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LETTER

Just fracking: a distributive environmental justice analysis of unconventional gas development in Pennsylvania, USA

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Abstract

This letter presents a distributive environmental justice analysis of unconventional gas development in the area of Pennsylvania lying over the Marcellus Shale, the largest shale gas formation in play in the United States. The extraction of shale gas using unconventional wells, which are hydraulically fractured (fracking), has increased dramatically since 2005. As the number of wells has grown, so have concerns about the potential public health effects on nearby communities. These concerns make shale gas development an environmental justice issue. This letter examines whether the hazards associated with proximity to wells and the economic benefits of shale gas production are fairly distributed. We distinguish two types of distributive environmental justice: *traditional* and *benefit sharing*. We ask the *traditional* question: are there a disproportionate number of minority or low-income residents in areas near to unconventional wells in Pennsylvania? However, we extend this analysis in two ways: we examine income distribution and level of education; and we compare before and after shale gas development. This contributes to discussions of *benefit sharing* by showing how the income distribution of the population has changed. We use a binary dasymetric technique to remap the data from the 2000 US Census and the 2009–2013 American Communities Survey and combine that data with a buffer containment analysis of unconventional wells to compare the characteristics of the population living nearer to unconventional wells with those further away before and after shale gas development. Our analysis indicates that there is no evidence of traditional distributive environmental injustice: there is not a disproportionate number of minority or low-income residents in areas near to unconventional wells. However, our analysis is consistent with the claim that there is benefit sharing distributive environmental injustice: the income distribution of the population nearer to shale gas wells has not been transformed since shale gas development.

1. Introduction

The production of shale gas in the United States (US) has grown rapidly from 0.2 trillion cubic feet in 1998 to 11.4 trillion cubic feet in 2013 (Sovacool 2014, US Environmental Information Agency (EIA) 2015). Shale gas accounted for only 1.6% of US natural gas production in 2000 but is forecast to account for 55.2% by 2040 (Wang and Krupnick 2013, US EIA 2015). The 'shale gas revolution' has been made possible by the development of 'unconventional wells', which use horizontal drilling and hydraulic fracturing ('fracking') technologies (Wang *et al* 2014). Fracking involves drilling deep into the shale layer and pumping in large quantities of liquid at high pressure to fracture the shale and release natural gas that flows back to the surface (Sovacool 2014). The rapid increase in shale gas production in the US has been hailed as enhancing energy security, reducing natural gas prices and providing economic development (Hanlon 2011, de Melo-Martin *et al* 2014, Willow 2015). However, it has also been the subject of fierce political disputes in some areas with opponents securing moratoria on unconventional well development in three US states, Maryland, New York and Vermont (Wilber 2012, Food and Water Watch 2015).

A wide range of environmental and public health concerns about shale gas production have been identified (Adgate *et al* 2014, Jackson *et al* 2014, Werner *et al* 2015). The academic literature has emphasized air and water pollution as the most significant environmental risks but other environmental concerns have been prominent in public discussions, including concerns about the very large quantities of water used in unconventional wells, the release of radioactivity, the contribution of shale gas production to climate change and the potential of fracking to cause earthquakes (Vengosh *et al* 2013, Sovacool 2014, Wang *et al* 2014). Public health concerns are based on both the known effects of chemicals emitted to air or water by shale gas production and the health problems reported by people living near to wells (Brown *et al* 2014, Saberi *et al* 2014, Webb *et al* 2014). Suggested health problems are of many different types, including: neourologic (e.g., headaches, dizziness, difficulty concentrating, fatigue); respiratory (e.g., coughing, difficulty breathing); gastrointestinal (vomiting, diarrhoea); dermatologic (hair loss, rashes, skin irritation, burning eyes); vascular (nosebleeds, stroke); reproductive and infant health (lower birth weight, neural tube defects, congenital heart defects); and mental health (anxiety) (McDermott-Levy *et al* 2013, McKenzie *et al* 2014, Rabinowitz *et al* 2015, Bamberger and Oswald 2015).

There is not a consensus on the public health effects of shale gas production due to the limitations of the available data (UK DECC 2012, Finkel and Hays 2013, Bunch *et al* 2014, Jackson *et al* 2014, Macey *et al* 2014, Brown *et al* 2015, Werner *et al* 2015). However, there are a number of studies that show statistically significant correlations between proximity to well sites and environmental and health problems, such as raised levels of methane in drinking-water wells and increased rates of self-reported upper respiratory and dermatologic problems (Osborn *et al* 2011, Steinzor *et al* 2013, Rabinowitz *et al* 2015, Werner *et al* 2015). Three large studies have also reported statistically significant correlations between the proximity to well sites of maternal residence during pregnancy and infant health problems (Hill 2013, McKenzie *et al* 2014, Stacy *et al* 2015).

These studies have led some authors to argue for an ethical analysis of shale gas production (de Melo-Martin *et al* 2014, Field *et al* 2014, North *et al* 2014, Short *et al* 2015, Wheeler *et al* 2015). In particular, some have argued that shale gas production raises issues of environmental justice (Carre 2012, Perry 2012, 2013, US Environmental Protection Agency (EPA) 2012, Fry *et al* 2015, Ogneva-Himmelberger and Huang 2015). Different conceptions of environmental justice will point our attention to different aspects of shale gas production (Bell 2016; Walker 2012, Schlosberg 2013). We might usefully distinguish three types of environmental justice concern. First, on a rights-based conception of environmental justice, we should be concerned if anyone suffers significant harm as a result of shale gas production (Agyeman 2005, Short *et al* 2015). Second, on an equity-based or distributive conception, we should be concerned if the distribution of hazards and/or benefits associated with shale gas production is unfair (Bell, 2004, Fry *et al* 2015, Ogneva-Himmelberger and Huang 2015). Third, on a procedural conception, we should be concerned if some people or some groups are excluded or marginalized when decisions are made about the regulation of shale gas production and the siting of wells (Fry *et al* 2015, US EPA 2015). These three types of concern are inter-related but they are analytically distinct and can be studied separately. In this letter, we focus on the second concern—distributive environmental justice.

Two recent studies have explicitly adopted a distributive environmental justice approach to shale gas production. However, these studies focus on two different aspects of distributive environmental justice. Fry *et al* (2015) focus on the relationship between the distribution of benefits and proximity to hazards. We will call this '*benefit sharing*' distributive environmental justice. More specifically, Fry *et al* examine the geographical distribution of the ownership of mineral rights in Denton, Texas to discover whether the people living near to shale gas developments—and suffering the hazards associated with proximity—are likely to benefit from future royalties from shale gas production. Their analysis shows that ownership of mineral rights does not track proximity to shale gas developments: 'individual homeowners in Denton own just 6.3% of the total value (of mineral rights) held by all owners' (Fry *et al* 2015, p 104). In this sense, there is distributive environmental *in*justice.

In contrast, Ogneva-Himmelberger and Huang (2015) present a '*traditional*' distributive environmental justice analysis, which focuses on whether unconventional wells in the Marcellus Shale region, covering parts of Pennsylvania, West Virginia and Ohio, are disproportionately located in areas with large minority or low-income populations. They find no evidence of this form of environmental injustice in West Virginia or Ohio. In Pennsylvania, they find evidence that unconventional gas wells are disproportionately located in areas with larger populations living in poverty but they find no evidence of race-based environmental injustice.

This letter is the first study of shale gas development to consider both 'traditional' and 'benefit sharing' aspects of distributive environmental justice. We ask the question: are there a disproportionate number of minority or low-income residents in areas near to unconventional wells in Pennsylvania? However, we extend this traditional analysis in two ways: we examine income distribution and level of education in addition to race and poverty; and we compare communities before and after shale gas development. The additional analysis contributes to discussions of benefit sharing distributive environmental injustice. In section 2, we describe the study area and outline the

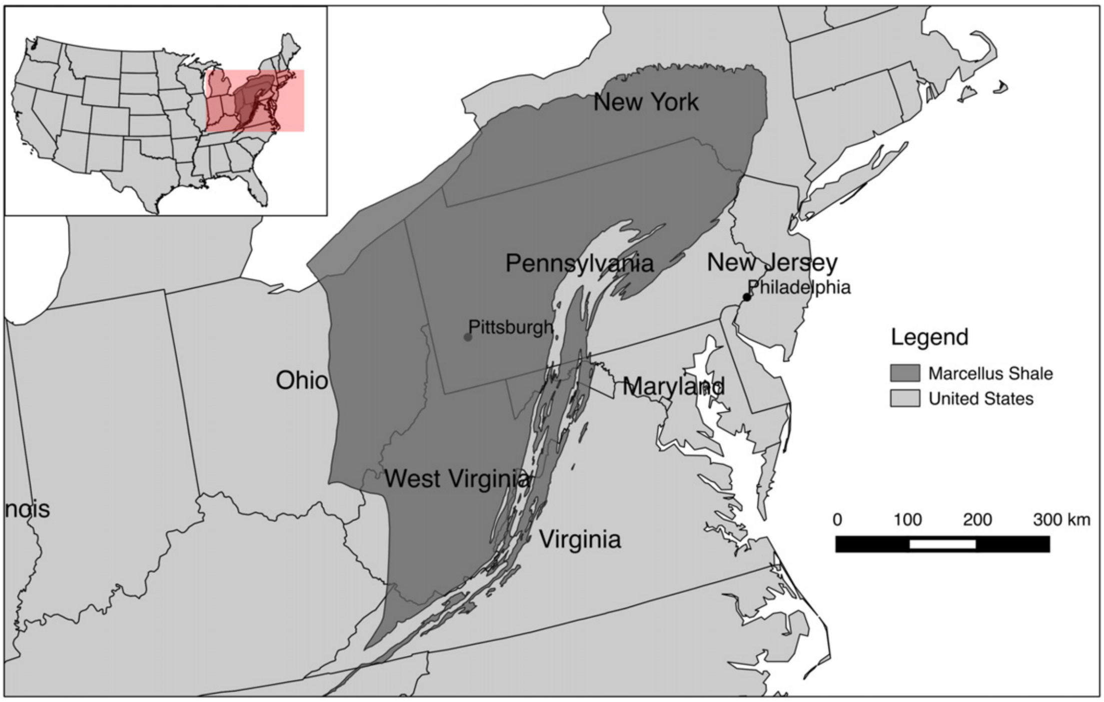

Figure 1. Extent of the Marcellus Shale in the Northeast United States.

previous research on environmental justice and shale gas development in Pennsylvania. Section 3 explains our study design. Section 4 presents our results, section 5 discusses them and section 6 concludes.

2. Study area: Pennsylvania and the Marcellus Shale

The Marcellus Shale is the largest shale gas area in play in the US (Kargbo *et al* 2010). It lies underneath most of Pennsylvania, as well as a good portion of New York, Ohio and West Virginia. Our study focuses on the large area (approximately 64%) of Pennsylvania that lies over the Marcellus Shale (figure 1). Pennsylvania covers an area of 119 282 km^2 with a population of 12.7 million in 2014 (US Cenus Bureau 2015). The population is unevenly distributed with 73% (9.2 million) living in 19 'urban' counties (with a population density of at least 284 persons per square mile) (Center for Rural Pennsylvania 2015). Thirteen of those urban counties, accounting for 52% of the population (6.7 million), are located in the south eastern area of Pennsylvania, most of which is not over the Marcellus Shale (US Cenus Bureau 2015). Of approximately 6 million people in Pennsylvania living over the Marcellus, 3.5 million live in 48 rural counties and 28 of those counties have a population density of less than 100 people per square mile (Center for Rural Pennsylvania 2015). The ethnic make-up of the population of the counties over the Marcellus is 91% White, 5% Black or African American and 2% Hispanic or Latino (US Cenus Bureau 2015). According to the 2009–2013 American Community Survey, approximately 12% of the population lived below the poverty line and just over half had received no university-level education.

Pennsylvania's economy was centered on coal in the nineteenth and early twentieth century and steel in the mid-twentieth century. In 2014, Pennsylvania had the sixth highest gross domestic product (GDP) by state in the US but a relatively small manufacturing sector (12.01% of state GDP in comparison with 19.94% of US GDP) (Bureau of Economic Analysis 2015). Despite the decline of the steel industry, unemployment in Pennsylvania was similar to the national average between 1990 and 2009 and has been lower than the national average for the last six years (US Bureau of Labor Statistics 2015). The contribution of the oil and gas industry to state GDP in 2013 (the last year for which data is available) was $5764 m or 0.90% of state GDP, which is more than it was in 2004 (0.08% of state GDP) but still proportionately smaller than the contribution of the industry to US GDP (1.33%).

The first unconventional wells were drilled in Pennsylvania in 2005 but initial development was slow with only 45 wells drilled by the end of 2006. However, there was rapid growth in the number of wells from 2007, which reached a peak in 2011 when 1961 new wells were drilled, bringing the total number of wells to 4873. Growth has continued at a slower pace with 9541 wells drilled by mid-November 2015 (Kelso 2015). There are wells in 39 counties but most (69%) of the wells are in six counties in the north east (Bradford, Lycoming, Susquehanna and Tioga) and south west (Washington and Greene) of Pennsylvania.

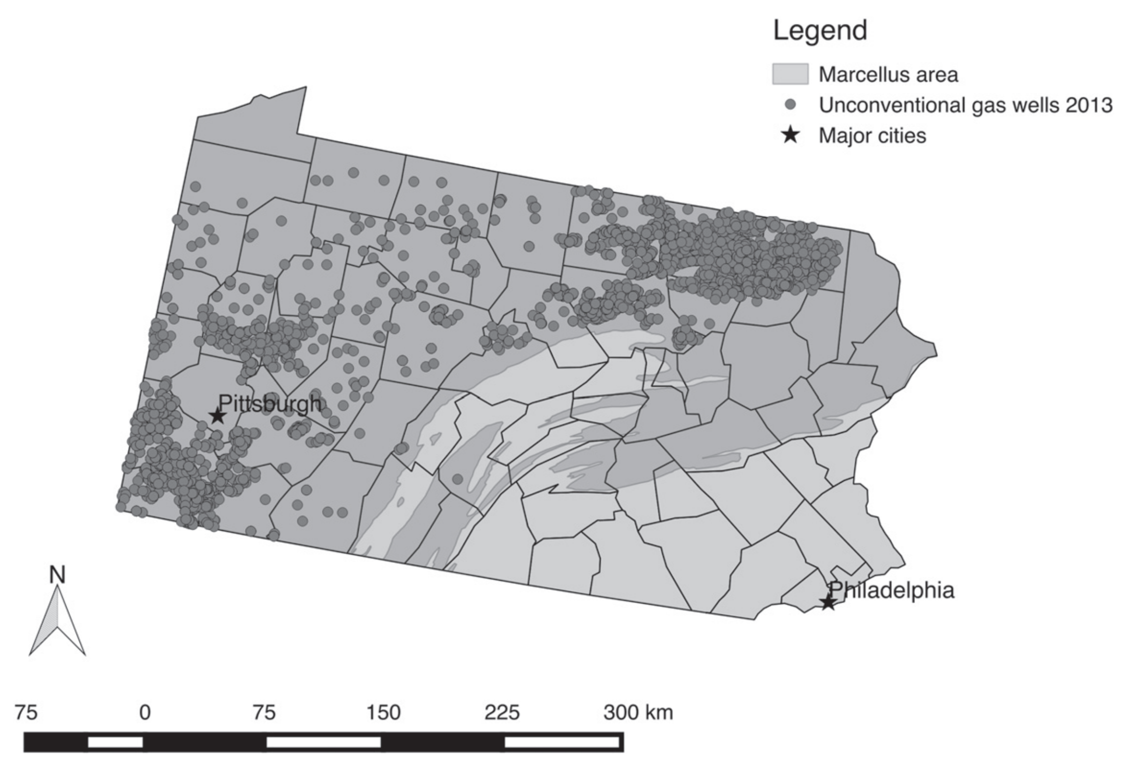

Figure 2. Unconventional wells in Pennsylvania, 2013.

Figure 2 shows the locations of wells in 2013 in Pennsylvania.

The rapid growth in the number of wells has been facilitated by pro-shale gas Governors, Ed Rendell (2003–11) and Tom Corbett (2011–15), who supported a permissive regulatory regime, which included a legislative attempt to prevent the use of local zoning regulations to impose limits on the location of well sites and kept the costs to operators low by imposing a per well impact fee rather than a traditional production tax (Navarro 2012). Corbett's failure to secure a second term has been blamed on his pro-industry stance with critics concerned about the failure to implement independent and systematic monitoring of the environmental and health effects of unconventional wells (Goldstein 2014). His successor, Tom Wolf, quickly imposed a moratorium on new leases in public parks and forests and has introduced proposals for a new severance tax and new environmental regulations (DiSavino and Goldberg 2015, Russ 2015).

Several recent studies might inform an environmental justice analysis of shale gas developments in Pennsylvania. Meng (2015) has examined the proximity of wells to urban areas and important infrastructure (roads, railways, rivers, wetland, open water) in Pennsylvania, with the aim of assessing the level of risk posed by shale gas development. His analysis identifies some geographical areas where we might be particularly concerned about the hazards associated with wells due to either the proximity of large numbers of people in urban areas (such as parts of Pittsburgh, Waynesburg, Connellsville–Uniontown, Monessen–California, and Fairdale) or the intensity of shale gas development (notably along the county boundary regions of Allegheny, Lawrence, Crawford, Cambria, and Monroe). These 'hot spots' might be understood as sites of rights-based environmental injustice: the populations of these areas suffer the hazards of shale gas development and some people in these areas may suffer significant harms. In another study, mentioned earlier, Ogneva-Himmelberger and Huang (2015) have examined traditional distributive environmental justice in Pennsylvania: they found no evidence of race-based environmental injustice but they found that unconventional gas wells are disproportionately located in areas with higher poverty rates.

Finally, there have been several studies that shed light on questions of benefit sharing distributive environmental justice in Pennsylvania. Wrenn *et al* (2015) found that the shale gas industry generated an overall employment increase of less than 20 000 by 2011 with less than half of those jobs (just over 7000) going to local residents. Kelsey and his colleagues have used data from income tax returns to consider whether counties with more shale gas development have enjoyed significant economic benefits (Kelsey *et al* 2012, Hardy and Kelsey 2015, Wrenn *et al* 2015). Their analysis (covering the years 2007–2010) suggests that the eight counties with 90 or more wells enjoyed an average 6% increase in total taxable income compared to an average 8.1% decline in total taxable income in the 32 counties without wells. This included a small increase in income from salaries and wages (1.5%) and a much larger increase in income from lease and royalty payments to owners of mineral rights (460.8% for all rents, royalties, patents and copyrights income). Unsurprisingly, rents and royalties increased significantly as a percentage of total taxable income in counties with 90 or more wells from 1.3% in 2004 to 8% in 2010 (Hardy and Kelsey 2015). However, Hardy and Kelsey (2015) found that fewer than 1 in 10 residents of counties with 90 or more wells who filed a tax return reported receiving rents, royalties, patents and copyright income. Moreover, in their study of land ownership (which they take as a proxy for ownership of mineral rights) in eleven counties with significant shale gas development, Kelsey *et al* (2012) found that more than 25% of land was owned by people living outside the county while almost 50% of land was owned by the top decile of local landowners. Their research strongly suggests that there is benefit sharing distributive environmental injustice: employment income and royalty payments are not likely to track proximity to the hazards of shale gas development.

3. Study design

In this study, we examine both traditional and benefit sharing distributive environmental justice. To do this, we compare the demographic composition of areas nearer and further away from gas wells before and after the wells were drilled (using 2000 US census and 2009–13 American Community Survey data[2]). Following most studies of traditional distributive environmental justice, we examine levels of poverty (as defined by the US government) and the racial composition of areas nearer and further away from gas wells. In addition, we examine income distribution and educational attainment data from 2000 and 2009–13. We used four categories for household income (less than \$20 000; \$20 000–\$39 999; \$40 000–59 999; and \$60 000 and above in 2000 and adjusted for inflation in the 2009–13 data) and five for educational attainment (some high school, high school diploma, some university, university graduate, and postgraduate) (Sicotte and Swanson 2007).

We use a buffer containment approach in which a buffer in the form of a circle of a given radius is drawn around each 'active' unconventional well (Chakraborty and Armstrong 1997). We distinguish units of residential land that are within the buffer zone of at least one well from units of residential land that are not within the buffer zone of at least one well. If the border of a buffer zone crosses a unit of residential land, the population within that unit of land is divided proportionally between inside and outside the buffer. We use buffers of radius 1 and 2.5 km around wells identified as 'ACTIVE' by the Pennsylvania Department of Environmental Protection[3] in 2013. We selected the buffers based on the results of environmental studies looking at air and water pollution as well as health effects from unconventional wells (Osborn *et al* 2011, Colborn *et al* 2012, Hill 2013). The method we use does not compare the intensity of well development in different areas. Therefore, it enables us to answer the question, 'Are there a disproportionate number of minority or low-income residents in areas near to unconventional wells?' but not the question, 'Are unconventional wells disproportionately located in minority or low-income communities?'(Ogneva-Himmelberger and Huang 2015).

One of the challenges that arises when examining questions of distributive environmental justice is deciding the geographic scale of the data to be examined. Most contemporary studies of environmental justice rely on census tracts or block group data. They examine the density of hazardous facilities and the demographic characteristics in a tract, usually making the assumption that those who live in a tract with a hazardous facility are exposed to that facility. This assumption works reasonably well in the context of urban areas where much environmental justice research has been conducted, as census tracts and block group areas are relatively uniform and small. It works less well in the geographic region we are studying. The areas of Pennsylvania lying over the Marcellus Shale are largely rural areas, where the largest census block group is just over 70 km^2. We know that some of these census block groups include large areas where no one lives and that some unconventional gas wells will be located in these areas away from communities. For this reason, we used a dasymetric mapping technique to remap the data onto areas which are populated (Mennis 2002, 2009). We used land use data from the PAMAP Program Land Cover for Pennsylvania 2005 to determine which areas are classified as residential land. This data was re-coded into simple binary: any area classed as residential, at any density, was distinguished from any area classed as non-residential land, including roads, water, farmland, and industrial[4]. The data was then converted from raster to polygon form. The demographic data from a census block group was projected onto each unit of residential land in that census block group; each unit of residential land being attributed a population reflecting its area as a proportion of the residential land in that census block group. This should give us a more accurate estimate of the geographic distribution of the population across Pennsylvania.

[2] The US census did not collect most of the community information of interest in the 2010 census, necessitating the use of the ACS.

[3] We used data from the Pennsylvania Oil and Gas Reporting Website. We used the Waste Reports for 2013, which provides the latitude and longitude of all gas wells, as well as their activity status and the amount of waste produced.

[4] Residential land includes all land coded as residential: 111–113, 1111–1113, 1121–1123, 1131–1133.

Table 1. Demographic characteristics inside and outside buffer zones 2000 census data.

	Within 1 km	Outside 1 km	Within 2.5 km	Outside 2.5 km
Poverty:				
Below poverty line	11.26%	11.13%	11.17%	11.14%
Race:				
Hispanic	0.45%	1.10%	0.53%	1.08%
Black	1.34%	5.22%	1.81%	5.13%
Income:				
up to \$19 999	25.57%	26.85%	26.29%	26.82%
\$20 000–39 999	30.46%	28.56%	30.37%	28.60%
\$40 000–59 999	21.51%	19.96%	20.92%	20.00%
\$60 000 up	22.47%	24.63%	22.42%	24.58%
Education:				
Some high school	18.75%	16.91%	18.52%	16.95%
High School	47.98%	41.55%	46.97%	41.71%
Some University	20.19%	21.95%	20.62%	21.91%
University	8.69%	12.44%	9.23%	12.35%
Postgraduate	4.40%	7.15%	4.67%	7.08%

Note: Using a t-test, all differences between inside/outside buffer zone statistically significant at $p < 0.05$ except 'below poverty line'.

Table 2. Demographic characteristics inside and outside buffer zones 2009–2013 American Community Survey.

	Within 1 km	Outside 1 km	Within 2.5 km	Outside 2.5 km
Poverty:				
Below poverty line	11.39%	12.39%	11.60%	12.40%
Race:				
Hispanic	1.10%	2.28%	1.06%	2.39%
Black	1.34%	4.48%	1.77%	4.72%
Income:				
up to \$24 999	22.12%	24.44%	23.19%	24.52%
\$25 000–49 999	27.91%	26.18%	27.37%	26.08%
\$50 000–74 999	20.49%	19.59%	20.46%	19.52%
\$75 000-	29.45%	29.76%	28.95%	29.85%
Education:				
Some high school	12.14%	10.37%	11.47%	10.29%
High School	47.07%	42.53%	46.58%	41.41%
Some University	24.07%	25.28%	24.20%	24.96%
University	11.39%	14.47%	11.89%	14.69%
Postgraduate	5.30%	8.39%	5.82%	8.61%

Note: Using a t-test, all differences between inside/outside buffer zone statistically significant at $p < 0.05$ except income category 75 000.

4. Results

Results from the 2000 census are presented in table 1; results from the 2009–2013 American Community Survey are presented in table 2.

4.1. Poverty

In 2000, we found that the percentage of those below the poverty line within the buffer zone was almost exactly the same as the percentage of those living outside the buffer zone. In the 2009–2013 data, we found that the percentage of those living below the poverty threshold was slightly lower in areas close to unconventional wells than in areas further away. This difference is small but statistically significant at $p < 0.01$ for both 1 and 2.5 km buffer zones.

4.2. Race

In both 2000 and the 2009–13 data, the percentage of blacks and Hispanics living in areas close to unconventional wells was much lower than it was further away.

4.3. Income

In 2000, the distribution of income was similar in areas close to unconventional wells and in areas further away. The clearest difference between those living inside and outside the buffer zones is in the highest income category: there is a higher percentage of people in the highest income category outside the buffer zones. This pattern is not apparent in the 2009–13 ACS data, where the percentage of people in the highest income category is very similar inside and outside the buffer zone. In the 2009–13 data, the clearest difference is that there is a higher percentage of those in the lowest income category outside the buffer zone than inside the buffer zone; this is particularly apparent for the 1 km case.

4.4. Education

In 2000, the percentage of people who received a high school diploma or less was much higher in the buffer zones than outside them; this was true for both 1 and 2.5 km buffer zones. Conversely, the percentage that had received an undergraduate or postgraduate degree is much higher outside the buffer zones than within the buffer zones. The pattern is similar in the 2009–13 ACS data. The likelihood of a university-level education was lower in areas close to unconventional wells than it was in areas further away with a 6% difference in the percentage of the population having studied at university-level. This difference was consistent across 1 and 2.5 km buffer zones.

5. Discussion

We find no evidence of traditional distributive environmental injustice. Our analysis of the 2009–13 ACS data shows that the proportion of people living below the poverty threshold was *lower* in areas close to unconventional wells than it was in areas further away. Similarly, the proportion of blacks and Hispanics was *lower* in areas close to unconventional wells than it was in areas further away. Our results are consistent with Ogneva-Himmelberger and Huang's (2015) findings on race but differ from their findings on poverty.

In our analysis of the 2009–13 ACS data, we did not find substantive differences between the income distribution inside and outside the buffer zones but we did find substantive differences between the likelihood of having a university-level education inside and outside the buffer zones. *Prima facie*, this is consistent with the claim that the shale gas industry has created highly paid jobs for manual workers and may be promoting benefit sharing distributive environmental justice. The Marcellus Shale Education and Training Center (MSETC 2011) estimates that only 9% of jobs on well sites in Pennsylvania require a four year degree and the US Bureau of Labor Statistics estimates the average wage in the oil and gas industry in Pennsylvania as $82 974 in 2012, much higher than the average Pennsylvania wage of $48 397 in 2012 (Cruz *et al* 2014).

However, we have seen that other research suggests that only a small proportion of jobs in the shale gas industry in Pennsylvania are filled by local people (Wrenn *et al* 2015). Our comparative analysis of 2000 census data and 2009–13 ACS data shows that the shale gas 'boom' did not transform the demography of communities in the areas where unconventional wells have been developed. The patterns of income and educational attainment inside and outside buffer zones were very similar in the two periods. This suggests that the relationship between level of education and income in the 2009–13 data is probably not explained by the shale gas industry providing a large number of well paid jobs for manual workers living near to well sites. Instead, this relationship is a longstanding feature of the demography of these areas and there is no evidence that there have been widely diffused benefits for people living near well sites.

However, the small but notable differences between 2000 and 2009–13 at the poverty threshold and in the lowest and highest income categories suggest that there may have been minor economic improvements at both ends of the income distribution inside the buffer zones. This appears consistent with the findings of Kelsey and his colleagues: a small number of landowners with mineral rights may have moved into the highest income category as a result of lease and royalty payments; and very limited diffusion of the economic benefits of shale gas development in communities closest to well sites may have helped to raise a small proportion of the worst off above the poverty threshold and out of the lowest income category (Hardy and Kelsey 2015). Unfortunately, there may be good reason for thinking that even this very limited diffusion of the benefits of shale gas development to the worst off in communities closest to well sites will be short-lived. The shale gas industry creates jobs—and brings well paid workers into an area—during the drilling phase not the processing phase so we might expect even more limited direct and indirect employment effects in the coming years as fewer new wells are drilled (MSETC 2011). In sum, our analysis is consistent with the claim that the shale gas industry in Pennsylvania creates benefit sharing distributive environmental *in*justice: the income distribution of the population living closest to shale gas wells has not been transformed, which suggests that the economic benefits of shale gas production are probably not concentrated among those living with its hazards.

6. Conclusion

This letter is the first analysis of unconventional gas developments in Pennsylvania to examine both traditional and benefit sharing distributive environmental justice. Our analysis of 2009–13 ACS data indicates no evidence of traditional race- or poverty-based distributive environmental injustice. However, our comparative analysis of 2000 census data and 2009–13 ACS data is consistent with the claim that many people who live close to well sites do suffer benefit sharing distributive environmental injustice: they suffer the hazards associated with proximity to well sites but are not enjoying substantial economic benefits from shale gas development.

Research on environmental justice and unconventional gas developments in Pennsylvania (and elsewhere) is at a very early stage of development. There are other important questions about distributive environmental justice that we have not addressed: Is the intensity of shale gas developments greater in areas where there is a higher percentage of the population in the lowest income categories? Precisely how are the benefits of shale gas developments distributed among those living closer to gas wells? There is also important research to be done on rights-based environmental justice: Who is actually harmed, and in what ways, by shale gas developments? Finally, there are important questions about procedural environmental justice. Our analysis of 2000 census data *prima facie* suggests that low income communities have not been disproportionately targeted by shale gas developers (Apple 2014). If this is correct, it may be a consequence of the permissive regime adopted at state level, which limited the ability of more affluent and better organized communities to prevent shale gas developments near to them. If the regulatory regime becomes less permissive under Governor Wolf's administration, it will be important to consider whether procedures for licensing developments make it more difficult for low income communities to resist shale gas development than it is for more affluent communities.

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