property owners.

### *Drilling sites*

Property owners who control the mineral rights to economically recoverable gas resources under their land may see substantial increases in property values. In Pennsylvania's Marcellus region, property values in gas-rich areas have risen significantly in the past several years.<sup>407</sup> An economic analysis prepared for Broome County in New York State, which sits atop large Marcellus shale deposits, predicted that if 2,000 wells were drilled in the county, property tax revenue was likely to increase by \$119 million.<sup>408</sup> This same analysis claimed that the taxable value of oil and gas properties in Texas' Barnett shale region increased from \$341 million to \$5.9 billion, a 1,730 percent increase, from 2000-2005.<sup>409</sup>

These increases in property value and the associated tax revenues result from two key factors. First, property owners often receive bonuses upon signing an oil and gas lease agreement. These agreements can range from \$5 per acre to \$20,000 per acre.<sup>410</sup> On properties where lease agreements have not been signed, potential buyers may factor expected bonus payment into the value of the property. Second, mineral owners receive royalties on income from gas production, typically earning 12.5 percent to 20 percent of the gas revenue generated at their wellhead.

Not all researchers agree on increased property values associated with natural gas drilling. A study commissioned by the town of Flower Mound, Texas, in the Barnett shale region, found that properties valued above \$250,000 experience a 3 percent to 14 percent decrease in value if the property is within sight of a drilling pad. The same study also found that if the drilling site is visually obscured, there was no impact on property values.<sup>411</sup> These decreases in property value were attributed to quality of life factors such as noise and visual impacts.

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<sup>407</sup> Kelsey et al., 2012; Laughner, 2012; Patton et al., 2010.

<sup>408</sup> This report overestimated natural gas prices based on 2009 forecasts by the U.S. Energy Information Administration. Given current price trends, tax revenue would be significantly lower.

<sup>409</sup> Texas Comptroller of Public Accounts via Weinstein and Clower, 2009.

<sup>410</sup> Kallenberg, 2011; Treacle, 2011.

<sup>411</sup> Integra, 2010.

Another study examining coalbed methane mining operations in southwest Colorado in the 1990s concluded that properties where drilling occurred experienced significant decreases in value. The net impact of wells on these properties was estimated to be a 22 percent decrease in value. Conversely, the study found that properties that did not have a gas well, but were located within 550 feet of well development, experienced a net increase in value.<sup>412</sup> This increase was attributed to the belief that drilling on a property was unlikely to occur if a well had been drilled “next door.”

### **Natural gas pipelines**

Pipelines are an essential tool for transporting natural gas from the wellhead to a distribution network. Currently, North Carolina has 2,848 miles of natural gas pipeline in place, consisting mostly of low-volume distribution lines.<sup>413</sup> A variety of studies conducted by researchers, industry and trade associations have sought to determine whether natural gas pipelines impact residential property values. For the most part, these studies find that natural gas pipelines do not significantly impact the value of nearby homes. However, some press reports and anecdotes report otherwise.

Two studies published in the journal of the International Right of Way Association, one conducted in the southwest United States and the other in Connecticut, find that natural gas pipelines do not impact property values.<sup>414</sup> Two studies from 2008, commissioned by pipeline developers and prepared by environmental consultancies in Oregon, also found no significant impact on property values from pipeline development.<sup>415</sup> Another study, prepared for the Interstate Natural Gas Association of America Foundation by a Texas-based consultancy in 2001, found no impacts on property values from pipeline developments in Connecticut, Oregon and two regions of Texas.<sup>416</sup> It is conceivable that potential property buyers would perceive proximity to a natural gas pipeline as a risk. However, research indicates that, in the absence of a high-profile accident (such as a pipeline rupture or major spill), fuel pipelines do not impact property values.<sup>417</sup>

Still, anecdotal evidence of pipeline construction resulting in lower property values does exist. In Texas, a recent appellate court decision upheld a jury award of \$600,000 to a family whose ranch was perceived to have been negatively impacted by the presence of a natural gas pipeline.<sup>418</sup> In addition, some advocacy groups claim that pipeline construction will reduce property values in their communities.<sup>419</sup>

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<sup>412</sup> BBC Consulting, 2001.

<sup>413</sup> Source: U.S. Energy Information Administration, 2012.

<sup>414</sup> Diskin et al., 2011; Kinnard et al., 1994.

<sup>415</sup> Fruits, 2008; Palmer, 2008.

<sup>416</sup> Allen et al, 2001.

<sup>417</sup> Hansen et al., 2006.

<sup>418</sup> Gilbert, 2012.

<sup>419</sup> Ga, 2012.



### **Natural gas processing facilities**

Natural gas processing facilities, including compressor stations and “sour gas” facilities, may have some impact on nearby property values. Currently, North Carolina is home to five natural gas compressor stations.<sup>420</sup> A small amount of academic research, coupled with a variety of anecdotal evidence, suggests that these facilities may have a negative impact on the value of nearby properties. A 2005 study in Alberta, Canada, indicated that rural properties within four kilometers (roughly 2.5 miles) of oil or “sour gas” processing facilities negatively impacted their property values.<sup>421</sup> However, two studies conducted in Alberta in 1988 and 1991, both commissioned by Shell of Canada, showed that sour gas facilities did not impact residential property values.<sup>422</sup>

Anecdotal evidence from several parts of the United States indicates that some of these facilities can impact quality of life of nearby residents, depress property values and in some cases cause individuals to leave the community. A number of residents – including Mayor Calvin Tillman – have moved out of Dish, Texas, citing health problems caused by air pollution attributed to several natural gas compressor stations in the town.<sup>423</sup> Reports from Decatur, Texas (in the Barnett shale region) also indicate health problems and declining property values associated with natural gas processing facilities.<sup>424</sup> While a wide variety of news media have reported on health problems and loss in property values, none of these negative impacts have been definitively linked to a specific natural gas processing facility.<sup>425</sup> Significant uncertainty remains as to whether processing facilities or compressor stations are responsible for the reported health problems.

### **Valuation and mortgage issues**

Evaluating the worth of a property with shale gas resources presents a potential dilemma for some banks and other lending institutions. If a property has economically recoverable gas resources, that property is likely to increase in value; however, banks and other potential lenders may not be able to accurately assess the monetary value of the resource. Lacking an adequate picture of a property’s true value, banks may be hesitant to extend mortgages or refinancing packages to landowners. Lenders may be concerned that they are either undervaluing or overvaluing a property, since gas development and resulting royalty payments are not uniform across all leased lands. In North Carolina, where minimal oil and gas development has occurred, lenders would find it difficult to make comparisons between what would appear to be comparable properties.

Reports from New York State’s Marcellus region suggests that confusion exists about how to value properties with shale gas potential. In some New York communities, landowners have

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<sup>420</sup> Source: U.S. Energy Information Administration, 2012.

<sup>421</sup> Boxall et al., 2005.

<sup>422</sup> Deloitte et al, 1988; Lore et al., 1991.

<sup>423</sup> Zelman, 2011.

<sup>424</sup> Heinkel-Wolfe, 2010.

<sup>425</sup> Bateman, 2010; Burnett, 2009; Heinkel-Wolfe, 2010; Lustgarten and Kusnetz, 2011; Wheeler, 2012; Zelman, 2011; Zook, 2010.



reported difficulty in finding lenders willing to extend credit on leased properties.<sup>426</sup> Potentially increasing confusion among banks, the Congressional Research Service released a letter in September 2011 indicating that Fannie Mae and Freddie Mac do not consider properties with oil or gas leases to fall into their “conforming loan” category.<sup>427</sup> The loans would be considered “non-conforming,” since appraisers may not be able to properly value the worth of subsurface minerals and may find it difficult to find comparable properties in the area. Typically, loans that are not “conforming” are more risky for lenders, as they are unable to re-sell the mortgages to Fannie Mae and Freddie Mac.<sup>428</sup> As a result, banks may be reluctant to extend credit for mortgages or refinancing packages to properties where oil or gas leases have been signed.

If gas leasing activity begins to grow quickly, homeowners who otherwise may sell could be inclined to “sit” on their properties in hopes of obtaining increased returns on their mineral estates. Anecdotal evidence from northeast Pennsylvania and Ohio suggest this type of activity may be inhibiting the property market in some communities.<sup>429</sup>

Property valuation questions may be further complicated by uncertainty over ownership of the mineral rights. In Lee County, N.C., gas leasing has led to confusion over ownership of some mineral estates. Due to old systems of recordkeeping, it may prove difficult for some owners to establish title to their mineral estates.<sup>430</sup>

### ***Analysis of data on property values***

For this study, DENR looked at average (median) list prices of properties in several regions where natural gas development has significantly increased over the past three years. Zillow real estate price tracking software was used to find the list price for real property in the regions studied. Note that “list price” refers to the initial price set by the seller and not the ultimate sale price. Data from the past three years suggest that property values have increased in some, but not all, regions where significant new gas drilling operations have begun.

In Colorado, property list prices declined across Colorado by six percent between 2009 and 2012. In the state’s top 10 gas-producing counties, however, property list prices declined by 19 percent. Colorado is the only region in this analysis where list values in the top gas-producing counties distinctly under-performed the rest of the region. The reasons for this finding are unclear.

In Oklahoma and Pennsylvania, listed property values in the top 10 gas-producing counties outperformed values in other counties by a wide margin. In Oklahoma, listed property values statewide declined by seven percent. In the top 10 gas-producing counties, listed values increased by seven percent, outperforming the rest of the state by 14 percent. In Pennsylvania, properties in the top 10 gas-producing counties showed an 18 percent increase from 2009-

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<sup>426</sup> Lucas, 2011; Tavernise, 2011; Urbina, 2011.

<sup>427</sup> Carpenter, 2011.

<sup>428</sup> U.S. Dept. of Treasury, Feb. 2011.

<sup>429</sup> Blevins interview, 2012; Pompili, 2012.

<sup>430</sup> Murawski, Nov. 2011; Treakle, 2011 presentation.

2012, compared with a 21 percent decline in the rest of the state. This represents a 39 percent difference.

In Texas' two major shale gas fields, the Barnett and Eagle Ford plays, property values in the top 10 gas-producing counties showed little difference from their regional counterparts.<sup>431</sup>

**Table 6-2. Change in Average Property Values, 2009-2012**

Region <sup>432</sup>	Average change, entire region	Average change, Top 10 Gas Producing Counties
CO entire state	-6%	-19%
OK entire state	-7%	+7%
PA entire state	-21%	+18%
TX Barnett	-5%	-6%
TX Eagle Ford	0%	+1%

Data Source: Zillow.com real estate data tool.

### **Limitations of data analysis**

This analysis provides a useful starting point for future research, but does not support a causal relationship between shale gas production and property values. A wide variety of factors have not been controlled for in this analysis. Some of these limitations are described below:

- Due to time and data limitations, DENR analyzed list prices instead of sale prices. As a result, we do not know whether these values held up in the final sale. Homeowners in gas regions of Oklahoma or Pennsylvania may have listed their land at values that the market would not accept.
- This is not a statistical analysis. The top 10 gas-producing counties in each of these regions may share common characteristics that are not controlled for in this analysis, including demographic, economic, social and quality of life factors. Simply put, a variety of local factors may be responsible for the differences in price between top gas-producing counties and the region as a whole.
- The data source, Zillow, is relatively new and untested. Zillow real estate price tracking software may not capture every property in a given market and therefore may distort the actual list prices in relevant regions.
- Three years is a relatively short time period. Changes in price over more years would give a better picture of how property values in each region would be impacted.
- The past five years have been a volatile time in the housing market around the United States. As the region averages show, many communities have experienced significant declines in property values. Impacts may differ during more stable periods in the national or regional housing markets.

<sup>431</sup> These two regions were analyzed distinctly from the entire state, given Texas' large size and wide variety of gas and oil producing areas.

<sup>432</sup> See below for counties included in Texas regions.

### ***Counties included in analysis of property values***

Colorado: All counties.

Oklahoma: All counties.

Pennsylvania: All counties.

Texas Barnett Region: Archer, Bosque, Clay, Comanche, Cooke, Coryell, Dallas, Denton, Eastland, Ellis, Erath, Hamilton, Hill, Hood, Jack, Johnson, Montague, Palo Pinto, Parker, Shackelford, Somervell, Stephens, Tarrant, Wise Counties.

Texas Eagle Ford Region: Atascosa, Bee, Brazos, Burleson, DeWitt, Dimmit, Edwards, Fayette, Frio, Gonzales, Grimes, Houston, Karnes, La Salle, Lavaca, Lee, Leon, Live Oak, Maverick, McMullen, Milam, Webb, Wilson, Wood, Zavala Counties.

## **C. Potential impacts on demand for social services**

As with many other potential social impacts, the demand on social service providers will likely depend on the scale of economic and population growth in the affected area. In North Carolina, a small population influx resulting from the oil and gas industry would likely have a small impact on social service demands; rapid industry growth would likely lead to more demand for services.

### ***Potential for decreased demand on social services***

Shale gas development has brought increased employment, higher incomes and new wealth to several regions of the country. The influx of economic activity from gas industry employees has also benefitted businesses in the shale regions that are not directly related to gas production. This increased economic activity has led to increased income and wealth for some, but not all, local residents.

When a region experiences gains in wealth for any reason, the demand for social services tends to drop. Those who do not gain from an economic boom, however, can experience negative impacts due to inflation of local housing costs, scarcity of low and moderate income housing, and overtaxed medical and mental health services. In areas with rapid population growth, the growth may result in overcrowded public schools. These impacts have been reported in a variety of American shale regions, but are not inevitable in North Carolina if shale gas development occurs.

### ***Housing assistance***

Sections 6.A and 6.B describe some of the potential impacts on local housing markets related to natural gas development. Greater demand for rental units can reduce the availability and affordability of rental housing. Although increased occupancy rates for rental units and hotels and upward pressure on rental rates may benefit local landowners, these same changes can negatively impact individuals on low or fixed incomes.

In northeastern Pennsylvania, increased rates of homelessness have been associated with increased housing costs in regions with heavy shale gas development.<sup>433</sup> These problems were exacerbated in Pennsylvania by severe flooding in the summer of 2001.<sup>434</sup> In North Dakota's Bakken region, industry workers and long-time residents have struggled to find affordable housing options.<sup>435</sup> In South Texas' Eagle Ford region, small towns have also experienced a surge in demand for housing.<sup>436</sup>

These types of shortages can increase demand for local, state, and federal housing assistance programs. The county human services director for Bradford County, Pa., indicates that the surge in population and resulting increase in rental rates there have led to a "huge impact" on county services for the homeless.<sup>437</sup>

Not all communities where shale gas drilling takes place experience these impacts, however. Armstrong and Butler counties, in southwestern Pennsylvania, have seen a modest amount of new gas drilling without any major impacts on rental affordability.<sup>438</sup> These two counties have experienced modest growth in hotel occupancy rates, which local officials attribute in part to shale gas drilling.<sup>439</sup> Both Armstrong and Butler counties have an adequate supply of affordable housing, which may lessen the likelihood of a housing shortage.<sup>440</sup>

### **Traffic and policing**

Increased traffic is a common occurrence in regions with new oil or gas drilling operations. Heavy and light-duty truck trips required for well pad construction, drilling, fracturing and completion number in the thousands for an individual well.<sup>441</sup> Significant increases in traffic may lead to additional motor vehicle crashes or increased demand for traffic control. Both place additional demand on police resources.

Transportation of liquids associated with hydraulic fracturing may also lead to additional policing requirements. Large trucks transport fresh water, produced water and liquid chemicals required for the drilling or fracturing process to and from the drill sites. Given the volume and nature of the liquids being transported, accident response can be both more complex and more time-consuming than a typical one or two-car accident. In Pennsylvania, spills from trucks transporting chemicals or produced water, along with an increase in accidents involving large trucks have increased demands on local police.<sup>442</sup> Any spills of hazardous chemicals require labor- and time-intensive responses from law enforcement and environmental agencies.

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<sup>433</sup> Blevins interview, 2012; Mocarsky, 2011; Maroney, 2011; Mullin and Lonergan, 2010; Reeger, 2010; Skillings, 2010; Turner, 2010.

<sup>434</sup> Ibid.

<sup>435</sup> Ellis, 2011; North Dakota Housing Finance Agency, 2011; Oldham, 2012; Shactman, 2012; Zarling, 2012.

<sup>436</sup> Hiller, 2011; Hiller and Vaughan, 2011; Mildenberg, 2011.

<sup>437</sup> Blevins interview, 2012.

<sup>438</sup> Andree interview, 2011; Coonley interview, 2011; Pozzuto interview, 2011; Raybuck interview, 2011.

<sup>439</sup> Ibid.

<sup>440</sup> Ibid.

<sup>441</sup> NYSDEC, 2011.

<sup>442</sup> Associated Press, Dec. 2011; Blevins interview, 2012; Crompton, 2011; Detrow, Nov. 2011.

Finally, additional policing may be required if gas drilling projects are accompanied by any increase in crime rates. Section 6.C, Traffic and policing, documents cases of increased crime in heavily drilled regions. Such increases in crime do not always accompany oil and gas production and it is not clear how, if at all, oil and gas activity contributes to regional changes in crime rates. Still, the anecdotes and the statistical analysis described in Section 6.C, Traffic and policing, indicate that additional policing may be required to respond to changes in crime rates.

### **Emergency services**

Over the past several years, requirements for emergency services have increased in some heavy oil and gas drilling regions. In regions unaccustomed to oil and gas activity, the specialized nature of the response required for spills, explosions or fires related to the industry may necessitate new equipment, training and staff.

In Pennsylvania and New York's Marcellus region, local police and fire crews have undergone additional training in responding to emergencies related to natural gas drilling.<sup>443</sup> Traffic accidents or well pad incidents involving natural gas-related chemicals or produced water may also require specialized response units.<sup>444</sup> In North Dakota's Bakken region, local officials cite the booming shale oil industry as the primary cause of a significant recent increase in ambulance calls, largely resulting from oilfield injuries and accidents involving large trucks.<sup>445</sup>

In rural areas where volunteer fire and rescue agencies handle most emergency responses, these additional demands may be particularly difficult to manage.

If natural gas extraction and production occurs in North Carolina, we should ensure that state agencies, local first responders and industry are prepared to respond to a well blowout, chemical spill or other emergency. We recommend that oil and gas operators be required to develop an emergency response plan; state criteria for an acceptable plan should include a requirement that a wild-well qualified person be on the well pad at all times and 911 addressing of all well locations. If shale gas development occurs in North Carolina, local governments will require additional funds to train their local emergency services providers. These providers will need training in responding to a variety of potential emergencies that could occur as a result of large truck accidents, hazardous materials truck accidents and accidents on drilling sites.

We also recommend that the General Assembly encourage the Department of Labor to review its readiness to inspect drilling sites and appropriately enforce the OSHA standards for this industry to prevent worker injuries or death.

### **Schools**

Economic activity that leads to population growth has the potential to increase demand for schooling. Workers in the oil and gas industry may be less likely to bring their families to the

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<sup>443</sup> Detrow, Nov. 2011; WICZ, 2011.

<sup>444</sup> Associated Press, Dec. 2011; Crompton, 2011; Detrow, Nov. 2011; Hamill and Buynovsky, 2011.

<sup>445</sup> Brissenden, 2012; Oldham, 2012; Springer, 2011.

regions where they work than employees of other, less mobile industries.<sup>446</sup> Nonetheless, fast-growing energy “boomtowns” can lead to strong growth in the local student population.<sup>447</sup>

Some U.S. regions with major, long-term shale oil or gas resources have reported increased demand for educational services. North Dakota’s Bakken region has experienced some of the fastest population growth from gas development in recent years and has strained to prevent school overcrowding.<sup>448</sup> Billings, Mont., which has increasingly supplied workers for companies operating in the Bakken region, is also expecting a surge in students.<sup>449</sup> In northeastern Pennsylvania, schools have also seen an influx of new students from gas industry workers.<sup>450</sup>

### **Other social services**

Anecdotal evidence and research from past decades indicate that some other social services may see increased demand. In Bradford County, Pennsylvania’s highest producing gas county, the local human services administration has seen increased demand for mental health and drug/alcohol counseling. This increased demand is a result of rapid population growth and not necessarily a reflection of increased per capita demand for services.<sup>451</sup> Research from “boomtowns” in the American Mountain West suggest that rapid community change can lead to additional demand for mental health services.<sup>452</sup>

Rapid population growth, resulting from extractive industries or any other reason, has the potential to strain a variety of local government services. If population growth increases employment in a local community, higher wages and wealth creation benefits the community in a variety of ways. However, local social service agencies may struggle to keep pace with increased demand for social services by residents who do not experience those benefits and find it more difficult to afford housing and other necessities because of price pressures. The increased demand for services may in turn increase the cost to local government to provide those services.

In some regions with heavy drilling activity, local social service providers have struggled to maintain an adequate workforce. In Bradford County, PA, high wages in the natural gas industry have made it harder for social service providers to recruit and retain employees. These employee shortages may decrease the availability or quality of social services in an affected city or county.<sup>453</sup>

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<sup>446</sup> The “boomtown” scenario outlined in section 6 B 5 describes the often-transitory nature of oil and gas drilling crews. Andree interview 2011; Brasier interview, 2012; Christopherson and Richtor, 2011; Ondracek and Witwer 2011.

<sup>447</sup> Jacquet, 2009.

<sup>448</sup> Ellis, 2011; Oldham, 2012; Shactman, 2012; Zarling, 2012.

<sup>449</sup> Trafton, 2012.

<sup>450</sup> Blevins interview, 2012; Penn State Cooperative Extension, 2012.

<sup>451</sup> Blevins interview, 2012.

<sup>452</sup> Bacigalupi and Freudenberg, 1983; Kassover and McKeown, 1981.

<sup>453</sup> Liguori, Tony. “Shale Development: Boomtimes-Agriculture.” Bradford County Conservation District. Presented Apr. 17, 2012. Accessed via USDA Rural Development Program website.

## D. Potential impacts on recreation activities

The light, noise and land-disturbing activity associated with natural gas drilling has the potential to impact recreation areas located near well sites. The extent of those impacts will depend on the distance between drill sites and the recreation area. Shale formations in North Carolina underlie tens of thousands of acres, including a significant number of parks, game lands, bike routes, boating access points and major water bodies and other recreation areas. The fact that these recreation areas sit above the shale formation does not necessarily mean that recreational activities will be impacted if drilling occurs. If natural gas drilling occurs in North Carolina, state regulations and local zoning ordinances could mitigate impacts to these recreation areas.

### *Game lands*

Shale formations underlie significant portions of land in the Game Lands Program managed by the N.C. Wildlife Resources Commission. Game lands provide public hunting opportunities and conserve wildlife habitat and natural communities. The presence of underlying shale does not necessarily mean that any given game land will be impacted; impacts are only likely to occur if drilling occurs on or near the game land. Maps showing game lands in the Triassic Basins are shown in Appendix B: Maps of recreation areas.

### *Bike routes*

Most bike routes in the Triassic Basins follow existing roadways. The presence of Triassic Basin shale formations underneath these bike routes does not necessarily mean they will be impacted, impacts are only likely to occur if drilling occurs on or nearby the bike routes.

### *Boating access points and major water bodies*

Triassic Basin shale formations underlie several water bodies that North Carolinians use for recreational purposes. In the Deep River Basin, these water bodies include Jordan Lake, Falls Lake, Harris Lake, the Deep River and the Pee Dee River. In the Dan River Basin, shale formations underlie the Dan River and are close to Belews Lake. Maps showing boating access points and major water bodies in the Triassic Basins are shown in Appendix B: Maps of recreation areas.

## E. Potential impacts on commercial and residential development

Many of the potential impacts associated with natural gas drilling have the potential to affect commercial and residential development. Water quality, water availability, air quality, property values, rental housing costs and many other aspects of this report each have the potential to impact trends in local and regional development. Like many other potential impacts, however, the scale of these impacts will depend on the scale of drilling activity.

### *Commercial development in other shale regions*

Anecdotal evidence from a variety of American shale plays indicates that high levels of drilling activity can spur commercial development in a given region. In Pennsylvania's Marcellus shale regions, high demand for restaurants and hotels has encouraged proprietors to expand and



invest in new equipment.<sup>454</sup> South Texas' Eagle Ford shale formation, similarly, has led to crowded restaurants and a dramatic increase in local sales tax revenues.<sup>455</sup> North Dakota's Bakken shale region has also experienced rapid increases in demand for service jobs, encouraging growth in local and regional service businesses.<sup>456</sup>

In some sparsely populated regions, rapid commercial growth has been constrained by labor shortages. In North Dakota's Bakken shale region, where population density is 4.8 people per square mile, businesses have had to increase wages to lure workers away from the oilfields and into local service jobs.<sup>457</sup>

For more information on the economic potential of the shale gas industry in North Carolina, see Section 5, Potential economic impacts.

### ***Implications of changes in rental costs***

In some communities around the United States, rental housing costs have increased dramatically as drilling activity brings hundreds or thousands of workers to the drilling region. Increased demand from oil and gas industry employees, along with rising wages for local workers, has the potential to drive housing costs higher in the impacted community. (For more details on this potential impact, see Section 6.A., *Potential impacts on housing availability*.)

In regions experiencing increased housing costs associated with oil and gas activity, hotels, motels and campgrounds tend to see demand increase first.<sup>458</sup> If drilling activity were to occur in North Carolina, these temporary housing sources would likely see temporarily increased demand. Businesses offering rentals of mobile homes, trailers or recreational vehicles would also likely see a temporary surge in demand.

Developers in some parts of the country, expecting drilling activity to continue for decades, have shown an increased interest in constructing housing options near drilling locations. These new construction projects have begun, or are in the planning stages, in rural regions of Pennsylvania, south Texas and North Dakota's Bakken shale region.<sup>459</sup> However, it is important to point out that housing demand from oil and gas activity is not constant over the life of the well. During the construction, drilling, fracturing and completion phases of development, large numbers of workers are required on site. After a well has been completed and the site reclaimed (typically a two to three month process), very few workers are required to maintain and monitor an individual well site.<sup>460</sup>

Rental housing development presents a potential problem for regions where drilling would occur over a short timeframe. If, for example, a one-year boom in drilling brought hundreds or

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<sup>454</sup> Andree interview, 2011; Biddle, 2012; Coonley interview, 2011; Gilliland, Dec. 2011; Hanger interview, 2012; Loreno, 2011; Penn State Cooperative Extension, Aug. 2011.

<sup>455</sup> Collette, 2011; Smith, M., 2011; Mildenberg, Dec. 2011; Vaughan, 2011.

<sup>456</sup> Ellis, 2011; Falstad, 2011; Kim, 2011; MacPherson, 2011; Oakes, 2011; Soraghan, June 2011.

<sup>457</sup> Source: U.S. Census Bureau, 2010. Bakken shale region includes Dunn, McKenzie, Mountrail, and Williams counties; Ellis, 2011; Falstad, 2011; Shactman, 2011.

<sup>458</sup> Institute for Public Policy and Economic Development, 2011; Mullin and Lonergan, 2011; Patton, 2011.

<sup>459</sup> Andree interview, 2011; Coonley interview, 2011; Ellis, 2011; Hiller, Jan. 2011.

<sup>460</sup> Marcellus Shale Training and Education Center, 2010.



thousands of workers to a rural region of North Carolina, newly constructed rental housing units would be underused or empty after drilling activity slows or stops. Twenty to 30 years of drilling, on the other hand, may well justify investments in hotels, motels and other rental housing options.

Industry operators in some areas with insufficient temporary housing options contract with temporary housing providers to supply modular housing units near drilling sites. These units, known as “man camps,” have sprung up in rural parts of North Dakota, Pennsylvania, and Texas.<sup>461</sup> Construction of these units can serve as adequate temporary housing, and lessens the need for construction of new hotels or rental housing.

### ***Implications of changes in property values***

For individuals interested in selling their properties, higher property values clearly have a beneficial impact. For individuals who wish to remain on their properties and *not* lease their mineral rights, property taxes may increase without a commensurate increase in cash for the landowner.

### ***Water supply issues in commercial and residential development***

Residents from many parts of the country have expressed concern over potential water contamination associated with hydraulic fracturing, as well as the volume of water required to fracture a well. Researchers continue to collect data, analyze information and pursue these questions vigorously. As of this study, no scientific consensus has been reached as to whether shale gas exploration and production cause systematic groundwater contamination. Other sections of this study will address potential impacts on water quantity in North Carolina if shale gas development were to begin in North Carolina.

Water, of course, is a crucial component to any commercial or residential development project. Without adequate water supply, a wide variety of construction, manufacturing and other business activities would cease to be viable. Without sufficient water supply or adequate water quality, residential development would also be severely damaged.

Public perception of water threats, whether grounded in science or not, could impact demand for future residential development near sites where shale gas exploration and development may take place. As of this report, however, no clear evidence has been found indicating that water quantity or quality problems associated with shale gas exploration and development have diminished the viability of commercial or residential development projects.

## **F. Potential noise impacts**

Natural gas development, like many industrial activities, involves significant amounts of noise, especially during the initial phases of well pad construction, drilling, hydraulic fracturing and site reclamation. These activities typically last two to three months per well pad, and involve

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<sup>461</sup> Associated Press, Dec. 2011; Andree interview, 2011; Coonley interview, 2011; Ellis, 2011; Hiller, Jan. 2011; Hohmann, 2011; Irvine, 2011; Konigsberg, 2011; Press and Sun Bulletin, 2011.

heavy machinery, large trucks and generators that could impact nearby communities.<sup>462</sup> After a well is completed, sustained production generates minimal noise.<sup>463</sup> However, each individual well may be re-fractured in the future, when truck activity could pick up once again.

The U.S. Department of Housing and Urban Development (HUD) uses the following scale to determine acceptable and unacceptable noise levels for different types of land use. This scale can be used as a reference for noise levels related to shale gas development:

**Table 6-3. HUD Daytime Land Use Compatibility Guidelines for Noise**

Land Use Category	Clearly Acceptable	Normally Acceptable	Normally Unacceptable	Clearly Unacceptable
Residential	<60	60-65	65-75	>75
Livestock farming	<60	60-75	75-80	>80
Office buildings	<65	65-75	75-80	>80
Wholesale, industrial, manufacturing, utilities	<70	70-80	80-85	>85

### **Access road construction**

Before activity at a well site can begin, access roads must be planned and constructed to allow the necessary equipment to move into place. Construction of access roads typically takes three to seven days, and occurs during the daytime.<sup>464</sup> Like any road construction, this process requires a number of heavy machines, and produces noticeable noise impacts.

The tables included in this section show average noise levels associated with each phase of construction related to drilling operations. They show decibel levels are various distances from the noise source. The decibel scale is logarithmic, meaning an increase of 10 decibels represents a tenfold increase in volume. (See *Appendix C: Common noise sources and levels at 50 feet* for decibel levels of common noise sources). These noise levels do not take into account noise reduction due to ground attenuation, atmospheric absorption, vegetation or topography.

**Table 6-4. Distance in Feet/Sound Pressure Levels in Decibels**

Access Road Construction	Quantity	Percent of time in use	50 ft	250 ft	500 ft	1000 ft	1500 ft	2000 ft
Excavator	2	40%	80	66	60	54	50	48
Grader	2	40%	84	70	64	58	54	52
Bulldozer	2	40%	81	67	61	55	51	49
Compactor	2	40%	79	65	59	53	49	47
Water truck	2	40%	75	61	55	49	45	43
Dump truck	8	40%	81	67	61	55	52	49
Loader	2	40%	78	64	58	52	48	46
<b>Composite Noise</b>			<b>89</b>	<b>75</b>	<b>69</b>	<b>63</b>	<b>59</b>	<b>57</b>

<sup>462</sup> Hefley, 2011; NYSDEC, 2011.

<sup>463</sup> NYSDEC, 2011.

<sup>464</sup> Ibid.

Source: New York State Dept. of Environmental Conservation

These noise levels indicate that residents or businesses located 2000 feet from access road construction would experience an average noise level of 57 decibels. This noise level is roughly equivalent to the noise levels associated with everyday conversations. Fifty feet from the construction site, however, residents or businesses could experience 89 decibels, similar to a shouted conversation.

### **Pad construction**

Once access roads are laid, construction can begin on the well pad itself. This process requires grading the land and, in some cases, clearing vegetation to prepare for the arrival of drilling equipment. The types of noise generated during this phase are common to other industrial construction projects, including noise from bulldozers, excavators and a variety of trucks. Well pad construction lasts, on average, seven to 14 days, and typically occurs during daytime hours.

The table below indicates levels of noise associated with key equipment used in the construction of the well pad. This table does not include the noise from roughly 45 round-trip truck trips required to bring materials to the site.

**Table 6-5. Distance in Feet/Sound Pressure Levels in Decibels**

<b>Well Pad Construction</b>	<b>Quantity</b>	<b>Percent of time in use</b>	<b>50 ft</b>	<b>250 ft</b>	<b>500 ft</b>	<b>1000 ft</b>	<b>1500 ft</b>	<b>2000 ft</b>
Excavator	1	40%	81	63	57	51	47	45
Bulldozer	1	40%	82	64	58	52	48	46
Water Truck	1	40%	76	58	52	46	42	40
Dump Truck	2	40%	76	61	55	49	45	43
Pickup Truck	2	40%	75	60	54	48	44	42
Chain saw	2	40%	84	66	60	54	50	48
<b>Composite Noise</b>			<b>84</b>	<b>70</b>	<b>64</b>	<b>58</b>	<b>55</b>	<b>52</b>

Source: New York State Dept. of Environmental Conservation

These noise levels indicate that residents or businesses located 2,000 feet from well pad construction could experience average noise levels of 52 decibels. This noise level is roughly equivalent to the noise levels associated with a quiet electric toothbrush. Fifty feet from the construction site, however, residents or businesses could experience 84 decibels, similar to a gasoline-powered handsaw.

### **Vertical and horizontal drilling**

The vertical and horizontal drilling process associated with shale gas extraction is the longest-lasting phase of construction. Once all equipment is in place, drilling lasts, on average, 28 to 35 days. More significantly, drilling is a 24-hour operation. Sound generated in the evening hours typically travels further and can have a more significant impact than sounds generated in the daytime. Some major pieces of equipment required for the drilling phase include:

- Diesel engines for the drill rig. The noise levels of these engines fluctuate depending on engine speed and the weight of the load.

- Air compressors powered by diesel engines. These units generate the loudest noises of the drilling stage. The exact number of compressors required for each well varies. Generally, more compressors are required as drilling advances.
- Tubular preparation and cleaning. Before sections of pipe are laid into the ground, workers hammer the outside of each pipe to clear internal debris. This process generates an acute noise every 20 to 30 minutes during drilling, and has generated a significant number of complaints from nearby landowners, especially during evening hours.<sup>465</sup>
- Drill pipe connections. Before rig workers can connect one length of pipe to another, they must release highly pressurized air that has been built up in the well. This release generates a high frequency noise, and occurs at 20 to 30 minute intervals during drilling.
- Truck trips. Roughly 355 round-trip heavy truck trips are required to bring materials to the well site during drilling.<sup>466</sup>

Table 6-6 indicates levels of noise associated with equipment involved in vertical and horizontal drilling. During the drilling process, the sound level remains roughly constant at the composite noise level. Noise impacts from drilling will likely be higher at night, since ambient noise levels are typically lower in the evening.

**Table 6-6. Distance in Feet/Sound Pressure Levels in Decibels**

<b>Vertical Air Well Drilling</b>	Quantity	50 ft	250 ft	500 ft	1,000 ft	1,500 ft	2,000 ft
Drill rig drive engine	1	71	57	51	45	41	38
Compressors	4	77	63	57	51	47	45
Hurricane booster	3	51	37	31	25	22	19
Compressor Exhaust	1	51	37	31	25	21	18
<b>Composite Noise</b>		<b>79</b>	<b>64</b>	<b>58</b>	<b>52</b>	<b>48</b>	<b>45</b>

**Table 6-7. Distance in Feet/Sound Pressure Levels in Decibels**

<b>Horizontal Drilling</b>	Quantity	50 ft	250 ft	500 ft	1000 ft	1500 ft	2000 ft
Rig Drive Motor	1	71	57	51	45	41	38
Generator	1	51	37	31	25	22	19
Top Drive	1	65	51	45	39	35	33
Draw Works	2	60	46	40	34	30	28
Triple Deck Shaker	2	75	61	55	49	45	43
<b>Composite Noise</b>		<b>76</b>	<b>62</b>	<b>56</b>	<b>50</b>	<b>47</b>	<b>44</b>

Source: New York State Dept. of Environmental Conservation

<sup>465</sup> NYSDEC, 2011.

<sup>466</sup> Truck trips include rig equipment, drilling fluids, non-rig drilling equipment, rig mobilization, completion chemicals, and completion equipment.

These noise levels indicate that residents or businesses located 2,000 feet from well pad construction could experience average noise levels of 44 to 45 decibels during the drilling phase. This noise level is roughly equivalent to the noise levels associated with a typical office space. Fifty feet from the construction site, however, residents or businesses could experience 76 decibels, similar to a loud air conditioner or washing machine.

### **Hydraulic fracturing**

Hydraulic fracturing requires up to 20 high-powered pumping trucks operating for two to five days, 24 hours per day. These trucks maintain the water pressure required to create fissures in the shale formation, and are powered by diesel engines that create a significant amount of noise. The amount of noise at any given time depends on the rotation speed of the diesel motor, which varies during the fracturing process. Noise from these pumper trucks is most noticeable in the low-frequency spectrum (50-250 Hertz).

Hydraulic fracturing also requires a large number of truck trips to supply the site with water, sand, chemicals and other items required to fracture a well. On average, 843 round-trip heavy truck trips are required for each fracturing of a well.<sup>467</sup> However, some fracturing operations transport their water through pipelines, significantly reducing the number of truck trips required per well.<sup>468</sup>

Table 6-8 indicates levels of noise associated with each phase of hydraulic fracturing. During the fracturing process, the sound level remains roughly constant at the composite noise level. Noise impacts from fracturing will likely be higher at night, since ambient noise levels are typically lower in the evening.

**Table 6-8. Distance in Feet/Sound Pressure Levels in Decibels**

<b>Hydraulic Fracturing</b>	Quantity	50 ft	250 ft	500 ft	1000 ft	1500 ft	2000 ft
Diesel Pumper Trucks (op. 1)	20	99	85	79	73	69	67
Diesel Pumper Trucks (op. 2)	20	104	90	84	78	74	72

Source: NYSDEC, 2011.

These noise levels indicate that residents or businesses located 2,000 feet from a hydraulic fracturing site would experience noise levels of 67 to 72 decibels during the fracturing operation. This noise level is roughly equivalent to the noise levels associated with freeway traffic. Fifty feet from the construction site, however, residents or businesses could experience 99 to 104 decibels, similar to the sounds of a loud motorcycle.

<sup>467</sup> Truck trips include fracturing equipment, fracturing water, fracturing sand, and produced water disposal. Estimates are based on 5 million gallons of fracturing water required per well.

<sup>468</sup> Murphy, Thomas. Presentation at Duke University, Jan. 9, 2012.

**Figure 6-9. Hydraulic Fracturing in Upshur Valley, West Virginia (Marcellus region)**

Source: Chesapeake Energy, 2008, via NYSDEC, 2011.

### ***Site reclamation and sustained production***

Site reclamation involves construction equipment similar to that used in well pad construction. During the reclamation process, heavy machinery restores the land surrounding the well pad to its natural state. The noise impacts from this process will likely be similar to that experienced during well pad construction phase.

During sustained production, noise from the wellhead is minimal. Occasional vehicle noise from well site monitors would be the primary noise generator during this phase, which can last seven to 10 years or more. Mowing of the well site also occurs during this phase.

### ***Pipeline construction***

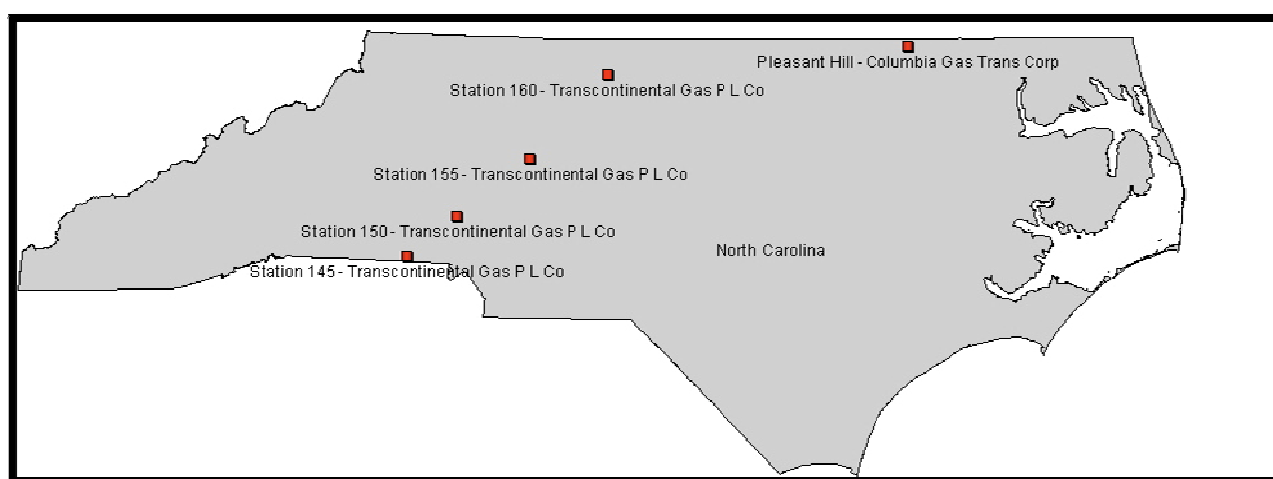
Underground natural gas pipelines are required to transport gas from a production pad to a distribution network. Most of the noise impacts would be generated by heavy equipment commonly used for clearing, grading and construction activities. Since construction progress moves forward over time, nearby communities would likely experience noise impacts sequentially and temporarily. The most noise-intensive step in pipeline construction would be pipe stringing, in which individual lengths of pipe are joined together above ground, and specialized equipment makes any necessary adjustments, such as bending lengths of pipe.

### Compressor stations

Natural gas pipelines require compressor stations at 40 to 100 mile intervals to maintain the appropriate level of pressure in the pipeline.<sup>469</sup> Residents in a variety of locations, including Arkansas, Pennsylvania and Texas have voiced concerns over noise levels associated with compressor stations in recent years.<sup>470</sup> Currently, there are five natural gas compressor stations in North Carolina.<sup>471</sup>

Noise levels at some natural gas compressor stations can approach 90 decibels, similar to the noise generated by a loud blender.<sup>472</sup> In some states, such as Arkansas, the state Oil and Gas Commission has adopted rules to limit noise emissions from compressor stations to 55 decibels.<sup>473</sup>

**Figure 6-10. Natural Gas Compressor Stations in North Carolina**



Source: U.S. Energy Information Administration

Station 145, Transcontinental Gas Pipeline Co., Cleveland County

Station 150, Transcontinental Gas Pipeline Co., Iredell County

Station 155, Transcontinental Gas Pipeline Co., Davidson County

Station 160, Transcontinental Gas Pipeline Co., Rockingham County

Pleasant Hill Station, Columbia Gas Transmission Co., Northampton County

## G. Potential visual impacts

Natural gas drilling and construction in North Carolina would introduce a number of unusual landscape features, such as drilling rigs, nighttime lighting and natural gas flaring. Some of

<sup>469</sup> Naturalgas.org website.

<sup>470</sup> Burnett, 2009; Glover, 2011; Hankins, 2009; Legere, 2011.

<sup>471</sup> Personal correspondence, U.S. Energy Information Administration, Jan. 2012.

<sup>472</sup> Sierra Club website, 2011.

<sup>473</sup> Glover, 2011.

these visual impacts could be perceived by residents and visitors to the area as detrimental. Each of these features would be temporary; once a well has been completed, visual impacts would be minimal.

Since North Carolina has little history of drilling for oil and natural gas, many residents could experience an unfamiliar set of visual impacts associated with drilling and hydraulic fracturing. These impacts may be most noticeable in rural areas, where residents are accustomed to farmland, open spaces and forested areas.

### **Access road and pad construction**

Construction of the access roads to a well pad site requires equipment similar to that used in construction of any small to medium-sized road. An access road to a well site looks very much like an unpaved access road on a farm. Pad construction involves heavy equipment including bulldozers, excavators and other heavy trucks. The visual impacts from these activities would last approximately 10 to 21 days, and would be visible during normal daytime hours. Well pads cover, on average, 3.5 acres of land, with additional land required for water storage ponds and equipment staging areas.<sup>474</sup>

New techniques have enabled drilling operators to occupy a smaller surface area than in previous decades. By drilling multiple wells from a single pad and using underground horizontal drilling, companies can minimize the amount of acreage required to access natural gas from a surrounding area. When compared with traditional vertical drilling techniques, this technology reduces the visual impact of the well pads and associated construction in a drilling area.

**Figure 6-11. Accessing Shale Field via Vertical Drilling**

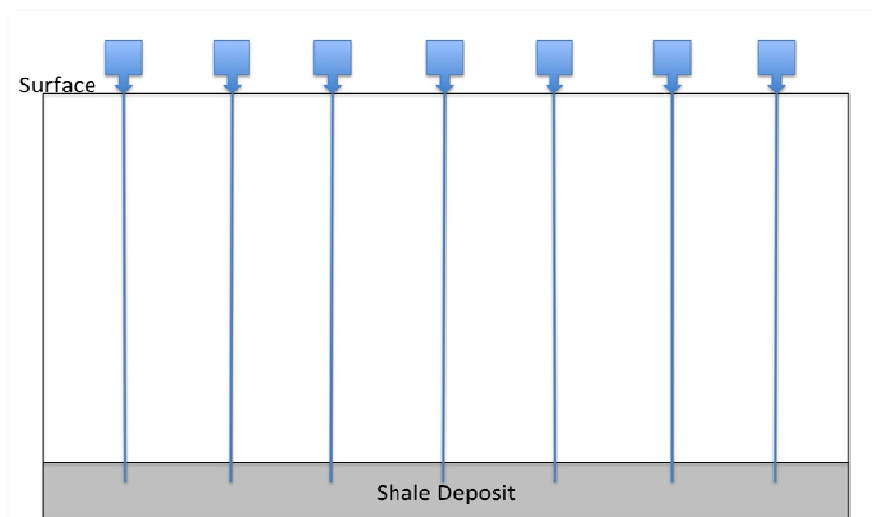


Image by Daniel Raimi, 2012

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<sup>474</sup> NYSDEC, 2011.



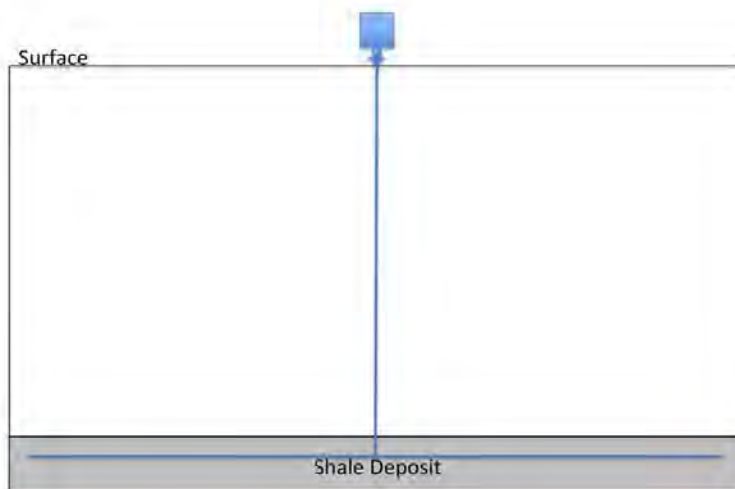
**Figure 6-12. Accessing Shale Field via Horizontal Drilling**

Image by Daniel Raimi, 2012

### **Drilling, lighting and storage**

Natural gas drilling rigs can range in height from 40 feet for a single rig to 150 feet for a triple rig.<sup>475</sup> Rigs are typically in place for 28 to 35 days, and create a significant visual impact in the vicinity of the site. Typically, one drilling rig is used per well site; however, at multi-well sites, two drilling rigs could be used simultaneously on the same well pad.<sup>476</sup> In forested landscapes, drilling rigs sometimes resemble cell phone towers or radio transmitters.

Since drilling activities continue 24-hours per day, powerful lights illuminate the well site to increase worker safety. Lights are often directed across the drilling pad, providing maximum coverage of the site, but also creating an impact on areas directly adjacent to the drilling site.<sup>477</sup> States such as Colorado and Louisiana have created buffer zones of 800 and 300 feet, respectively, between drilling sites and roads to minimize glare for passing drivers.<sup>478</sup> Visual impacts from lighting could also be decreased by instructing drilling operations to direct their lighting downwards, instead of across the well pad.

During the drilling process, drilling fluids, cuttings, mud and other discarded materials must be stored near the well site. These discarded elements may be housed in plastic or steel containers, or in open "drilling pits." When drilling pits are employed, they are typically lined with plastic, and located adjacent to the well site.<sup>479</sup>

<sup>475</sup> Single rigs are capable of holding one length of piping at a time, while triple rigs can hold up to three connected lengths of piping at a time.

<sup>476</sup> NYSDEC, 2011.

<sup>477</sup> Upadhyay and Bu, 2010.

<sup>478</sup> NYSDEC, 2011.

<sup>479</sup> Ibid.

### ***Hydraulic fracturing, flaring and water impoundments***

Hydraulic fracturing requires a large number of heavy trucks and heavy equipment moving to and from the well site over the course of two to five days. During this time, approximately 843 round-trip heavy truck trips are required to complete the fracturing process.<sup>480</sup> These trucks are visible on roadways and in staging areas, where they collect water, coordinate activities or simply wait until they are needed. Trucks and other specialized equipment are sometimes stored on unreclaimed well pads, creating a longer-lasting visual impact on a well site.<sup>481</sup>

Flaring of natural gas at the well site is sometimes necessary in the 12 to 24 hour period after hydraulic fracturing has been completed. During this period, wells produce a large volume of flowback water, and gas is flared instead of captured for storage or transport.<sup>482</sup> Flaring can have a significant impact, especially in the nighttime hours. In Bradford County, Pa., intense flaring from newly drilled wells has created significantly brighter nighttime background lighting.<sup>483</sup> Flaring also has the potential to disturb local residents, who sometimes see it as a sign of decreased tranquility in their community.<sup>484</sup>

Surface water impoundments are also required near hydraulic fracturing sites. Typically, one water impoundment services the water requirements of wells within a four-mile radius.<sup>485</sup> These impoundments are typically lined with plastic, and hold water before it is used in the fracturing process. Freshwater impoundments can hold millions of gallons of water, and can cover up to five surface acres of land.<sup>486</sup> These impoundments can be visible from miles away, and easily seen from the air.<sup>487</sup> Water-hauling trucks would make regular trips to and from such impoundments, which would likely increase traffic and noise in the surrounding areas.

Water impoundments can also be used for on-site flowback water storage. States regulate the requirements for storage of this water differently, and in some instances allow for flowback water to be stored in open, lined pits. These pits can cover acres of surface area, and can also emit smells that bother nearby residents.<sup>488</sup>

### ***Completion and reclamation***

Once a well is drilled and fractured, a “Christmas tree” is placed on top of the wellhead to manage and distribute the natural gas. This piece of equipment is fairly small, and would cause minimal visual impact. Additionally, two to three storage tanks to handle flowback water are installed near the well. These tanks range in size from five to 10 feet tall, with a diameter of

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<sup>480</sup> Ibid. Truck trips include fracturing equipment, fracturing water, fracturing sand and produced water disposal. Estimates are based on 5 million gallons of fracturing water required per well.

<sup>481</sup> Upadhyay and Bu, 2011.

<sup>482</sup> NYSDEC, 2011.

<sup>483</sup> Long, 2010.

<sup>484</sup> Andree interview, 2011; Coonley interview, 2011; Raybuck interview, 2011; Roth interview, 2011.

<sup>485</sup> NYSDEC, 2011.

<sup>486</sup> Ibid.

<sup>487</sup> Upadhyay and Bu, 2011.

<sup>488</sup> Gregory, Kelvin. Presentation at Duke University, Jan. 9, 2011; Griswold, 2011; Plikunas et al, 2011.

between five and 10 feet.<sup>489</sup> With no obstacles in their line of site, they can be visible from up to three miles away. However, trees, brush or other vegetation could easily obscure the wellhead and storage tanks. These objects remain in place for the productive life of the well. While visual impacts of brine storage tanks can be small, the tanks sometimes emit odors that can disturb nearby residents.<sup>490</sup>

Reclamation of the well site requires additional trucks and heavy machinery. The visual impacts of restoration are temporary and would be similar to those experienced during well pad or access road construction.

### **Pipeline construction**

Pipeline construction has the potential to have significant visual impacts in North Carolina. Before pipelines can be laid in the ground, workers must clear trees and other materials within the pipeline's right of way. These clearings must be maintained during the pipelines operational lifetime, as workers need access to the area for maintenance and inspections.

The visual impacts associated with pipeline construction are typically long, thin corridors, similar to the clearing produced for overhead power lines. Currently, North Carolina has 2,848 miles of natural gas pipeline in place.<sup>491</sup> None of these pipelines are gathering lines, which would be needed to transport gas from the wellhead to the larger interstate and intrastate lines. North Carolina may also need additional interstate and intrastate lines, if gas development comes to the state. Table 6-9 gives the length, in miles, between Sanford, N.C., and the five compressor stations currently operating in North Carolina.

**Table 6-9. Distances, in Miles, Between Potential Shale Regions and North Carolina Compressor Stations\***

	<b>Sanford</b>	<b>Durham</b>	<b>Madison</b>	<b>Wadesboro</b>
Transco Station 145 <b>Cleveland County, N.C.</b>	133	156	116	85
Transco Station 150 <b>Iredell County, N.C.</b>	98	112	66	72
Transco Station 155 <b>Davidson County, N.C.</b>	60	73	44	56
Transco Station 160 <b>Rockingham County, N.C.</b>	76	65	0	98
Columbia Pleasant Hill Station <b>Northampton County, N.C.</b>	117	85	135	179

Source: distancecalculator website.

\* Note: All distances measured "as the crow flies."

<sup>489</sup> Upadhyay and Bu, 2011.

<sup>490</sup> Gregory, Kelvin, Presentation at Duke University, Jan. 9, 2011.

<sup>491</sup> Source: U.S. Energy Information Administration.

Pipelines also require compressor stations to maintain proper flow of the natural gas. These stations vary in size, depending on the volume of the gas flowing through the pipeline. Compressor stations are typically required every 30 to 40 miles along a pipeline, and could generate some visual impacts depending on their location and size.

**Figure 6-13. Drilling Rig from Two Miles**



Source: Uphadyay and Bu, 2011

**Figure 6-14. Marcellus “Double Rig”**



Source: NPR State Impact, Pennsylvania

**Figure 6-15. Hydraulic Fracturing Operation, Canadian County, Oklahoma**



Source: Society of Petroleum Engineers website, JPT.com



**Figure 6-16. Lighting and Natural Gas Flaring at a Marcellus Natural Gas Well, Pennsylvania**



Source: Naturalgasforums.com website

**Figure 6-17. Brine Tanks at a Producing Well, Bradford County, Pennsylvania**



Source: Uphadyay and Bu, 2011

## H. Potential impacts on crime rates

Major discoveries of oil and gas throughout the history of the United States have been accompanied by rapid population growth in the area of the “play.”<sup>492</sup> This surge in population, whether in Pennsylvania in the 1860s, Texas in the early 1900s or in modern-day Williston, North Dakota, is primarily composed of young men – skilled in jobs associated with oil and gas extraction, and often living apart from friends, family and social support networks.<sup>493</sup> In some cases, these men lived and worked in cramped quarters, in rural communities that were unprepared for the population surge that accompanied the energy boom.

### *Examples from other states*

Sociological literature indicates that in some energy boomtowns, crime rates increase at a faster rate than population growth.<sup>494</sup> Most of this research was carried out in rural parts of the American West, as high oil prices drove growth in energy development during the late 1970s and early 1980s.

Stories of increased crime and other social problems have also emerged in some modern energy boomtowns. In northeast Pennsylvania, local officials and newspapers have reported increases in crime rates due to the influx of workers in the natural gas industry, especially drunk driving charges.<sup>495</sup> In Sublette County, Wyo., increased drilling activity has, according to local officials, led to dramatic increases in drug usage and crime rates.<sup>496</sup> North Dakota’s Bakken shale region has also seen reports of increased crime rates associated with the boom in oil production.<sup>497</sup>

Drug use has also been a concern among workers in the modern oil and gas industry. In a 2010 survey of natural gas employers in Pennsylvania’s Marcellus region, 12 percent described drug use as a “very big challenge,” and 53 percent cited drugs as “somewhat of a challenge” in finding new employees.<sup>498</sup> This issue, of course, is not unique to the oil and gas industry. News reports and magazine articles from Pennsylvania, Texas, Colorado, and Wyoming have cited drug use, particularly methamphetamine, as a problem in some drilling communities.<sup>499</sup>

Research and reporting from some states also suggests that rates of sexually transmitted diseases (STDs) may increase alongside oil and gas activity. One northern Pennsylvania hospital cited increased demand for treatment of STDs, drug problems and construction or drilling-related injuries.<sup>500</sup> Other research suggests that energy development projects may be linked to

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<sup>492</sup> Yergin, 1991.

<sup>493</sup> Gilmore, 1976; Kassover and McKeown, 1981; Konigsberg, 2011; Massey et al, 1976; Massey 1980; Yergin, 1993.

<sup>494</sup> Brookshire and D’Arge, 1980; Covey and Menard, 1983; Freudenberg and Jones, 1991; Kohrs, 1974; Krannich et al., 1989; Little, 1976-77.

<sup>495</sup> Blevins interview, 2012; Levy, 2011; Long, 2010; Needles, 2011; Pennsylvania Budget and Policy Center, 2011.

<sup>496</sup> Fuller, 2010; Sublette County, WY website, 2011.

<sup>497</sup> Ellis, 2011; Levy, 2011; Oldham, 2012; Shactman, 2012; Springer, 2012.

<sup>498</sup> Marcellus Shale Education and Training Center, 2010.

<sup>499</sup> Chakrabarty 2007; Fuller, 2010; Porter, 2011.

<sup>500</sup> Covey, S. 2010.

more risky sexual behavior in youth, leading to higher rates of STDs.<sup>501</sup> It is unclear whether these rate increases occur in the local population or reflect STD rates among transient oil and gas crews.

The research, newspaper reports and anecdotes described above do not reflect all communities that have experienced growth in natural gas or oil development. While some (mostly rural) regions of the country report increases in crime rates and other social problems, no modern empirical research has found a causal relationship between increased oil and gas activity and increased crime rates.

A recent study by researchers at Pennsylvania State University found no empirical evidence of increased crime associated with drilling in the Marcellus region.<sup>502</sup> Newspapers from the regions around Texas' Eagle Ford and the Barnett shale plays, Oklahoma's Woodford shale and Louisiana's Hayneville and Fayetteville shales have not reported upticks in crime. Similarly, counties in southwest Pennsylvania, where Marcellus drilling has boomed in recent years, have not reported significant increases in any of these social problems.<sup>503</sup>

### **Statistical analysis overview**

As part of the analysis of potential social impacts, DENR conducted a statistical analysis of crime rates in six regions of the United States that have experienced major growth in the oil and/or gas industry over the past three to five years. These regions are Colorado's Western Slope, all of Oklahoma, Pennsylvania's Marcellus shale region, Texas' Barnett and Eagle Ford shale plays, North Dakota's Bakken shale region, and Wyoming's Green River Basin.<sup>504</sup>

The analysis compares changes in levels of oil and gas production in relevant counties with the reported rates of a variety of crimes. The analysis controls for factors other than oil and gas development that could potentially impact crime rates in each county.

This statistical analysis comes with certain limitations. Since the data come from the county level, it may not capture trends occurring at more localized levels. For example, crime rates may change dramatically in a small town where drilling has occurred without significantly affecting countywide crime statistics. In that case, a county-wide analysis may not reflect the small town's experience. This limitation may be particularly present in counties that cover a large physical area (like Wyoming's large counties), or counties with large populations (such as in Texas' Barnett region).

### **Statistical analysis results<sup>505</sup>**

In some heavily drilled regions, the data show a small but significant relationship between increased drilling activity and crime rates. These impacts vary by region, with counties in Colorado and Wyoming showing increased rates in violent crimes associated with increased

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<sup>501</sup> Goldenberg et al, 2008.

<sup>502</sup> Kowalski and Zajac, 2012.

<sup>503</sup> Interviews from Armstrong, Butler, and Westmoreland counties, PA.

<sup>504</sup> Based on a survey of accessible local and regional newspapers, radio, and television outlets.

<sup>505</sup> For information on data, methods, sources, and detailed results, please see Appendix D: Statistical analysis methodology.



rates of natural gas production. In Texas, however, both the Eagle Ford and the Barnett shale regions showed decreased rates in assorted crimes associated with increased natural gas production.

In Colorado's Western Slope region, increased rates of natural gas production were strongly correlated with slightly elevated rates of aggravated assault (99 percent confidence level). The strong relationship between aggravated assault and gas production helped drive a significant relationship between increased gas production and elevated rates of violent crime (95 percent). Interestingly, the data also show that increased oil production in Colorado counties was significantly related to *decreased* reported cases of rape (99 percent).

In Wyoming's Green River Basin region, strong growth in oil and gas production were both positively correlated with elevated rates of certain crimes. Increased production of natural gas showed a statistically significant relationship with slightly elevated rates of aggravated assault and overall violent crime (both 99 percent confidence level). Increased rates of oil production were correlated strongly with elevated rates of murder (95 percent), burglary (95 percent), non-violent crime (99 percent), and overall crime (99 percent).

In Texas, both the Barnett and Eagle Ford shale regions showed increased rates of gas production to be strongly correlated with *decreased* rates of certain crimes. In the Eagle Ford region, increased natural gas production correlated strongly with a slight decrease in murder rates (99 percent confidence level). In the Barnett shale region, increased natural gas production showed a strong relationship with slightly lower rates of burglary (95 percent), larceny (99 percent), and overall non-violent crimes (99 percent). Neither region showed a significant relationship between increased oil production and crime rates.

North Dakota's Barnett shale region, all of Oklahoma, and Pennsylvania's Marcellus shale region showed no significant relationships between changes in oil and gas production and crime rates.

### ***Discussion of results***

The results of these state-level analyses leave several important questions unanswered and pose new questions for further research. While the analysis controls for a variety of factors, the limited amount of data means that none of these findings establish that oil or gas drilling directly cause either high or low crime rates. The results do not show that oil or gas workers were responsible for either high or low crime rates. Oil and gas workers may be the perpetrators of crimes, the victims of crimes, or both. Further research is required to accurately answer this question.

Second, the results do not show a clear pattern with regard to impacts related to rural versus urban settings. If rural regions experienced stronger relationships between oil and gas production and crime rates, North Dakota's Bakken shale region would show the strongest relationship, and Texas' Barnett shale region would show the weakest. However, the results are mixed. Colorado and Wyoming, where drilling regions are sparsely populated, show significant relationships between increased drilling and high crime rates, but sparsely populated drilling regions in North Dakota and Texas do not.

In Texas' Barnett and Eagle Ford regions, significant relationships between increased drilling and *low* crime rates defy the "boomtown effect" narrative. The reason for this relationship is unclear, but may be related to the fact that many oil and gas workers live in Texas. Given Texas' long history in the oil and gas industry, the workforce can work close to home, limiting the impact of a transient workforce experienced in more typical "boomtowns."

High rates of violent crime can be linked to diminished social cohesion in a community.<sup>506</sup> Since Texas has a long history of drilling, and a local workforce trained to work on oil and gas rigs, increased oil and gas production in Texas may not significantly disrupt community character or population characteristics. In areas where the oil and gas workforce must be imported, such as Colorado and Wyoming, community disruption would be more likely to occur. However, North Dakota and Pennsylvania, two regions without a strong local oil and gas workforce, defies this explanation, as no significant relationships were found between increased drilling and crime rates.

The types of crime driving this analysis also merit discussion. In Colorado and Wyoming, aggravated assault rates showed strong relationship with increased natural gas production. Aggravated assault, while a serious crime, does not typically have the disruptive effect on communities that crimes like murder or robbery do. Bar fights, for example, may be classified as aggravated assaults. Issues of community division (see section 6.I, *Community Impacts*) related to oil and gas production could contribute to increases in aggravated assaults.

### **Data analysis limitations**

The data used in this study are limited, and additional research is required to confirm or refute the findings. For example, population data on transitory workforces is very difficult to obtain. As a result, natural gas and oil production is used as a proxy for the population changes that may impact crime rates when drilling activities occur. Since oil and gas production peaks at a well site after completion of the well, production rates are an imperfect measure of population changes in a community. Production peaks may lag behind population changes by weeks or months, depending on when natural gas gathering lines have been installed.

Second, workers may not be living and spending their off hours in the counties where oil or gas production occurs. As noted in Section A, *Potential impacts on housing availability*, workers sometimes commute an hour to and from their worksite. In areas where housing supplies are short, workers are especially likely to live some distance from the well pad. As a result, oil or gas production in any given county does not necessarily align with population or community changes in that county.

Third, policing tactics likely differ between counties and states, which may impact the data. Methods of policing are not controlled for in this analysis.

Fourth, the data for crime reporting may not fully reflect crime rates in the counties analyzed. Uniform Crime Reports, compiled for each county, are the sole tool for assessing changes in crime rates in this analysis. However, other indicators of crime, such as calls to local police,

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<sup>506</sup> Mazerolle et al., 2010; Sampson et al., 1997; Sampson and Raudenbush, 1999.

number of traffic stops and data on unreported or underreported crimes would be useful to paint a more complete picture.

### ***Implications for North Carolina***

If natural gas drilling occurs in North Carolina, it will not necessarily experience the impacts of a typical “boomtown.” Local and regional characteristics play a large part in determining how communities interact with any new development. The anecdotal reports and statistical analysis described above indicates that problems with crime may occur in some drilling communities, but whether or not these problems will occur in North Carolina is not predictable.

One potential factor in determining if oil or gas development may impact crime is whether or not companies hire locally. Since North Carolina does not have a trained workforce in natural gas development, the state can expect many of the drilling crews to come from other parts of the country. Industry workers often travel without their families.<sup>507</sup> Since changes in crime rates are often related to changes in community character, an influx of workers from out of state may increase the likelihood of crime impacts.<sup>508</sup>

Local infrastructure and population density may also play a role in determining if an influx of new workers impacts local crime rates. Preliminary research in Pennsylvania finds that rural areas were impacted more strongly by social disruptions (though not necessarily crime) associated with the natural gas industry.<sup>509</sup> Likewise, anecdotes of social problems and increased crime rates primarily come from more sparsely populated regions in northeast Pennsylvania, Colorado, Wyoming and North Dakota.<sup>510</sup>

Population density varies greatly between potential areas of exploration in North Carolina and areas that have documented increased crime rates related to oil and gas development. Table 6-10 compares the population densities of North Carolina’s Dan and Deep River basins with impacted regions of Pennsylvania, Wyoming and North Dakota.

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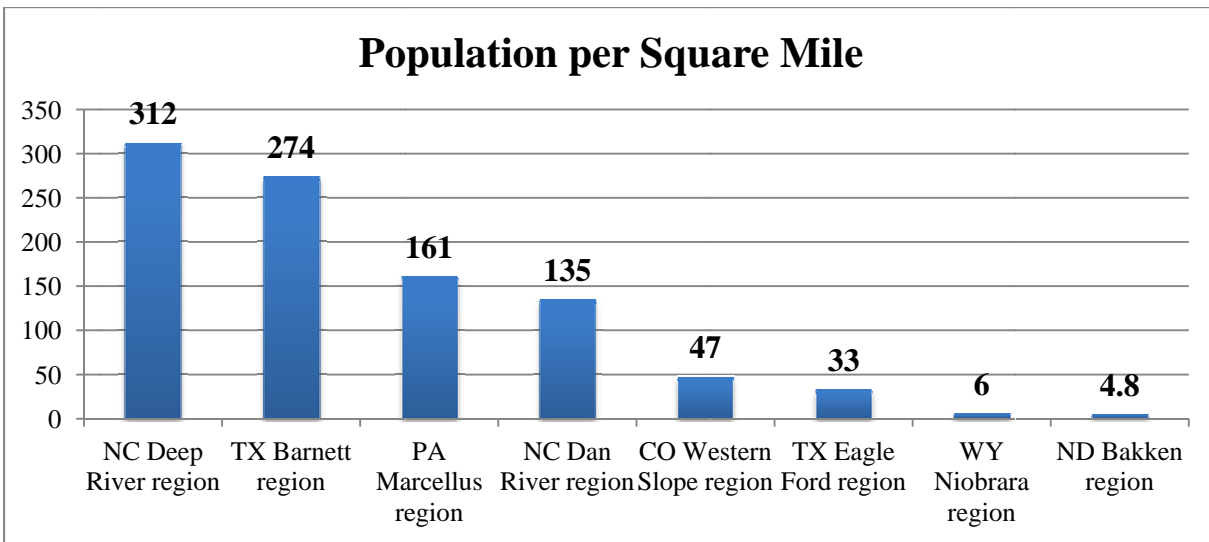
<sup>507</sup> Fuller, 2010; Levy, 2011; Long, 2010; Needles, 2011; PA Budget and Policy Center, 2011; Interviews, 2011.

<sup>508</sup> Mazerolle et al., 2010; Sampson et al., 1997; Sampson and Raudenbush, 1999.

<sup>509</sup> Brasier and Filteau, 2010.

<sup>510</sup> Blevins interview, 2012; Ellis, 2011; Fuller, 2010; Levy, 2011; Sublette County website, 2011.

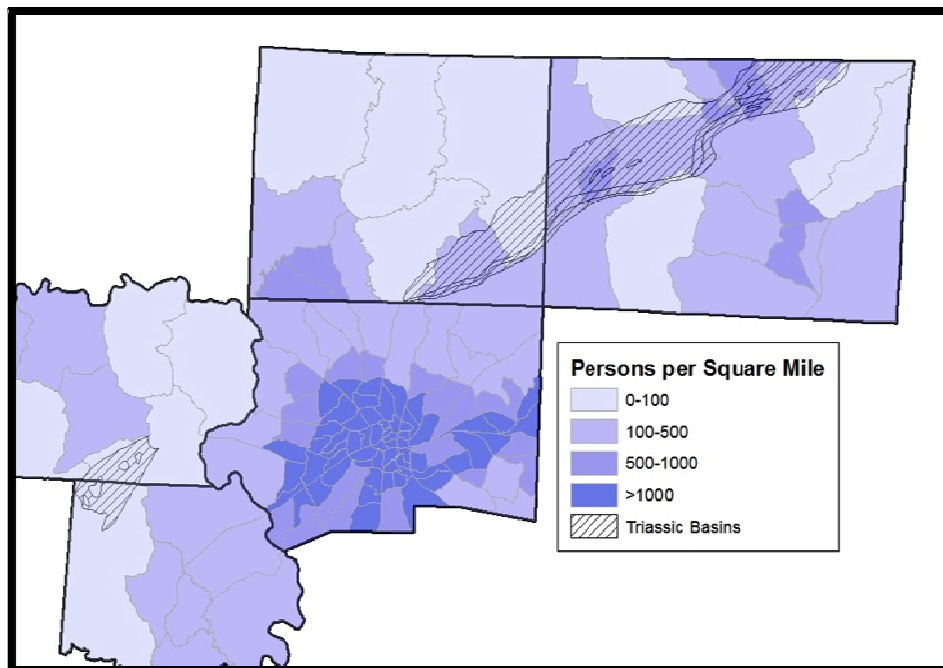
**Table 6-10. Population Densities in Oil/Gas regions, and in the North Carolina Deep and Dan River Basin Regions**



Source: U.S. Census 2010.

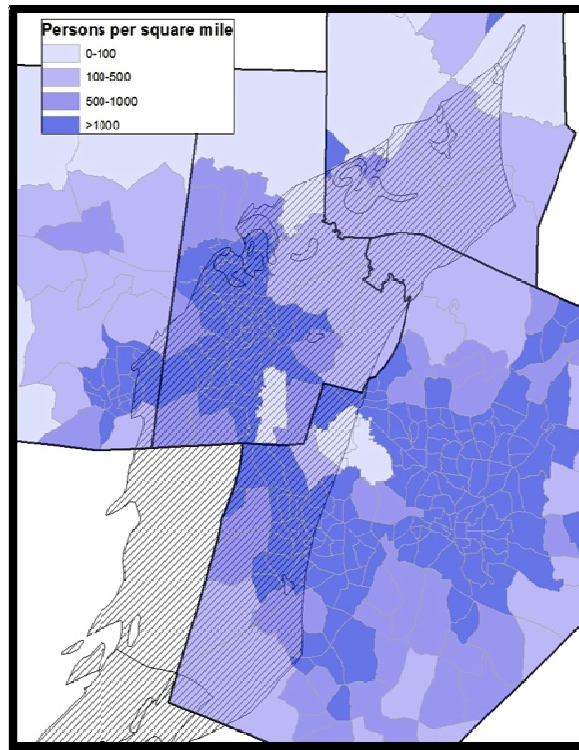
Clearly, North Carolina’s shale formation regions have significantly higher population densities than some of the areas experiencing crime impacts associated with drilling projects. If higher population density lessens crime impacts, North Carolina would likely not experience the same level of impact as its more rural counterparts in Wyoming or Colorado.

**Figure 6-18. Dan River Basin Population Density**



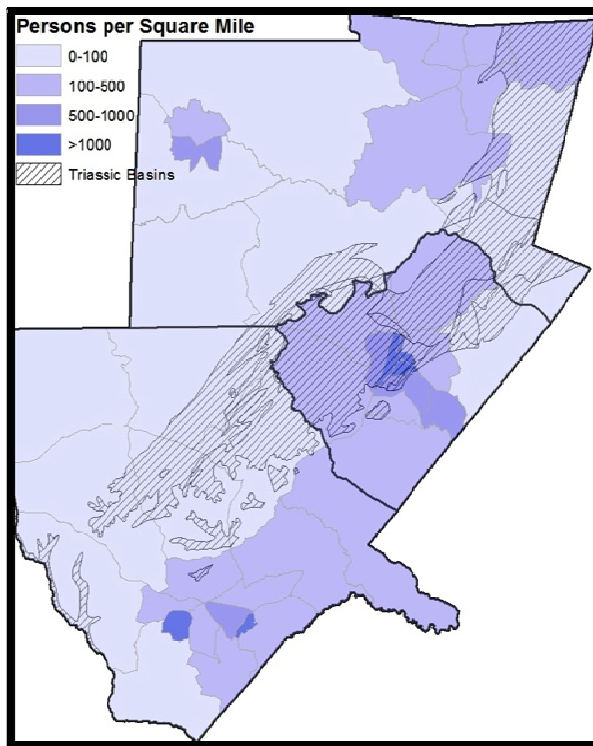
Source: U.S. Census Bureau, NC Onemap geospatial data, N.C. Geological Survey

**Figure 6-19. Durham Sub-basin Population Density**

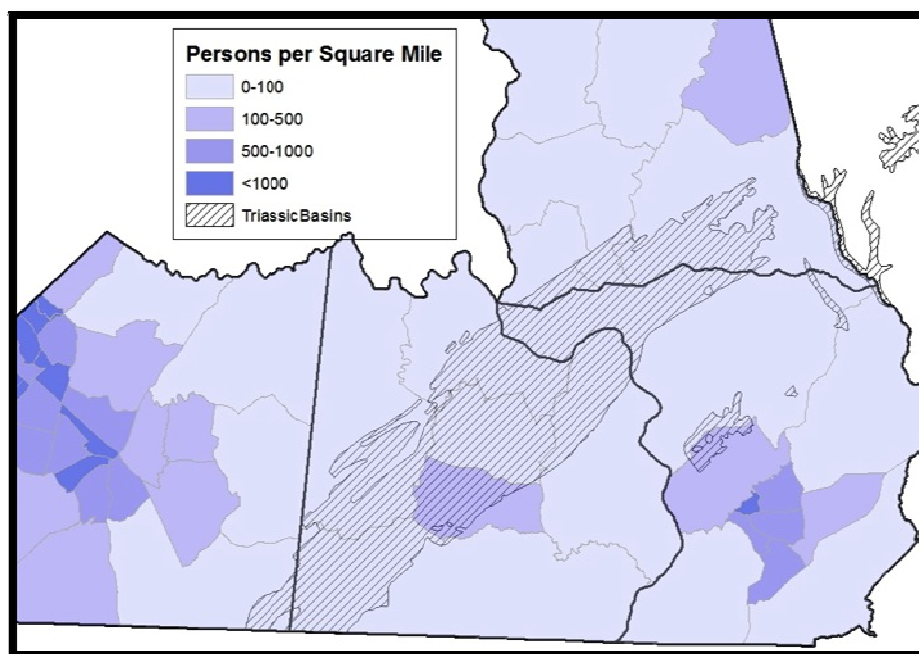


Source: U.S. Census Bureau, NC Onemap geospatial data, N.C. Geological Survey

**Figure 6-20. Sanford Sub-basin Population Density**



Source: U.S. Census Bureau, NC Onemap geospatial data, N.C. Geological Survey

**Figure 6-21. Wadesboro sub-basin population density**

Source: U.S. Census Bureau, NC Onemap geospatial data, N.C. Geological Survey

## I. Potential community impacts

Natural gas drilling has the potential to affect community dynamics in both rural and urban areas. Some residents will favor drilling, while others will oppose it; this divide can affect relationships between friends, neighbors and community groups. Natural gas drilling also has the potential to significantly change the character of a community by introducing an industrial-scale activity to a previously quiet rural area.

### *Distributional impacts and potential for community division*

If gas drilling occurs in North Carolina, some residents will benefit more than others. Although it is a natural result of economic processes, uneven distribution of benefits and costs from drilling activity has the potential to create divisions within communities. While some residents may benefit substantially from drilling, most members of the community will experience the impacts of gas production – such as visual impacts, noise, traffic and a potential increase in rental housing costs. In particular, landowners in possession of the mineral rights to their property stand to gain financial rewards from drilling; those who don't own mineral rights may only experience the inconveniences associated with gas drilling. In addition, landowners in possession of mineral rights may receive different lease terms (based on a variety of factors) – creating another source of strain among neighbors.

This uneven distribution of benefits and costs has the potential to increase tension in communities, in some cases pitting neighbor against neighbor. In Mount Pleasant, Pa., disagreements over whether or not to drill in a community has led to angry letters, arguments



and a sense of mistrust between neighbors.<sup>511</sup> Surveys of residents and community leaders in Pennsylvania's Marcellus region indicate that this division between "haves and have-nots" has occurred in a variety of communities.<sup>512</sup>

In New York State, landowners debate the pros and cons of natural gas drilling, with some who oppose drilling receiving letters that they describe as threatening.<sup>513</sup> In Southlake, Texas, home to the Barnett shale play, drilling opponents have received similar threatening letters.<sup>514</sup> Academic research reflects these anecdotes, showing that an uneven distribution of benefits and costs resulting from energy development can increase divisions in a community.<sup>515</sup>

These divisions have the potential to sour friendships, community groups and other social organizations important to any community. In some cases, disputes over drilling have led to lengthy and costly lawsuits, hardening the divisions. These lawsuits are sometimes between neighbors; in other cases, lawsuits arise between local communities and drilling companies.<sup>516</sup>

### ***Landowner coalitions***

Shale gas exploration has also united communities in some areas. In communities where leasing activity has begun, neighbors frequently join together to form landowner coalitions. These coalitions, which negotiate lease terms on behalf of their members, have the potential to result in better monetary outcomes, improved property rights protection and stronger environmental safeguards for landowners. These coalitions can also foster a sense of community among neighbors.

Examples of these coalitions include groups in Louisiana's Haynesville shale region, Pennsylvania and New York's Marcellus shale regions, Ohio's Utica shale region and Texas' Barnett shale region.<sup>517</sup>

### ***Quality of life***

The economic, social and environmental impacts discussed in other sections of this report can also affect natural amenities and quality of life for residents. Natural amenities include things like a quiet place to come home to, pristine views of surrounding land, and other factors that allow individuals to enjoy their community's natural surroundings. The impacts of increased traffic, noise, light and other aspects of industrial activity can be particularly jarring in a rural community. Research and reports from a variety of drilling locations describe some of these concerns over the past several years.

In parts of northern Pennsylvania, a dramatic increase in heavy truck traffic has diminished local residents' sense of their communities' rural character, and placed a burden on local

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<sup>511</sup> Koenig, 2011.

<sup>512</sup> Laughner, 2012.

<sup>513</sup> Applebome, Oct. 2011; Banerjee, 2012.

<sup>514</sup> Gibbs, 2011.

<sup>515</sup> Brookshire and D'Arge, 1980; Little, 1976-77; Summers and Branch, 1984.

<sup>516</sup> Koenig, 2011; Mazzone, 2011; Primm, interview, 2011.

<sup>517</sup> Dickers, 2012; Integra Realty, 2011; Kallenberg, 2011; Jacquet, 2009.

governments to maintain roads.<sup>518</sup> In south Texas' Eagle Ford shale region, increased traffic has also impacted a largely rural community, slowing commutes and adding noise to a previously quiet region.<sup>519</sup> Local governments in southern New York State are bracing for increased traffic issues if the state decides to lift its moratorium on natural gas drilling.<sup>520</sup>

Natural gas drilling can also impact the visual quality of a region. Nighttime flares from newly drilled wells illuminate the skies of Bradford County, Pa., to the extent that "you don't need a nightlight."<sup>521</sup> In West Virginia's Marcellus shale region, residents have complained about visual impacts including light from gas flaring, the presence of large trucks on rural roads, and the sight of drilling rigs in rural areas (see section 6.G, *Visual impacts* for more details).<sup>522</sup>

Natural gas drilling also has the potential to impact natural amenities by increasing noise in and around a well site (see section 6.F, *Noise impacts* for more details).

On the other hand, the visual and noise impacts associated with natural gas drilling can be short-term, lasting only two to three months per well.<sup>523</sup> Once construction, drilling and fracturing have been completed, the visual and noise impacts from a well are minimal.

Some rural communities have cited natural gas development as a way to sustain a rural way of life. In southwestern Pennsylvania, farmers have leased their mineral rights and used the income to upgrade their equipment, make capital improvements, and supplement their annual income.<sup>524</sup> In Ohio, leasing around the Utica shale formation has similarly allowed farmers to sustain their operations.<sup>525</sup>

Longtime residents of communities affected by energy development projects sometimes perceive changes to the community very differently than newcomers who arrive to work in the industry. A variety of researchers have explored the old timer versus newcomer issue in energy development communities, focusing primarily on rural areas in the American West. In some areas, longtime community residents oppose oil and gas projects because energy development can disrupt the rural way of life and established social patterns.<sup>526</sup> Relative newcomers who relocated to a rural area for the peace and quiet may also oppose new energy projects out of fear that new development will destroy the very qualities that attracted them.<sup>527</sup>

In some parts of rural Colorado, oil and gas workers have said that local townspeople don't appreciate their presence and that they feel unwelcome.<sup>528</sup> In parts of Pennsylvania or Texas

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<sup>518</sup> Blevins interview, 2012; Braiser and Filteau, 2011; Christopherson, 2010; Herr, 2011; Jacquet, 2009.

<sup>519</sup> Daugherty, 2011.

<sup>520</sup> Reilly, 2011; Sullivan County, 2009.

<sup>521</sup> Long, 2010.

<sup>522</sup> Maskell, 2011.

<sup>523</sup> NYSDEC, 2011.

<sup>524</sup> Haggerty, 2010; Kelsey et al., 2012; Koenig, 2011.

<sup>525</sup> Vega et al, 2011.

<sup>526</sup> Little, 1976-77; Massey, 1980; Smith and Krannich, 2000.

<sup>527</sup> Graber, 1974. Starrs and Wright, 1995.

<sup>528</sup> Chakrabarty, 2007.



where spills or other negative impacts have occurred, local residents sometimes perceive gas companies as an enemy of their community.<sup>529</sup>

On the other hand, recent news reports from Ohio describe excellent relationships between gas workers and the local businesses and restaurants that seek to attract their business.<sup>530</sup>

Community leaders and local government officials in southwestern Pennsylvania tend to describe the gas companies as “good neighbors” who have an interest in positive community relations.<sup>531</sup>

In some cases, energy development projects in rural areas have led to increased mental health problems among community residents.<sup>532</sup> As energy development projects have transformed their community and social networks, some longtime residents struggle to cope and form the same types of “small-town” bonds that are extremely valuable. This stress has led residents in some energy boomtowns to seek mental health counseling services.<sup>533</sup>

### ***Implications for North Carolina***

Many of the quality of life and natural amenity issues examined in the research and reporting described above occurred in extremely rural areas. North Carolina’s Deep and Dan River shale regions are significantly more populated than the western regions described in much academic research and some reporting. As a result, many of the issues arising in the old timer versus newcomer scenarios may be less applicable to the Deep and Dan River regions. Although some parts of the Triassic Basin (particularly the Wadesboro sub-basin and parts of the Dan River basin) are sparsely populated, none of the region’s counties are as rural as the areas of Colorado, North Dakota, or Wyoming that were the subject of sociological research in previous decades.

Additionally, North Carolina’s gas producing regions may not attract the same scale of industrial activity experienced in parts of the Marcellus, Eagle Ford, or Bakken shale formations. Less drilling activity would mean fewer newcomers and fewer visual, noise, and traffic impacts, mitigating the some of the community impacts described above. To give a sense of scale, Bradford County, Pa., currently has 1,935 Marcellus wells permitted.<sup>534</sup> The N.C. Geological Survey has estimated, very roughly, that the Deep River basin could support up to 368 gas wells.<sup>535</sup>

The prospect of natural gas production has the potential to divide North Carolina residents just as it has in other parts of the country. Landowners who control their mineral estates may be more likely to support drilling in the shale gas regions, as they are more likely to profit if drilling were to occur. However, confusion over ownership of the mineral estates on a number of

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<sup>529</sup> Blevins interview, 2012; Heinkel-Wolfe and Brown, 2011; McCoy and Tanfani, 2011.

<sup>530</sup> Smith, R., 2011.

<sup>531</sup> Andree interview, 2011; Coonley interview, 2011; Primm interview, 2011; Roth interview, 2011.

<sup>532</sup> Bacigalupi and Freudenberg, 1983; Kassover and McKeown, 1981; Little, 1976-77; Massey, 1980.

<sup>533</sup> Freudenberg, 1983; Freudenberg, 1986.

<sup>534</sup> MarcellusGas.org website, Jan. 3, 2012.

<sup>535</sup> Interviews with Dr. Jim Simons and Dr. Kenneth Taylor, 2011.

properties in Lee County may indicate some of the challenges associated with natural gas drilling in parts of North Carolina that have limited experience with extractive industries.<sup>536</sup>

Conflicts between neighbors also have the potential to occur in North Carolina. Since North Carolina is not as sparsely populated as Wyoming, Colorado or North Dakota, residents are more likely to be impacted by the decisions and actions of their neighbors. Community divisions surrounding natural gas drilling in more densely populated parts of Texas and Pennsylvania demonstrate some of the conflicts that could arise in North Carolina communities.<sup>537</sup>

However, one issue has arisen as a common concern for communities where new shale gas operations have begun: traffic. News reports, local officials and researchers in gas drilling regions have all reported significant increases in traffic volumes, especially large trucks, associated with new natural gas operations.<sup>538</sup> Increased traffic has the potential increase commute times and to frustrate local drivers, especially in rural communities unaccustomed to heavy traffic. For more details on potential traffic impacts, see section 3.B (infrastructure impacts).

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<sup>536</sup> Murawski, Nov. 2011.

<sup>537</sup> Gibbs, 2011; Koenig, 2011.

<sup>538</sup> Brasier interview, 2012; Collette, 2011; Chakrabarty, 2007; Christopherson, 2011; Daugherty, 2011; Ellis, Oct. 2011; Heinkel-Wolfe and Brown, 2011; Herr, 2011; Jacquet, 2009; Primm interview, 2011.