The Extractive Industries and Society xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

The Extractive Industries and Society

journal homepage: www.elsevier.com/locate/exis

Review article

A decade of Marcellus Shale: Impacts to people, policy, and culture from 2008 to 2018 in the Greater Mid-Atlantic region of the United States

Jeffrey B. Jacquet[a,*], Anne N. Junod[a], Dylan Bugden[b], Grace Wildermuth[c], Joshua T. Fergen[a], Kirk Jalbert[d], Brian Rahm[b], Paige Hagley[a], Kathryn J. Brasier[c], Kai Schafft[c], Leland Glenna[c], Timothy Kelsey[c], Joshua Fershee[e], David L. Kay[b], Richard C. Stedman[b], James Ladlee[c]

[a] Ohio State University, 2021 Coffey Road, Suite 210, Columbus, OH, 43210, United States
[b] Cornell University, 111 Fernow Hall, Ithaca, NY, 14853, United States
[c] Pennsylvania State University, 105-B Armsby University Park, PA, 16802, United States
[d] Arizona State University, PO Box 875603, Tempe, AZ, 85287-5603, United States
[e] West Virginia University, 101 Law School Drive, Morgantown, WV 26506 United States

ABSTRACT

It's been just over a decade since Unconventional Oil and Gas development began in earnest in the Marcellus Shale, a dense shale formation that, along with the deeper and larger Utica Shale, covers much of the mid-Atlantic United States. Since January 2008, approximately 15,939 wells have been drilled and fracked at 5674 sites across these shales. This decennial documents the pace, scale, and stages of actual development and takes stock of the social science on impacts to communities, people, policies, and culture. We have divided this article into the following sections that are categorized both geographically and thematically: Pennsylvania: Heart of the Marcellus Shale Play, focuses on the plethora of social science research that has occurred on impacts to Pennsylvania communities, health, economics, and agricultural production; West Virginia and Ohio: Legacies of Extraction discusses research on the overlapping historical legacies of extractive industries in the region and details results of original research examining perceived impacts to residents amid complex historical natural resource lineages; and New York: Fracking, Culture and Politics examines how the regulatory process to develop the Marcellus Shale affected both the state and nation's culture, politics, and policy as one of the most densely populated regions of the US came to grips with hosting the modern-day Oil and Gas Industry. We conclude with a discussion of emerging research opportunities and directions as a new generation of social scientists document future development in the Marcellus and Utica Shales.

It's been just over a decade since Unconventional Oil and Gas development began in earnest in the Marcellus Shale, a dense shale formation that, along with the deeper and larger Utica Shale, covers much of the mid-Atlantic United States (see Fig. 1). Since January 2008, approximately 15,939 wells have been drilled and fracked at 5674 sites across these shales, with 11,037 wells drilled in Pennsylvania (PA DEP, 2018), 2528 in West Virginia (WV DEP, 2018), 2374 in Ohio (ODNR, 2018), 9 in Maryland (FracTracker, 2017), and 9 in New York (NY DEC, 2018) (see Table 1)[1], producing more than 41,675,025 MMcf of natural gas (15% of national consumption during that period) as well as billions of barrels of natural gas and oil liquids (US EIA, 2018). It is a major and controversial activity that has unfolded across a vast and densely populated region.

This decennial documents the pace, scale, and stages of actual development and takes stock of the social science on impacts to communities, people, policies, and culture. We have divided this article into the following sections that are categorized both geographically and thematically: Pennsylvania: Heart of the Marcellus Shale Play, focuses on the plethora of social science research that has occurred on impacts to Pennsylvania communities, health, economics, and agricultural production; West Virginia and Ohio: Legacies of Extraction discusses research on the overlapping historical legacies of extractive industries in the region and details results of original research examining perceived impacts to residents amid complex historical natural resource lineages; and New York: Fracking, Culture and Politics examines how the regulatory process to develop the Marcellus Shale affected both the

* Corresponding author.
E-mail addresses: jacquet.8@osu.edu (J.B. Jacquet), Junod.6@osu.edu (A.N. Junod), Deb325@cornell.edu (D. Bugden), Gvw5117@psu.edu (G. Wildermuth), Fergen.1@osu.edu (J.T. Fergen), kirk.jalbert@asu.edu (K. Jalbert), bgr4@cornell.edu (B. Rahm), hagley.6@osu.edu (P. Hagley), kbrasier@psu.edu (K.J. Brasier), kas45@psu.edu (K. Schafft), llg13@psu.edu (L. Glenna), tkelsey@psu.edu (T. Kelsey), joshua.fershee@mail.wvu.edu (J. Fershee), dlk2@cornell.edu (D.L. Kay), rcs6@cornell.edu (R.C. Stedman), jladlee@psu.edu (J. Ladlee).

[1] Approximate as of May 15th, 2018. Irregularities exist within and across the state-level datasets. Numbers reflect all unconventional wells that were drilled, including those later capped or plugged. Well database entries with identical location data were treated as one well. Wells within 250 feet of each other were considered to be on one well pad.

https://doi.org/10.1016/j.exis.2018.06.006
Received 15 March 2018; Received in revised form 5 June 2018; Accepted 7 June 2018

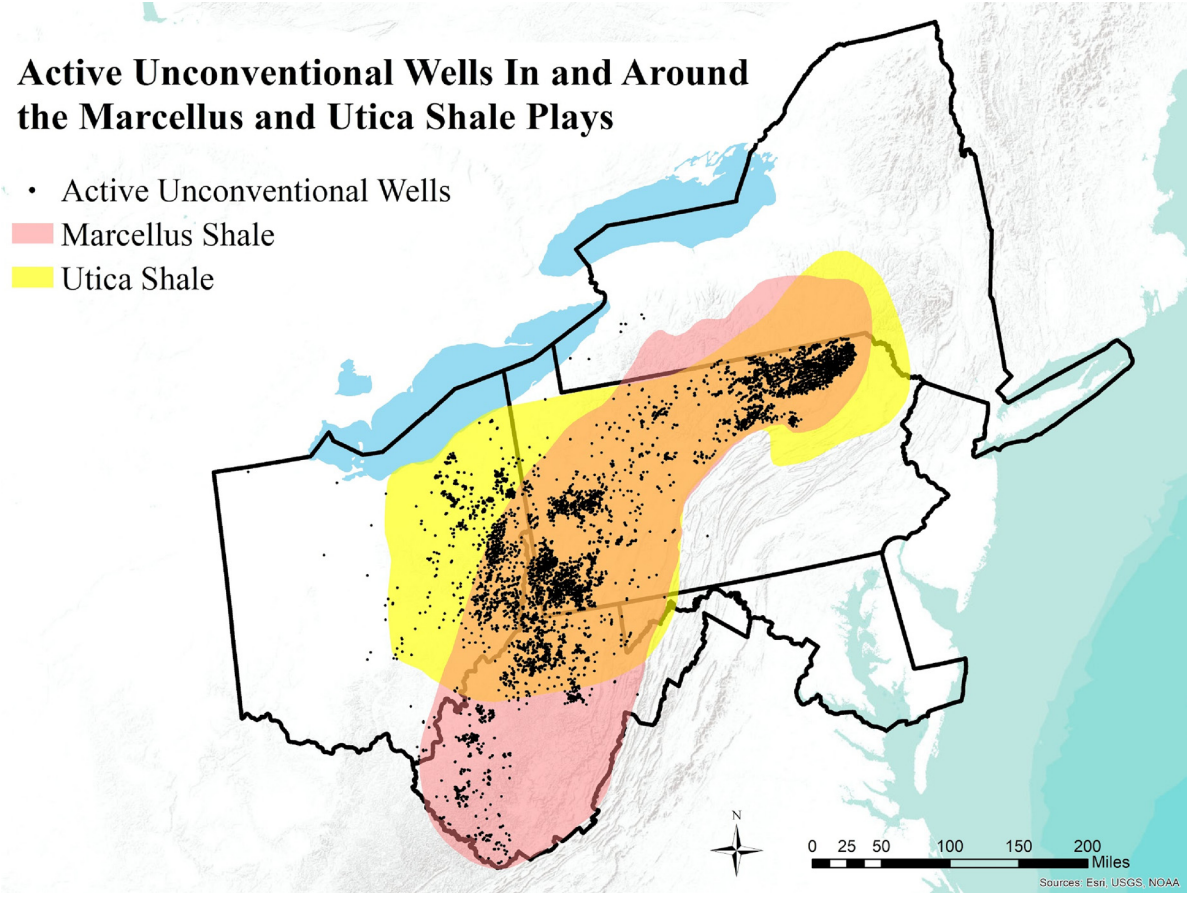

Fig. 1. Spatial distribution of unconventional wells. 2008–2018.
Sources: PA DEP, 2018; WV DEP, 2018; ODNR, 2018; FracTracker, 2017; NY, DEC, 2018.

Table 1
Number of Unconventional Wells Drilled and Number of Well Pads by State, January 1st 2008 to May 15th 2018.
Sources: PA DEP, 2018; WV DEP, 2018; ODNR, 2018; FracTracker, 2017; NY, DEC, 2018.

	Ohio		West Virginia		Pennsylvania		Total Region	
	Pads	Wells	Pads	Wells	Pads	Wells	Pads	Wells
1 well pad	557	557	763	763	1278	1278	2598	2598
2 well pad	175	350	119	238	571	1142	865	1730
3 well pad	116	348	70	210	371	1113	557	1671
4 well pad	95	380	66	264	362	1448	523	2092
5 well pad	42	210	40	200	215	1075	297	1485
6 well pad	49	294	49	294	275	1650	373	2238
7 well pad	16	112	24	168	117	819	157	1099
8 well pad	12	96	17	136	84	423	113	655
9 well pad	3	27	7	63	47	672	57	762
10 well pad	0	0	14	140	39	390	53	530
11 well pad	0	0	2	22	22	242	24	264
12 well pad	0	0	0	0	24	288	24	288
> 12 Well Pad	0	0	2	30	31	497	33	527
Totals	1065	2374	1173	2528	3436	11037	5674	15939

state and nation's culture, politics, and policy as one of the most densely populated regions of the US came to grips with hosting the modern-day Oil and Gas Industry.

We conclude with a discussion of emerging research opportunities and directions as a new generation of social scientists document future development in the Marcellus and Utica Shales. Shale energy is still a relatively young industry in the Mid Atlantic, and production has overall been constrained by infrastructure limitations. Indeed, orders of magnitude more recoverable natural gas is thought to remain in the Marcellus and Utica. As new processing facilities, factories, and gas fired electrical generators come online, industry and political representatives have begun to tout the Appalachian Basin as the next petrochemical corridor (Commonwealth of Pennsylvania, 2017; AFPA, 2018).

1. Introduction

The Mid-Atlantic region is home to some of the most densely and diversely populated areas of the US, ranging from the 50 million people who live in the Northeast Megalopolis that includes New York City, Philadelphia, Baltimore, and Washington D.C., to the collection of large- and medium-sized cities that includes Pittsburgh, Albany, Scranton and many others. Yet the majority of land in these states is rural, with many small towns and hamlets in the rolling mountains of the mid-and-northern Appalachian Range. Similar to many areas of the US in past decades, the rural areas of this region are experiencing extended trends of economic contraction, outmigration, and aging populations (ARC, 2017; Alter et al., 2007; Thomas and Smith, 2009).

Many of these communities have historically been dependent in one way or another on energy extraction economies, including oil, coal, and gas resources. Native Americans in the Mid-Atlantic region have utilized naturally occurring oil and natural gas deposits for centuries. The world's first commercial natural gas well was dug in northwest New York in 1821 and the world's first producing oil well was drilled in northwest Pennsylvania in 1859 (Dolson, 1959; Black, 2003). Mass

production of both commodities boomed in the 1800 s, with the nascent industry quickly spreading westward sprouting up oil boomtowns from Oil Springs, Texas to Wizbang, Kansas (Grann, 2017). While modest production from these historic fields in the Mid-Atlantic continues today, the oil and gas industry had not been a major fixture of life in this region for the better part of a century.

By the late 1990 s and early-to-mid 2000 s, the US oil and gas industry successfully employed new advances in horizontal and directional drilling technologies and well stimulation using high-volume hydraulic fracturing across much of the American West in states like Texas, Oklahoma, Utah, Colorado, New Mexico and Wyoming *(See other articles in this issue)*. With these new technologies proving viable, emerging geological analyses positioned the Mid-Atlantic Marcellus and Utica shales as not only accessible for development but perhaps two of the largest Natural Gas reserves worldwide. The Marcellus alone was estimated as yielding 489 TCF of recoverable gas, or roughly enough to satisfy about two decades of natural gas demand in the U.S. (Coleman et al., 2011; Engelder, 2009; Vidic et al., 2013; U.S. EIA, 2012). Early boosterism-style economic studies borrowed from the experience of the Dallas Fort Worth region to estimate Texas-sized effects on regional employment (Considine et al., 2009; Weinstein and Clower, 2009) and by the mid to late 2000 s, the region seemed on the brink of what appeared to be an unprecedented economic windfall (Harper, 2008; Waples, 2012). Yet few people outside remote western boomtowns like Vernal, Utah or Pinedale, Wyoming were acquainted with “fracking” or the modern day Oil and Gas industry (e.g. Kenwood, 2006). Social scientists in the Mid-Atlantic region looked to research on these western energy boomtowns for guidence on what impacts to expect in the Marcellus, although differences in geography and population density left uncertainty to the degree of transferability (Brasier et al., 2011; Jacquet and Kay, 2014).

By 2004, shale wells across West Virginia and southwest Pennsylvania had begun to be drilled; however, it wasn’t until energy prices contracted during the great recession of 2008–2010 that much of the industry began to focus on securing the rights to produce shale energy in northern Pennsylvania and New York: energy companies scrambled and jockeyed for valuable landholdings and production units based on a rapidly emerging understanding of geology and engineering capability (Grace, 2008; Chesapeake Energy, 2013). Land professionals, attorneys, and landowner coalitions enrolled tens of thousands of landowners under leases for potential development, and energy firms organized these contracts into valuable packages of drilling rights with huge production potential (Wilber, 2008; Jacquet and Stedman, 2011).

The industry then went to work moving hundreds of drilling rigs and thousands of workers from western states into Pennsylvania, West Virginia, and Ohio to secure those leases into near-perpetuity, demonstrate the resource potential to market investors and earn revenue from the sale of the gas. The average number of active drilling rigs in the region was 56 in 2008, 69 in 2009, 113 in 2010, 140 in 2011, 128 in 2012, 119 in 2013, 124 in 2014, 85 in 2015, 44 in 2016, 70 in 2017, and 77 so far in 2018 (US EIA, 2018). In response to queries from landowners, university extension educators in Pennsylvania, New York, West Virginia, and Ohio hosted community forums and offered printed information on drilling to local residents (e.g. Brasier et al., 2009; Campbell and Hogan, 2013; Weidner, 2013; Cox and Fershee, 2015).

Favorable economic and environmental impact assessments of the new industry were partially predicated on the ability to drill as many as dozens of wells on single pad as a mitigation against environmental disturbance. A few years into the development Ladlee and Jacquet (2011) noted that, in practice, the average number of wells per pad was only a little more than 2, although they assumed the average was poised to increase as operators returned to these pads to drill additional wells. In 2018, a re-running of Ladlee and Jacquet’s analysis here reveals that the per-pad well average in Pennsylvania has increased only modestly to 3.2, while the averages in Ohio and West Virginia are 2.2 and 2.1, respectively (Table 1). Whether operators eventually do fully develop those pads remains to be seen (a handful of Pennsylvania sites do have as many as 38 wells). Yet, 10 years into the development of the Marcellus shale, the original dream of multi-well pad development remains largely unrealized.

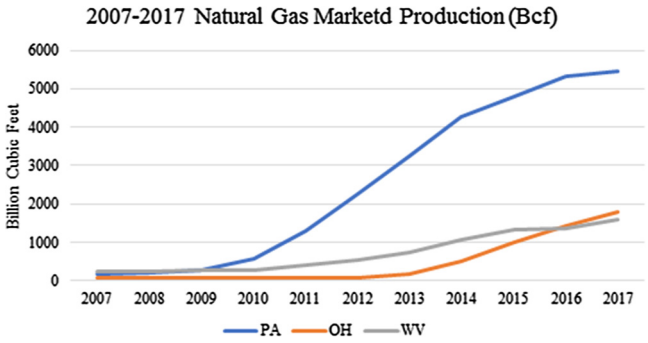

Fig. 2. Total Natural Gas Production from Pennsylvania, Ohio, and West Virginia 2007-2017. (US EIA, 2018).

From west to east, the geology of the Marcellus and Utica shale plays permits petroleum production throughout much of eastern Ohio and both wet and dry gas production in western Pennsylvania, eastern Ohio, and West Virginia, and dry gas in central and northeastern Pennsylvania, western Maryland, and New York (Staub, 2015; US EIA, 2017a). Wet gas, which includes natural gas liquids like ethane, propane, butanes, and natural gasoline, have been targeted in recent years because they usually bring a price premium over dry natural gas. (US EIA, 2014). Since 2011, continued advances in unconventional oil and gas development improved the economic viability of drilling in the deeper and liquids-rich Utica shale, contributing to significant increases in oil and gas production across Ohio and West Virginia (Fig. 2).

2. Pennsylvania: heart of the Marcellus Shale

Research on community impacts has largely focused on population change, residents’ views of the development activity and its perceived impacts on the community, and community services and infrastructure. Early analyses of population change indicated that in most Pennsylvania counties experiencing shale development, resident population (as measured by the decennial US Census and the American Community Survey) showed relatively little change in trajectory (McLaughlin et al., 2014). Counties experiencing population loss or gain prior to shale development (between the 2000 decennial Census and the 3-year ACS estimate 2005-7) continued those patterns in the period of rapid shale development (2010 Census). The exception to these trends was found in Bradford County, PA, the only county studied by McLaughlin et al (2014) that indicated a population turnaround, from population loss to population gain during this same period. Qualitative analyses (e.g., Brasier et al., 2011, Williamson and Kolb,2011) indicate the likely undercount of temporary and transient residents associated with the industry, and suggest that other tools and data sources (e.g., housing occupancy surveys, hotel occupancy counts, housing permits, etc.) need to be examined to more accurately assess population fluxes associated with the industry.

Population pyramid analyses of gender and age ratios indicate slight growth in some counties of younger men, consistent with the employee profile of the oil and gas industry. Filteau’s work (Filteau, 2014, Filteau, 2015a, 2015b) indicates that the workers are not only predominantly male, but bring with them a type of masculinity focused on breadwinning, which separates them from their families and creates hardships, which may influence the type of behavior they practice in local communities. He further argues that this form of masculinity threatens the dominant masculinities in rural communities experiencing decline of extractive and manufacturing economies, further exasperating conflicts among newcomers and long-term residents.

School districts are often focal points of impacts of development, as they potentially need to integrate students and serve families from differing cultural and economic backgrounds, address local social conflict that may arise from rapid community change, and adjust curriculum to prepare students for new economic opportunities (Schafft et al., 2012). Yet school districts have no local taxing authority to adjust and respond to changing student needs (Kelsey et al., 2012a). Analyses of quantitative data on school enrollment show relatively little aggregate change in Pennsylvania school districts affected by shale development (Schafft et al., 2013a, 2013b), yet qualitative data from school district personnel indicate the need to respond to both the risks associated with community change and the economic opportunities for student employment and skill development. Studies of youth perspectives on shale development offer mixed results. Schafft and Biddle (2013) find youth focus groups express concern about both environmental and social changes occurring in their communities, and skepticism that they would want to pursue jobs in the industry because of safety and travel requirements. However, McLaughlin et al (2017), in their longitudinal study of rural youth in Pennsylvania find that students in shale-affected school districts are more optimistic about the future of their communities.

One of the earliest studies qualitatively assessed residents' views on the beginning stages of shale development, and suggested that residents were excited about the potential economic activity in regions that had been in decline, but concerned about the potential community and environmental impacts (Brasier et al., 2011). Additional studies examined views of residents quantitatively, finding that perceived risks of development are tied closely to the degree of trust in the natural gas industry (Brasier et al., 2013). In these early stages, views of development vary across the region, with residents in the southwestern part of Pennsylvania reporting greater familiarity overall with oil and gas extraction (Brasier et al., 2011). Residents in the Northern Tier report the highest levels of support for development; this stands in stark contrast to the residents in New York, with the strongest levels of opposition (Stedman et al., 2012) (Table 2).

Though residents indicate optimism about the economic opportunities and futures for their communities because of shale development, they also report concerns about environmental impacts (drinking water and water quality), community relationships, quality of life (particularly traffic, noise, and safety), housing availability and affordability, and community services (e.g., emergency, government, education) (Brasier et al., 2011, 2014; Stedman et al.,2012). Results from a 2015 survey (Brasier et al., 2017) similarly indicates both optimism for the future and overall substantial support for development (nearly 60% indicating support for development) but continued concerns about certain issues. These concerns include roads and traffic, though respondents also reported that the gas companies had improved road quality, and heightened concerns about drug and alcohol abuse in their communities related to shale development. In addition, inequality among community members arose as a concern in this latter survey (Brasier et al., 2017). (Additional research on environmental inequality has also raised concerns about the degree to which the benefits of development are shared by those close to wells; see Clough and Bell, 2016.) These views also vary across the counties studied, with Greene County (in the southwest corner of Pennsylvania) consistently reporting the most negative community and environmental impacts, and the two more urban counties (Lycoming and Washington) reporting the most positive overall impacts. Individual responses were more positive for those with the ability to economically benefit through holding a lease, having a household member employed in the industry, or owning their homes (consistent with findings from Jacquet, 2012, Cooley and Casagrande, 2017 Northern Pennsylvania surveys), men, and those with higher incomes.

Among the top concerns expressed by residents are crime, traffic and safety. Several reports and publications have examined these issues, finding relatively little overall change in crime with the exception of minor increases in arrests for driving under the influence and disorderly conduct in counties experiencing higher numbers of shale wells (Brasier and Rhubart, 2017). Qualitative studies indicate law enforcement agencies in the highest activity counties (including Pennsylvania State Police, county, and local agencies) have been stretched thin by increased monitoring of both traffic and criminal activity (Brasier and Rhubart, 2017; Brasier and Rhubart, 2014). Transportation safety issues are a primary concern given the number of heavy truck loads needed to drill and complete each shale well. The most rural counties in the Northern Tier of Pennsylvania with the highest number of wells experienced more crashes, especially heavy truck crashes, in 2010 and 2011, when the activity was at its height. When activity decreased in the following two years, the number of crashes declined (Brasier, 2017, Graham et al.,2015). Abramzon et al. (2014: 4) estimated that the costs of roadway maintenance from increased truck traffic on state roads in 2011 to be about $13,000–$23,000 per well.

Table 2
Support and Opposition to Shale Development by Region and State (2010). Data Source: Willits et al., 2010.

	Oppose	Neither Oppose nor Support	Support
North Central Pennsylvania (Lycoming, Tioga, Bradford, Sullivan)	15%	26%	60%
Northeastern Pennsylvania (Susquehanna, Wyoming, Lackawanna, Wayne)	24%	27%	49%
Southwest Pennsylvania (Washington, Greene, Fayette, Westmoreland, Indiana	20%	34%	45%
Central Pennsylvania (Clearfield, Centre, Cameron, Clinton)	19%	37%	45%
Alleghenies Pennsylvania (Somerset, Cambria, Blair, Bedford)	13%	44%	43%
New York (Broome, Chemung, Delaware, Schuyler, Steuben, Sullivan, Tioga, Tompkins)	31%	30%	39%
Total	**22%**	**33%**	**45%**

2.1. Agricultural impacts

Uncertainty remains surrounding the effects of shale development on agriculture, especially as some may materialize slowly over time. Marcellus developments affect agriculture directly through the conversion of farm land to gas-drilling land, such as creating roads, clearing areas for well pads and equipment, and establishing pipeline corridors (Adams and Kelsey, 2012, Glenna et al., 2014). Furthermore, pollution from drilling sites could contaminate fields and water that are necessary for crop and animal production (Olmstead et al., 2013, Bamberger and Oswald, 2012). Development could also affect agriculture indirectly as some landowners profit from leasing and royalty payments, farmers may pay off loans, buy new equipment, and expand their operations. Although this seems positive at first glance, there are some potential negative outcomes to agricultural production. Appreciation from higher land values could hinder generational land transfer, lead to many farm exits for those not receiving royalty and lease payments, and foster concentration of land holdings into fewer hands (Weber et al., 2016; Weber and Hitaj, 2015). Some farmers may use the new revenues to transition from labor-intensive farming, such as dairy, to less labor-intensive production, such as beef and crops (Adams and Kelsey, 2012, Glenna et al.,2014). Finally, some residents in areas with heavy Marcellus development have stated that farmers must compete with the gas industry for inputs, such as straw, grass seed, fertilizer, equipment, labor, and land (Glenna et al., 2014).

Using National Agricultural Statistics Service (NASS) data on number of dairy cows in Pennsylvania, Adams and Kelsey (2012) found

that intensity of gas drilling and decline in dairy cow numbers seem to be associated. However, they caution that the data do not allow them to do more than speculate on the nature or direction of that association. Finkel et al. (2013: 189) conducted a similar study and found that, "Milk production and milk cows decreased in most counties after 1996, with larger decreases occurring from 2007 through 2011 (when unconventional drilling increased substantially) in five counties with the most wells drilled compared to six adjacent counties with fewer than 100 wells drilled." Like Adams and Kelsey (2012), the authors caution that these are findings from a descriptive study that has not established causation.

Focusing on county-level data in four rural Pennsylvania with substantial Marcellus gas activity, Glenna et al. (2014) found no clear patterns in land-use change, land concentration, farm numbers, or other factors. However, consistent with Adams and Kelsey (2012); Glenna et al. (2014) found a pronounced decline in dairy cow inventory in the four counties with heavy gas activities.

Although Marcellus gas development affects a substantial portion of Pennsylvania, it also extends into other states, most notably West Virginia, Ohio, and New York. Since New York has Marcellus gas reserves but hasn't allowed extraction in the state, Hoy et al. (2018) used a quasi-experimental design to examine the impacts of Marcellus development on 18 agricultural variables in Pennsylvania, Ohio, and West Virginia while using several New York counties and some counties in the other the states as a controls. Although they did not find significant changes in the number of farms or land in farms in drilling counties in Pennsylvania, Ohio, and West Virginia relative to non-drilling counties, they did find "an increase in median farm sizes, indicating potential consolidation in drilling counties" (Hoy et al., 2018: 1) The study also found a link to a decline in beef farms. They found other patterns of influence, but those patterns were not statistically significant. They conclude that individual-level information is needed to make firmer conclusions and that the many factors influencing agricultural transitions need to be understood to fully capture the influence of Marcellus development relative to other factors (Hoy et al., 2018).

2.2. Health impacts

Despite considerable national concern for the public health effects of unconventional shale gas development, limitations on data availability has served as a challenge for researchers. Even so, a number of studies on public health effects of Marcellus Shale development in Pennsylvania have begun to shed light on the topic using self-report health surveys and secondary data. Through a series of interviews conducted over time in Pennsylvania, Ferrar et al. (2013) documented the self-reported health impacts and stressors perceived to result from proximity to development. The most frequently-reported symptom: stress, which remained constant over the course of the study (2010–2012). Perceived health impacts increased over time, with nearly sixty unique health impacts reported in total. Similarly, a self-reported health survey was conducted in Washington County, Pennsylvania with 180 randomly selected households with ground-fed wells in areas of active drilling (Rabinowitz et al., 2015). They found that skin conditions and upper respiratory conditions were both more likely to be reported in households nearer to a gas well than those farther away, with the total number of reported health symptoms per person also greater in close proximity to a well. Both of these studies rely on self-reported data, and call on exposure-based epidemiological studies to test their findings. While research on health impacts has remained limited, numerous articles have documented impacts to mental health perhaps the most widely noted health impact caused by hydraulic fracturing, including stress and other types of psychological disruptions as residents and workers contend with rapid and dramatic changes to their lives (Hirsch et al., 2017; Jacquet, 2014).

In addition to health symptoms, researchers have also examined effects of Marcellus Shale development on health care access and utilization (Monnat et al., 2017, Davis et al., 2014). Employing a variety of secondary data sources, Monnat et al compared health indicators between counties by development level (2017). They found that the percentage of adults without health insurance increased less in counties with wells than those without. However, for poor children particularly, the percentage without health insurance showed greater decline in counties with no wells. Hospitalizations for respiratory and digestive symptoms increased in counties with the most wells, while they declined in those without wells. The authors emphasize that the aggregate results could be masking spatial variations in health indicators, and again call for further research on the topic.

In addition to the research presented here, concerns about public health related to Marcellus Shale development have been documented by state and national advisory committees, but researchers have noted the lack of individuals with health expertise present within these groups (Goldstein et al., 2012). This suggests a future imperative not only for more systematic population-based studies on the public health effects of Marcellus Shale development, but for pathways to emerge to connect this research to public policy and shale gas governance.

2.3. Economic impacts and impacts to inequality

Much of the political and business interest in Marcellus shale development has focused on the economic impacts, with industry groups, politicians, and others touting the employment and wage benefits accruing from the activity. Yet, economic research on available employment statistics is mixed, with some studies showing no measurable impact (Cosgrove et al., 2015; Munasib and Rickman, 2015; Paredes et al., 2015; Weinstein and Partridge, 2011) and other studies finding some impact but less than often touted. For example, Wrenn et al (2015) found a modest positive effect on local employment, while Komarek (2016) found gains to employment and wages in the years following the start of drilling. The main conclusion that can be drawn from employment data is that for local residents the employment effects are relatively small and temporary, in large part because much of the employment benefits from the activity goes to workers living outside the host communities (Wrenn et al., 2015).

Locals benefiting from Pennsylvania's gas boom included younger residents who possessed the skills, experience and qualifications to take on jobs in well pad and pipeline construction, drilling, and heavy equipment and vehicle operations (Brundage et al., 2011; Brasier et al., 2011, Waples, 2012; Wilber, 2012). For example, local residents with commercial driver's licenses, experience with operating heavy machinery or with welding experience and certifications were more favorably positioned to take advantage of new job opportunities. The shale gas industry is gendered, with most of the high salaried employment available to men rather than women. As a consequence, shale gas related opportunities available to most women often were in clerical support positions or in service industries in one way or another supporting the gas industry (McHenry-Sorber et al., 2016).

Development in the Marcellus and Utica remains unprecedentedly dependent on the cooperation of private landowners to allow development on their land and created new opportunities and wealth in the form of leases and royalties for landowners (Considine et al., 2010; Costanzo and Kelsey, 2012; Hardy and Kelsey, 2015; Kinneman, 2011; Schafft et al., 2013a, 2013b). Those who owned especially large tracts in key drilling areas could sometimes command thousands of dollars per acre in leasing income, supplemented by signing bonuses and additional royalties on production (McGraw, 2011).

Hardy and Kelsey (2015) found very positive impacts on taxable income of local residents, which could not be explained by relatively modest local employment and salary impacts. In two of the highest drilling activity counties, for example, total taxable income increased by more than 19% between 2007 and 2010, while statewide such income decreased by 5% during the same time period. In some regions of Pennsylvania, collective bargaining through landowner coalitions

played a prominent role in leasing conditions, and generally resulted in better lease terms, bonus payments, and royalty percentages on average than did individuals operating within the same context (Wildermuth, 2018).

However, there has been little attention to the distribution of the economic impacts. Kelsey et al. (2012a, 2012b) considered land ownership patterns, and found that about half of lease and royalty dollars will go to the top 10% of local landowners by acreage, while the bottom 70% of landowners will collectively receive 2.8% of all such dollars. Of course, the vast majority of local residents were not rural landowners and thus were unable to take advantage of gas leasing for revenue (Kelsey et al., 2012a, 2012b). The biggest issue for many economically vulnerable residents came in the form of radically tightening housing markets, coupled with skyrocketing housing costs and shrinking availability (Fernando and Cooley, 2016; Ryser and Halseth, 2011; Schafft et al., 2017). The in-migration of workers not only increased the demand for rental housing, but their salaries commanded a purchasing power that most local renters were unable to match (Williamson and Kolb, 2011). Communities in the center of the drilling activity experienced three- or fourfold rental increases over a several year period, residentially displacing low-income persons. Some worker dormitories were constructed by gas industry interest, but these “man camps” as they are colloquially known, did relatively little to offset the demand for housing.

In ethnographic work conducted across four highly impacted counties in Pennsylvania, of 39 low-income respondents interviewed, 16 were either homeless at the time of the interview, or had been homeless within the five years preceding the interview. Two respondents had not experienced homelessness, but described needing to change residences because of circumstances they associated with the gas industry. Eight of the 16 respondents who described experiencing homelessness also described residential displacement they directly or indirectly attributed to the gas industry (McHenry-Sorber et al., 2016).

These observations raise important questions regarding how new or more deeply entrenched forms social and economic vulnerability may arise from strains on housing and other infrastructure, coupled with the bifurcated nature of labor markets. Especially at issue for both researchers and policy makers is how vulnerability often intersects with a variety of individual and household-level characteristics, including those that are demographic, gendered, spatial, and economic.

2.4. Challenges to municipal authority

Pennsylvania has served as a battleground over unconventional development regulatory jurisdiction. The 1984 Pennsylvania Oil and Gas Act generally empowered the state with regulatory authority over oil and gas activities and pre-empted the authority of municipalities (as established through the Commonwealth’s *Home Rule Charter*), although some exceptions existed. As contention grew over the question of state or local control, Governor Corbett signed the *Pennsylvania Gas Well Impact Fee Act* (also referred to as *Act 13*) in February 2012 (Davis, 2014). *Act 13* introduced a per-well fee, charged to energy operators at the time the well is drilled, as opposed to a severance tax found in most other states that is levied on the value of natural gas produced. The fee revenues are then distributed by the Public Utilities Commission with approximately 40% of the revenue allocated for statewide uses and 60% distributed to local governments “to defray both developmental and environmental costs, including water needs, road maintenance, emergency preparedness, and planning” (Davis, 2014: 8400). (For further discussion of impact fees and usage, see Paydar et al., 2016; PA, PUC, 2017) While the impact fee provision still stands today, more controversial aspects of the Act have been since overturned through high profile legal battles (Fershee, 2014). For instance, the Act set forth a regulatory structure which preempted local zoning authority, with impact fee revenue withheld from local governments who chose to enact regulations inconsistent with those of the state. A 2012 lawsuit was brought against this provision (as well as other components of the Act), resulting in a temporary halt and eventual favorable ruling. The Corbett administration appealed the decision to the Pennsylvania Supreme Court, who upheld that the zoning restrictions were unconstitutional in their December 2013 ruling, restoring the ability of municipalities to exercise some types of planning authority over oil and gas drilling operations (Davis, 2014). Emboldened by this ruling, groups opposed to shale development have focused on strengthening municipal level zoning codes as a way to limit development (Hopey, 2017, Frazier, 2018a, 2018b; Staggenborg, 2018).

2.5. Citizen science and public engagement

Increased attention to impacts and risks from Marcellus Shale oil and gas extraction has led to a broad range of civic engagement, including the rise of “citizen science” programs that focus on the collection of data by non-experts. Citizen science water monitoring programs were established as early as 2010 to assess potential changes in water quality that might result from drilling fluid spills and other pollution incidents. Dickinson College’s Alliance for Aquatic Resource Monitoring (ALLARM), propagated standardized sampling protocols, training programs, and monitoring networks that extended into neighboring states of New York and West Virginia (Jalbert et al., 2014; Jalbert, 2016, 2017) . Carnegie Mellon University’s Community Robotics, Education and Technology Empowerment Lab (CREATE) and Southwest Pennsylvania Environmental Health Project (EHP) used citizen collected data to pair health data of patients living near well pads and compressor stations with air quality data in the same locations (Rabinowitz et al., 2015; Spence, 2015; Matz et al., 2017). Other groups, such as Earthworks, have armed residents and community groups with high-end monitoring tools such as thermal imaging cameras in order to reveal emissions from oil and gas facilities unobservable by the naked eye (Earthworks, 2018).

In the early years of Marcellus Shale development, basic data such as regulatory violation, waste reports, and even the locations of well pads were generally unknown to the public, and a number of information transparency, data collection and participatory mapping initiatives were launched. Noteworthy examples of efforts to expand access to industry and regulatory data include the nonprofit FracTracker Alliance, first established in 2010 at the University of Pittsburgh’s Graduate School of Public Health (Malone et al., 2012; Jalbert et al., 2017), West Virginia based SkyTruth (Platt et al., 2018), as well as data-driven investigative reporters such as Public Herald (Troutman et al., 2017).

A diverse network of advocacy campaigns evolved to push back against industry expansions. In addition to a focus on water and air pollution concerns, other issues such as the risks of crude oil train shipments (Masur et al., 2015), siting well pads near schools (Ridlington et al., 2016) and permitting of wastewater injection wells (Cusick, 2017) came to the forefront. Recent campaigns have also focused heavily on proposed pipeline projects—perceived as a risk to the communities through which they pass, but also seen as foundational infrastructures locking the region into long-term extraction dependencies. Some of the more prominent anti-pipeline campaigns evolved around projects such as Sunoco’s Mariner East 2 (Kelly, 2018, Nobel, 2018), Transco’s Atlantic Sunrise (Argento, 2017), and Shell Appalachia’s Falcon Ethane Pipeline—the latter of which will facilitate the construction of a large petrochemical facility north of Pittsburgh (Litvak, 2018).

3. Ohio and West Virginia: Legacies of extraction

West Virginia was one of the first states to experience unconventional development in the Marcellus shale, with hundreds of wells drilled in the mid to late 2000 s; today, West Virginia is the ninth-largest natural gas producing state with annual production exceeding 1

trillion cubic feet (US EIA, 2017c). Ohio did not experience such significant development until after 2010, when the "wet gas" petroleum liquids prevalent in the western Marcellus and Utica shales became more valuable. Indeed, between 2011 and 2016, natural gas production increased in Ohio by nineteen-fold, recently suprasing West Virginia (see Fig. 2).

Literature examining social and community impacts of shale development in both Ohio and West Virginia is limited, perhaps due in part because early drilling in West Virginia did not receive nearly the media attention received in Pennsylvania, and large-scale development in Ohio is relatively recent (Collins, 2013, Ohio Environmental Council, 2015). Both states, however, have extensive histories of coal mining: West Virginia has historically led the nation in coal production (more recently 2nd behind Wyoming) while Ohio coal production peaked in the 1960 s and has since steadily declined (Milici, 1997). While oil and gas drilling has received short shrift in academic literature, coal-related social and environmental impacts have received a more extensive examination (see, for example, Austin and Clark, 2012; Bell and York, 2010; Bell et al., 2016; Betz et al., 2015; Lewis, 1993, Meyers et al.,2017; Spencer and Camp, 2008).

In West Virginia, Sangaramoorthy et al. (2016) find hydraulic fracturing contributed to the disruption of residents' place conceptions and related identities, social ties, and perceptions of personal health. In a similar study of two Ohio counties, Fisher et al. (2018) find multiple sources of psychological and social stressors associated with shale development, including environmental concern, disruption to family and community ties, noise and light pollution, and physical health concerns. Both studies underscore uncertainty about future impacts as a central characteristic of shale development-precipitated stress.

Environmental justice issues associated with shale development have also been examined in Ohio and West Virginia as part of larger Appalachian basin or Marcellus shale studies (Eisenberg, 2015, Willow, 2014; Wylie et al., 2016). In their review of social and environmental impacts in Marcellus and Utica states, Eisenberg (2015) finds that in addition to Pennsylvania, many communities in Ohio and West Virginia proximate to hydraulic fracturing operations experience both power and information asymmetries relative to industry actors. In this vein, Ogneva-Himmelberger and Huang (2015) map population distributions around well sites, finding clusters of disproportionate exposure in West Virginia among higher poverty, elderly, and lower-education populations, and in Ohio in some areas with higher populations of children. Whereas literature examining community responses to shale development is becoming vast (see, for example, Jalbert et al., 2017, Leadbeater,2014), there is a paucity of scholarship examining such social movements in Ohio and West Virginia (see Cable, 2018; Willow et al., 2018 for notable exceptions).

Relative to neighboring states, Ohio hosts a disproportionate number of injection wells where oilfield flowback brine is disposed in underground geologic formations, with 217 injection wells in Ohio, 62 in West Virginia, and 10 in Pennsylvania. This disparity is the result of moratoriums in neighboring states, favorable geologic conditions, and interstate commerce laws preventing Ohio from refusing wastewater from other states (Maloney and Yoxtheimer, 2012, Lutz et al., 2013). The increase in injection wells brings local concerns regarding drinking water contamination, earthquakes, and lack of control of natural resources (Eisenberg, 2015; Ellsworth, 2013; Willow and Wylie, 2014; Hagley, 2017). The industry has moved toward recycling flowback water by using about 80 percent of the flowback water as "makeup water" to be used at future well sites (Ziemkiewicz et al., 2014). This has helped dramatically reduce the amount of waste to be injected; however large volumes of waste must still be disposed.

Fershee (2012) finds mixed perceptions of economic benefits in West Virginia, with residents reporting concern that they may not benefit from shale development as much as may be initially purported. Split estates are common in Ohio and West Virginia due in large part to the region's coal mining history, with many mineral and surface rights severances initiated over one hundred years ago. Indeed, in West Virginia, Collins (2013) finds nearly 40 percent of gas wells located on private property, and of these, approximately 70 percent are on split estates.

The legacy of resource extraction and historically lower economic and human capital growth throughout the Appalachian Basin have prompted some characterizations of the region as being afflicted by the "Natural Resource Curse," a phenomenon whereby areas with valuable natural resources are also most impacted by the environmental, economic, and social externalities of developing said resource (Eisenberg, 2015, Weinstein and Partridge, 2011). Similarly, such areas have also been referred to as "Sacrifice Zones," where environmentally destructive practices are concentrated such that distant locations benefit while proximate areas experience ecological, environmental, and/or social harms (Fox, 1999; Purdy, 2011). "Sacrifice Zones" are also associated with dependence on single-industry economies that produce mixed socioeconomic outcomes, varying from persistently impoverished counties in Appalachia to boom-and-bust energy communities in the American West (Freudenburg, 1992; Freudenburg and Wilson, 2002; Perdue and Pavela, 2012; Betz et al., 2015). Some scholars contest the pejorative determinism and ubiquity of a "Curse" or "Zone," (e.g., Holifield and Day, 2017), with others finding more nuanced impacts in Appalachian coal communities in particular, as coal mining is associated with both positive and negative long-term quality of life and economic outcomes (Betz et al., 2015; Lobao et al., 2016; Tickamyer and Duncan, 1990).

In addition to direct impacts, other scholars find past resource extraction may also affect place and identity conceptions and associated perceptions of future resource development. In West Virginia, Bell and York (2010) find industry efforts to shape regional economic and social identities around coal by co-opting cultural iconographies and instituting pervasive community support initiatives, thereby supporting pro-coal regional identities. Similarly, Bugden et al. (2017) find perceived positive or negative valence of past mining activity robustly predicts both support and opposition to shale development, suggesting that in communities where even different types of resource extraction have occurred, potential shale development activity is likely to be conceived and understood through legacy frames of previous development.

Similarly, in a forthcoming case study of the legislative and regulatory disputes related to hydraulic fracturing in Pennsylvania (Peck, forthcoming), a study reviewed events in Pennsylvania, Ohio, and West Virginia, and concluded that new solutions in lawmaking processes are necessary to soften participants' hardening of their own identities and negative characterizations of other groups, and proposes borrowing from peace and conflict studies research to help the legislative process address and move beyond identity-based conflicts.

Scholars more critical of the industry have paid particular attention to the role of unequal access to government and market systems in affecting material, social, and psychological outcomes (Finewood and Stroup, 2012; Lave and Lutz, 2014; Perry, 2012; Willow, 2014; Kennedy et al., 2017). Willow and Wylie (2014) and Finewood and Stroup (2012) conceptualize shale development processes as conduits of social and environmental dispossession driven by neoliberal market and government forces, the effects of which include obfuscation and normalization of environmental and health impacts (Finewood and Stroup, 2012), "dividing and conquering" of community groups (Willow and Wylie, 2014: 227), and the deliberate sowing of disinformation and active production of ignorance (Willow and Wylie, 2014). In Ohio, Willow (2014) finds the effects of these and similar processes to include psychological unease resulting from pervasive uncertainty and fears associated with unknown health impacts in particular.

3.1. Current research: Ohio

To examine perceptions of oil and gas development amid the rich

Table 3
Ohio Interviews.

County	Interviews (n)	Coal Mining	Shale Development Activity	2015 est. Population
Belmont County	19	Ongoing	High shale development	69,154
Wayne County	12	No history	Potential shale development (periphery)	116,063
Coshocton County	12	Past (coal legacy)	Potential shale development (periphery)	36,569
Athens County	8	Past (coal legacy)	Potential shale development (periphery)	65,886

legacy of coal mining, we conducted in-depth, semi-structured interviews (n = 51) with residents in four Ohio counties: one experiencing significant shale development and long-time and ongoing coal mining activity (Belmont County), and three on the periphery of shale development with favorable prospects for future development, two of which have past coal mining legacies (Athens and Coshocton Counties) and one which does not (Wayne County).

Of the study communities, only Belmont County maintains robust coal production levels – the highest in Ohio – with over 10.5 million short tons produced annually from 7 active mines (Ohio DNR 2015). An agricultural and manufacturing community, Wayne County has no coal production history (Table 3).

Among other themes, the interview protocol examined residents' shale development perceptions and associated perceptions of risk to the environment and community. Key informant sampling (Marshall 1996) was employed to identify adults from market, state, and civil society groups with long-time residency, and Ohio State University Extension staff also helped identify participants in some cases.

3.2. Findings: coal development, risk discounting, and shale development perceptions

With few exceptions, most participants expressed moderate to positive attitudes toward future shale development, sharing hope for personal or community economic gain. In the coal development and coal legacy communities, many positive attitudes toward future shale development were often expressed in association with coal. A number of participants suggested shale development "is coming at just the right time," to ease either past or anticipated declines in coal productivity. In Belmont County, the majority of participants approached with offers to lease their property did so (13 of the 15 participants approached chose to lease), reporting modest to moderate improvements in quality of life or lifestyle as a result.

Of the few respondents who expressed reticence or opposition to future shale development, the two Belmont County residents who refused land leases worked in environmental or policy fields on water quality and mining issues. In the three periphery communities, Athens County respondents expressed greatest reticence toward future shale development, with many discussing ongoing negative impacts from past coal mining activity, including environmental harms like poisoned streams, and social and health impacts such as death, crime, and population loss as potential problems with future shale activity. Even so, only one Athens County respondent expressed firm opposition to future shale development, referencing coal's impact, saying, "Coal raped us. No." All other participants in both Coshocton and Athens Counties, while discussing negative impacts of coal mining, nonetheless expressed reticent to exuberant optimism about potential economic benefits from shale. As one Athens County respondent said, "Even if it just brings one more job to the gas station, that would help us."

Across the coal and coal legacy communities, most participants suggested that the potential economic benefits of shale development would likely outweigh potential harms, often referencing the positive impacts of past coal mining while minimizing expressed harms. This may also be due, in part, as Bell and York (2010) suggest, to the development of a coal "identity" or related ideology, influencing residents' positive perceptions of the coal industry despite expressly related negative impacts. This was particularly evident in Athens and Coshocton Counties, the two communities which have experienced significant coal decline and minimal to no shale development. In Athens County, respondents discussed the negative impacts of coal development at length, including catastrophic mining accidents, ongoing water quality concerns, high and pervasive poverty, and significant population decline. Similarly, nearly all Coshocton participants discussed ongoing economic and population losses associated with the legacy of coal. Nonetheless, the majority of Athens and Coshocton participants referenced positive place and identity conceptions associated with coal mining, with most describing the region as "coal country." One participant explained their support for shale development in relation to the area's coal history, saying: "If it's in the ground, let's get it out! That's what we do."

Comparatively, in Wayne County, the shale development periphery community with no coal mining history, most participants also expressed positive attitudes toward shale development due to anticipated economic benefits, but also suggested that if future development were not to reach them, their community would be fine due to their steady agricultural and manufacturing sectors.

Respondents in coal development and coal legacy communities seemed to discount both experienced and potential shale risks, either by minimizing or dismissing concerns, or framing them within the area's coal history. In Belmont County, where coal mining continues, participants described a sense of coal "*déjà vu*" regarding shale development, and that although there were environmental and social challenges, much like coal, they have not been so disruptive to justify initial concerns. Such unmet risk expectations parallel recent findings in Bakken shale periphery communities (Junod et al., 2018), yet stand in contrast to other research finding high risk perceptions and manifestations in other Utica/Marcellus shale communities (Fisher et al., 2018). As Bugden et al. (2017) and Fershee (2012) suggest, this may be due, in part, to the moderation of shale development perceptions by positive, and in this case, ongoing, perceptions of coal development.

3.3. Discussion

In Ohio, we find residents may hold multiple and contradictory views of past natural resource development simultaneously, supporting other environmental development perception research (Heberlein, 2012). Even when expressing predominantly negative past coal impacts, the majority of participants held positive impacts and related identities in higher esteem, ultimately supporting other future extractive activity. Our research at times supports research finding shale development activity may be viewed through either positively-or-negatively-valenced resource development frames (Bugden et al., 2017), but demonstrates the need for a more nuanced examination of the influence of ongoing, former, and potential resource development.

4. New York: policy, culture and politics

Though it possesses considerable resource potential (Coleman et al., 2011), the state of New York has had quite a different experience with shale development than Pennsylvania, West Virginia, or Ohio. State-level organizations leveraged environmental-impact review laws to pass an early moratorium halting industry activity in 2010, foreshadowing a long and contentious public debate about the future of the industry. The

state spent several years conducting socioeconomic, environmental and health research to assess the impacts of the industry, generating controversy and prompting widespread grassroots activity. As a sign of the local fervor around the industry's potential impact, over 350 municipalities passed ordinances opposing, restricting, or barring shale development within their boundaries (Arnold and Long, 2018, Dokshin, 2016). Finally, in 2014, citing severe risks posed by the industry, Governor Andrew Cuomo banned shale development statewide.

The dynamics within the state—its early moratorium and ban, its Democratic political leadership and voting base, huge urban populations dependent on aquifers within the shale boundaries, a history of environmental activism, and its strong home-rule tradition—have broadly shaped not only its own experience with shale development but also influenced national and international public discourse around hydraulic fracturing (Heikkila et al., 2014). Social science targeted at New York has produced dozens of studies highlighting these core dynamics, which may be loosely be categorized into three types: policy and governance, public perceptions and cultural representations, and socioeconomic impacts from development or the lack thereof. We address each of these topics here.

4.1. Policy and governance

While Pennsylvania cleared the way for oil and gas firms to rapidly develop the Marcellus Shale, the politics in the state of New York placed a serious constraint on development. Murtazashvili (2015) notes several differences to account for these inter-state differences: state-level governmental control (Democratic control in NY and Republican control in PA), greater local oppositional response in New York (Weible and Heikkila, 2016), and public opinion polls that showed less public support amongst New Yorkers (Stedman et al., 2012). New York's moratoria, its lengthy and detailed public comment process, and the concurrent local bans on shale development suggest a robust public participation process. However, other scholars have noted that the public participation process run by New York's Department of Environmental Conservation, although lengthy and open to public comment, was perceived as less transparent than usual by stakeholders, including both industry and environmental groups (Rinfret et al., 2014). Other scholarship has pointed to the lengthy review process in New York as a form of political gridlock, emerging from contested interpretations of economic and environmental costs and benefits by stakeholder groups (Dodge and Lee, 2017). Regardless of the view on the rulemaking process, Richardson et al. (2013) show that New York's proposed shale gas regulations—which were abandoned following the statewide ban—were arguably the most comprehensive in the country among state regulatory approaches. New York not only would join West Virginia in regulating all twenty elements of the development process analyzed by Richardson et al. (2013) but also proposed a number of unprecedented mitigation techniques. Had New York begun to regulate unconventional oil and gas, such regulations could have put upward pressure on other states to better manage the industry (Fershee, 2015).

Perhaps the most unusual characteristic of New York's experience with shale gas is the high number of ordinances passed by local governments to ban or restrict shale development. As Weible and Heikkila (2016) note, New York presents an unusual case of highly active local anti-shale development coalitions. Stedman et al. (2012) also find that New York residents are more likely than their Pennsylvania counterparts to participate in a public participation process related to shale development. The root of this unusual degree of organized local opposition is New York's home-rule tradition, which grants considerable autonomy to local governments to shape policy (Arnold and Holahan, 2014, Simonelli,2014; Kenneally and Mathes, 2010). As part of the broad effort to oppose shale development in the state, local coalitions also engaged in discursive boundary work to differentiate and assimilate oppositional and supportive organizations and groups (Metze and Dodge, 2016). Through a range of discursive and policy-based oppositional efforts, local anti-shale development coalitions passed more 350 ordinances opposing, restricting, or barring shale development (Arnold and Long, 2018).

Conversely, other local governments in New York sought to *promote* the industry, especially when the southern region with potential for development (Arnold and Neupane, 2017, Dokshin,2016). Zirogiannis et al. (2016) note that regions proximate to Pennsylvania's development were more supportive of development, while Democratic and more educated municipalities were more likely to adopt restrictive ordinances. Indeed, Dokshin (2016) demonstrates that local bans tend to occur in a "sweet spot" where the ban area is proximate to potential development but unlikely to experience any actual development.

A final key feature of shale gas policy and governance in the Marcellus context is the nature of mineral rights ownership. In the Northeast, much of the land and mineral rights available for development are owned by private landowners. These landowners must lease or sell their property and/or mineral rights to firms to develop shale gas resources (Bugden et al., 2017). The process through which landowners negotiate development has been termed "private participation" (Jacquet, 2015). Private participation is a form of micro-level governance wherein landowners engage in quasi-public participatory processes that can produce both individual and collective benefits. One form that private participation takes is in the organization of landowner coalitions. Landowner coalitions throughout the region organized to collectively bargain with firms to improve member benefits in the form of greater royalty and signing bonuses as collective landownership became a influential attribute (Jacquet and Stedman, 2011).

4.2. Public perceptions and cultural representations

Perception research has especially focused on comparing public perceptions between New York and Pennsylvania due to the natural experiment offered by the many differences in the state's responses. Two major survey efforts capture this comparison: Stedman et al. (2012) and Borick et al. (2014). Both survey efforts found New Yorkers are more likely than their Pennsylvania counterparts to perceive risk and to oppose the industry. Borick, Rabe, and Lachapelle found 54% of Pennsylvania residents support shale development, compared to 29% of New York residents. New York residents are much more likely to perceive severe risk and to view the term "shale development" negatively. New York residents also appear to be more informed on the issue: they are more likely to correctly identify the state policy in Pennsylvania then vice versa. Stedman et al. (2012), surveying the regions two years prior, additionally found that New York residents were less likely to trust the institutions responsible for regulating the industry and providing information on the issue. These inter-state differences led Stedman et al. (2012) to speculate that legacies of resource extraction may explain greater comfortability with the industry in Pennsylvania. However, Bugden et al. (2017), in a test of this hypothesis, demonstrate that Pennsylvania's legacy of coal extraction does *not* explain inter-state variation. To date, empirically supported explanations of inter-state difference remain absent from the literature.

Kromer (2015) finds New Yorkers (66%) are more likely than both Marylanders (57%) and Pennsylvanians (47%) to view the word "fracking" negatively. Kromer (2015) also shows that New Yorkers are the most likely of the three respondent groups to believe that their state policies have hindered economic growth; that the shale gas industry benefits at the expense of local communities; and are the most likely to oppose shale development. New Yorkers who view sustainability as an important issue are more likely to oppose shale development, while individuals who view resilience as an important issue are more likely to support shale development (Evensen et al., 2017). Evensen and Stedman (2017) demonstrate that beliefs about impacts do not necessarily impact attitudes toward shale gas. Quite to the contrary, these authors use structural equation modeling to demonstrate that beliefs about impacts may flow *from* attitudes toward shale gas,

problematizing the model that presumes that perceived impacts are the foundation for attitudes toward shale development.

Using New York as a comparison, other research has looked at how local perceptions differ from national perceptions. Evensen and Stedman (2016); Clarke et al., (2016), and Bugden et al., (2017) suggest local discourses differ fundamentally from national discourse, with subsequent effects on public perceptions. Specifically, these studies argue that local discourse concretizes around specific local impacts, while national discourses tend to draw on political ideology and other abstract associations to inform beliefs and attitudes. This has been reiterated in studies of public discourse—specifically regional newspaper coverage (Ashmoore et al., 2016; Evensen et al., 2014a, 2014b). Hedding (2017) attributes local variation in newspaper coverage in New York, Pennsylvania, and North Carolina to the information sources available in those states: the greater presence of industry activity in Pennsylvania led to the greater use of industry sources while the local anti-shale development organizations and the moratorium on industry activity in New York led to journalists relying more heavily on oppositional sources. Hedding (2017) also shows that the dominant frame in New York media coverage of shale gas was in fact conflict itself rather than specific impacts or regulation.

The shale gas industry relied on several key approaches to shape public discourse: appeals to energy independence and patriotism; the use of pro-environmental imagery; and contrasting scientific reason with irrational obstructionism (Matz and Renfrew, 2015). Meanwhile, Vasi et al. (2015) demonstrate how local opposition groups used local screenings of the anti-shale gas documentary "Gasland" to drive online searching, increase media coverage, and drive mobilization and local ordinances (Vasi, 2018). Mazur (2016) demonstrates how the Deepwater Horizon spill in the Gulf Coast drove increased coverage of shale development. Agriculture is held as symbol of rural agrarian life, and possible impacts to farmers have been used by both proponents and opponents to garner public support (Sneegas, 2016).

Opposition to the hydraulic fracturing process has become a touchstone issue of modern day environmentalism, a cause taken up by celebrities, the subject of major motion pictures and academy-award nominated documentaries. It wasn't always this way: while some western environmental groups were opposed to unconventional oil and gas development on the basis of chemical inputs (Wylie et al., 2016), many environmental organizations had officially supported natural gas development as a mitigation against the climate impacts of coal and oil (Walsh, 2012). By the summer of 2008, around the time *Gasland* documentarian Josh Fox received a lease offer for his wooded family-owned property in northern Pennsylvania, environmentalists in the Finger Lakes region of New York and in New York City were forming groups dedicated to opposing the practice of hydraulic fracturing in particular, with the activists in around Ithaca, NY producing iconic signs with the word "Frack" crossed out with red paint (Shaleshock, 2008).

The simplification of discourse to focus on the process of hydraulic fracturing was arguably an effective oppositional strategy, but led to the degradation of scientific communication as the public began to use the word "fracking" to refer to any or all aspects of unconventional oil and gas development, while scientists, regulators, and industry continued to specify "fracking" as just one event within a complicated chain of processes required to develop a shale gas well (Evensen et al., 2014a). Experts from various sectors (NGO, industry, academia, and government) showed relative agreement on priority risk pathways that had less to do with hydraulic fracturing itself and more to do with site construction, water extraction, the storage and treatment/disposal of waste fluids, and the venting of methane during drilling and completion (Thomas et al., 2017; Molofsky et al., 2013; Krupnick et al., 2013; Boyer et al., 2012). Meanwhile, an incredulous public, having seen videos of people lighting their methane-contaminated water on fire, began to clamor for evidence and viewed experts that tried link certain risks to particular risk pathways as out-of-touch, at best. Anti-fracking activists (or "Fracktivists") grew critical of any scientific results that failed to directly link hydraulic fracturing with environmental or bodily harms; similarly, the oil and gas industry launched their own organizations to counter claims made on the risks hydraulic fracturing by either activists and scientists (Vasi, 2018). Some experts in fields like petroleum engineering and geology began to publicly advocate for support or opposition to shale development, resulting in prior and subsequent research being contested and further eroding the barrier between impartial "expert" and a biased advocate.

The high profile media attention, a deeply suspicious and polorarized public, and unsettled scientific understanding helped to scramble traditional notions of bias, advocacy and expertise among both scientists and science consumers.

4.3. Actual impacts in New York State

Assessing the actual impacts of shale development in New York is challenging given that drilling never took place. Yet, New York's moratorium did not totally insulate it from the risks and costs associated with shale development occurring, in some cases, less than a mile from its borders: Pennsylvania's wastewater disposal requirements resulted in the transport of millions of gallons of wastewater and other solid wastes to disposal sites across the region, including New York (Patterson and Maloney, 2016). Industry workers and equipment commonly frequent towns along the Southern Tier of New York. Weber and Hitaj (2015) find that New York farm real estate in the Marcellus region increased in value as a result of leasing for shale development, while a later study found New York landowners in potential development areas experienced on average a 23% decrease in property value as a result of the moratorium (Boslett et al., 2016).

5. Research for the next decade

In 1988, Rosa, Machlis, and Keating outlined a research agenda for social science and energy development corresponding either to periods of energy supply stability, or energy supply crisis: that of energy development as an *underpinning of social structure and change*, or that of energy development as a *critical social problem* (1988:168). Unprecedented hydrocarbon development of the past decade is expected to continue through 2050 as the United States continues to transform global natural gas markets, emerging as a net exporter in 2017 and projected to account for one fifth of global supply by 2022 (EIA, 2018). During the same period, the Marcellus shale is projected to increase natural gas production by 45 percent, even at relatively low price levels, and natural gas is projected to outpace coal globally by 2040, second only to crude oil (EIA, 2018).

In this new era, Rosa et al.'s (1988) disparate agenda must be synthesized, as shale energy development and related impacts may prove to supercede the stability/crisis binary. Thus, the scope of future social scientific scholarship must respond to identified and ongoing social and structural challenges, opportunities, and uncertainties, *as well as* those that may present as punctuated, acute problems; that is, future research efforts must be both problem-oriented in addition to long-ranging. As concerns of "peak oil" are supplanted by "peak CO2;" as the footprint of energy development expands across rural and urban communities alike; and as new economic, social, political, and cultural contexts increasingly shape and are shaped by development activity, we outline a research agenda that may be responsive to both ongoing and acute, as well as known and unknown future challenges, opportunities, and uncertainties.

5.1. Problem-oriented future research

Interdisciplinary social scientific approaches to energy and society scholarship are critical to understanding and addressing the increasingly Gordian challenges and impacts of energy development in the

twenty-first century, particularly problem-specific challenges that cut across disciplinary bounds, such as:

- Community perceptions and responses to shale development in natural resource legacy communities, particularly how past extraction shapes future extraction through changes to economic, political, or cultural contexts;
- Relationships between state/jurisdictional regulatory interventions and social/civic/economic outcomes;
- Comparative studies across different regulatory and energy regimes;
- Social movement and community conflict studies examining causes, objects, and outcomes of conflict across different geographic, social, and political contexts; and,
- Empirical and theoretical development of Energy Justice frameworks for application in siting, regulatory, and impact assessment contexts

5.2. Long-Ranging future research

The coming years present unique opportunities for longitudinal analyses in energy and non-energy communities which face the prospect of future or continued development, particularly over a protracted period, including:

- Examinations of the persistence or resilience of social problems and/or economic/social benefits over time;
- Development and identification of community resilience and adaptation indicators and associated necessary and sufficient community characteristics and conditions;
- Lifecycle examinations of impacts and perceptions in non-energy communities as energy development is introduced and increases;
- Tests of prolonged, mini-boom/mini-bust development and impact patterns;
- Updates and testing to the “Natural Resource Curse” concept in long-term shale communities; and,
- Long-term impacts of project decommissioning

As U.S. oil and gas development is likely to continue and expand in the coming years across many energy communities, shale development may increasingly present as both an underpinning of social and cultural change, as well as a critical social problem. In the Mid-Atlantic, attention should be paid to mutable and evolving scales of *time* and *distance* in relation to public perceptions and responses, particularly as development increases, in addition to how extractive legacies shape social-structural conditions that may lead to increased support or opposition to new forms of resource extraction. In examining both problem-specific and long-ranging questions, the social sciences may prove responsive to both ongoing and acute, as well as known and unknown future challenges, opportunities, and uncertainties associated with shale energy development.

References

Kromer, M., 2015. Public perceptions of hydraulic fracturing in three Marcellus Shale states. Issues Energy Environ. Policy 20, 1–12.
Abramzon, S., Samaras, C., Curtright, A., Litovitz, A., Burger, N., 2014. Estimating the consumptive use costs of Shale natural gas extraction on Pennsylvania roadways. J. Infrast. Syst. 20 (3), 06014001.
Adams, R., Kelsey, T.W., 2012. Pennsylvania Dairy Farms and Marcellus Shale, 2007–2010. Penn State Cooperative Extension Marcellus Education Fact Sheet.
Alter, T.R., Bridger, J.C., Findeis, J., Kelsey, T.W., Luloff, A.E., McLaughlin, D., Shuffstall, W.C., 2007. Strengthening Rural Pennsylvania: An Integrated Approach to a Prosperous Commonwealth. Metropolitan Policy Program Research Brief. The Brookings Institution, Washington DC.
American Fuel and Petrochemical Manufacturers, 2018. In Petrochemical Industry, A Second Wave of Growth Brought by Shale Politico.com Sponsored Content. Available Online:. Accessed 04/10/2018. www.politico.com/sponsor-content/2018/03/second-wave-of-growth-brought-by-shale.
Appalachian Regional Commission (ARC), 2017. County Economic Status in Appalachia, FY 2018.” Retrieved January 9th 2018. https://www.arc.gov/research/MapsofAppalachia.asp?MAP_ID=137.
Argento, M., 2017. 26 Singing Protesters Arrested at Atlantic Sunrise Pipeline Site. USA Today, October 17. Accessed May 16, 2018. https://www.usatoday.com/story/news/nation-now/2017/10/16/protesters-arrested-atlantic-sunrise-pipeline/770035001/.
Arnold, G., Holahan, R., 2014. The federalism of fracking: how the locus of policy-making authority affects civic engagement. Publius J. Federalism 44 (2), 344–368.
Arnold, G., Long, L.A.N., 2018. policy expansion in local government environmental policy making. Public Adm. Rev.
Arnold, G., Neupane, K.W., 2017. Determinants of pro-fracking measure adoption by New York Southern tier municipalities. Rev. Policy Res. 34 (2), 208–232.
Ashmoore, O., Evensen, D., Clarke, C., Krakower, J., Simon, J., 2016. Regional newspaper coverage of Shale gas development across Ohio, New York, and Pennsylvania: similarities, differences, and lessons. Energy Res. Soc. Sci. 11, 119–132.
Austin, K., Clark, B., 2012. Tearing down mountains: using spatial and metabolic analysis to investigate the socio-ecological contradictions of coal extraction in appalachia. Crit. Sociol. 38 (3), 437–457.
Bamberger, M., Oswald, R.E., 2012. Impacts of gas drilling on human and animal health. New Solut. 22 (1), 51–77.
Bell, S., York, R., 2010. Community economic identity: the coal industry and ideology construction in West Virginia. Rural Sociol. 75, 111–143.
Bell, S., Fighting, King, Coal, 2016. The Challenges to Micromobilization in Central Appalachia. MIT Press.
Betz, M.R., Partridge, M.D., Farren, M., Lobao, L., 2015. Coal mining, economic development, and the natural resource curse. Energy Econ. 50, 105–116.
Black, B., 2003. Petrolia: The Landscape of America’S First Oil Boom. John Hopkins University Press, Baltimore.
Borick, Christopher P., Rabe, B.G., Lachapelle, E., 2014. Public perceptions of shale gas extraction and hydraulic fracturing in New York and Pennsylvania. Issues Energy Environ. Policy 20, 1–18.
Boslett, A., Guilfoos, T., Lang, C., 2016. Valuation of expectations: a hedonic study of Shale Gas Development and New York’s Moratorium. J. Environ. Econ. Manage. 77, 14–30.
Boyer, E.W., Swistock, B.R., Clark, J., Madden, M., Rizzo, D.E., 2012. Impact of Marcellus Gas Drilling on Rural Drinking Water Supplies. The Center for Rural Pennsylvania.
Brasier, K., 2017. Traffic Impacts of Marcellus Shale Development. Center for Rural Pennsylvania, Harrisburg.
Brasier, K., Rhubart, D., 2014. Effects of Marcellus Shale Development on the Criminal Justice System. Center for Rural Pennsylvania, Harrisburg.
Brasier, K., Rhubart, D., 2017. Changes in Crime Related to Marcellus Shale Development. Center for Rural Pennsylvania, Harrisburg.
Brasier, K., Fogle, N., Schramm, B., Kelsey, T., 2009. Questions Citizens and Local Leaders Should Be Asking. Penn State Cooperative Extension. Marcellus Education Fact Sheet. .
Brasier, K., Filteau, M.R., McLaughlin, D.K., Jacquet, J., Stedman, R.C., Kelsey, T.W., Goetz, S.J., 2011. Residents’ perceptions of community and environmental impacts from development of natural gas in the Marcellus Shale: a comparison of Pennsylvania and New York cases. J. Rural Soc. Sci. 26 (1), 32–61.
Brasier, K., McLaughlin, D.K., Rhubart, D., Stedman, R.C., Filteau, M.R., Jacquet, J., 2013. Risk perceptions of natural gas development in the Marcellus Shale. Environ. Pract. 15, 108–122.
Brasier, K., Davis, L., Glenna, L., Kelsey, T., McLaughlin, D., Schafft, K., Babbie, K., Biddle, C., Delessio-Parson, A., Rhubart, D., 2014. The Marcellus Shale Impacts Study: Chronicling Social and Economic Change in North Central Pennsylvania. Final Report to the Center for Rural Pennsylvania. .
Brasier, K., Chandler, R., Glenna, L., Hesse, A., Kelsey, T., Monnat, S., Schafft, K., Suchyta, M., 2017. The Marcellus Shale Impacts Study Wave 2: Chronicling Social and Economic Change in Northern and Southwestern Pennsylvania. Final Report to the Center for Rural Pennsylvania. .
Brundage, T.L., Kelsey, T.W., Lobdell, J., Michael, L.L., Jacquet, J., Ladlee, J.R., Lorson, J.F., Murphy, T.B., 2011. Pennsylvania Statewide Marcellus Shale Workforce Needs Assessment. Marcellus Shale Education & Training Center, Williamsport, PA.
Bugden, D., Evensen, D., Stedman, R., 2017. A drill by any other name: social representations, framing, and legacies of natural resource extraction in the fracking industry. Energy Res. Soc. Sci. 29, 62–71.
Cable, S., 2018. Natural gas fracking on public lands: the trickle-down impacts of neoliberalism in Ohio’s Utica Shale Region. In: Ladd, A.E. (Ed.), Fractured Communities: Risks, Impacts, and PRotest Against Hydraulic Fracking in U.S. Shale Regions. Rutgers University Press, New Brunswick.
Campbell, J., Hogan, C., 2013. Adapting to Shale-Based Development Through a Countywide Approach: Lessons Learned from Jefferson County, Ohio. Community Development Fact Sheet 1283. Ohio State University Extension, Columbus, Ohio.
Chesapeake Energy, 2013. Chesapeake’s History. Retrieved from:. http://www.chk.com/about/pages/history.aspx.
Clarke, C.E., Bugden, D., Hart, P.S., Stedman, R.C., Jacquet, J.B., Evensen, D.T.N., Boudet, H., 2016. How geographic distance and political ideology interact to influence public perception of unconventional oil/natural gas development. Energy Policy 97, 301–309.
Clough, E., Bell, D., 2016. Just fracking: a distributive environmental justice analysis of unconventional gas development in Pennsylvania, USA. Environ. Res. Lett. 11 (2).
Coleman, J.L., Milici, R.C., Cook, T.A., Charpentier, R.R., Kirschbaum, R., Klett, T.R., Pollastro, R.M., Schenk, C.J., 2011. Assessment of Undiscovered Oil and Gas Resources of the Devonian Marcellus Shale of the Appalachian Basin Province, 2011. (Fact Sheet 2011-3092). US Geological Survey, Reston, VA.
Collins, A.R., 2013. Divided rights, expanded conflict: the impact of split estates in natural

gas production. In: Selected Paper Prepared for Presentation at the Agricultural & Applied Economics Association'S 2013 AAEA & CAES Joint Annual Meeting. Washington, DC, August 4-6, 2013.
Commonwealth of Pennsylvania 2017 March 21 Governor Wolf Releases Report and Plans for Enhancing Petrochemicals, Plastics Manufacturing in Pennsylvania [Press release] Retrieved from: https://www.governor.pa.gov/governor-wolf-releases-report-and-plans-for-enhancing-petrochemicals-plastics-manufacturing-in-pennsylvania/.
Considine, T., Watson, R., Entler, R., Sparks, J., 2009. An Emerging Giant: Prospects and Economic Impacts of Developing the Marcellus Shale Natural Gas Play. The Pennsylvania State University, Dept. of Energy and Mineral Engineering, University Park, PA August.
Considine, T.J., Watson, R., Blumsack, S., 2010. The Economic Impacts of the Pennsylvania Marcellus Shale Natural Gas Play: An Update. The Pennsylvania State University College of Earth and Mineral Sciences Department of Energy and Mineral Engineering, University Park, PA.
Cooley, R., Casagrande, D., 2017. Marcellus Shale as Golden Goose. In: Jalbert, K., Willow, A., Casagrande, D., Paladino, S. (Eds.), ExtrACTION: Impacts, Engagements, and Alternative Futures. Routledge, Abingdon, Oxon; New York, NY, pp. 46–60.
Cosgrove, B.M., Lafave, D.R., Sahan, T.M., Donihue, M.R., 2015. The economic impact of shale gas development: a natural experiment along the New York/Pennsylvania border. Agric. Resour. Econ. Rev. 44 (2), 20–39.
Costanzo, C., Kelsey, T.W., 2012. Marcellus Shale and Local Collection of State Taxes: What the 2011 Pennsylvania Tax Data Say. Penn State Center for Economic and Community Development, University Park, PA.
Cox, S., Fershee, J., 2015. Forced Pooling and Dispute Resolution. West Virginia Extension Service, Morgantown.
Cusick, M., 2017. State Sues Townships That Tried to Ban Injection Wells. NPR StateImpact Pennsylvania, March 29. Accessed May 16, 2018. https://stateimpact.npr.org/pennsylvania/2017/03/29/state-sues-townships-that-tried-to-ban-injection-wells/.
Davis, C., 2014. Substate federalism and fracking policies: does state regulatory authority trump local land use autonomy? Environ. Sci. Technol. 48 (15), 8397–8403.
Davis, L.A., McLaughlin, D., Uberoi, N., 2014. The Impacts of Marcellus Shale Development on Health and Health Care. Center for Rural Pennsylvania, Harrisburg, PA.
Dodge, J., Lee, J., 2017. Framing dynamics and political gridlock: the curious case of hydraulic fracturing in New York. J. Environ. Policy Plan. 19 (1), 14–34.
Dokshin, F.A., 2016. Whose backyard and what's at issue? Spatial and ideological dynamics of local opposition to fracking in New York State, 2010 to 2013. Am. Sociol. Rev. 81 (5), 921–948.
Dolson, H., 1959. The Struck Oil. The Gaudy and Turbulent Years of the First Oil Rush: Pennsylvania. Hammond, Hammond & Company, London, pp. 1859–1880.
Earthworks, 2018. Community Empowerment Project. Accessed May 16, 2018. https://earthworks.org/stories/citizens_empowerment_project/.
Eisenberg, A.M., 2015. Beyond science and hysteria: reality and perceptions of environmental justice concerns surrounding marcellus and Utica Shale gas development. Univ. Pittsburgh Law Rev. 77, 183–234.
Ellsworth, W., 2013. Injection-induced earthquakes. Science 341 (6142).
Engelder, T., 2009. Marcellus. Fort Worth Basin Oil Gas Magazine August, 18–22.
Evensen, D., Stedman, R., 2016. Scale matters: variation in perceptions of Shale gas development across national, state, and local levels. Energy Res. Soc. Sci. 20, 14–21.
Evensen, D., Stedman, R., 2017. Beliefs about impacts matter little for attitudes on Shale gas development. Energy Policy 109, 10–21.
Evensen, D., Jacquet, J.B., Clarke, C.E., Stedman, R.C., 2014a. What's the 'fracking' problem? One word can't say It all. Extr. Ind. Soc. 1 (2), 130–136.
Evensen, D.T., Clarke, C.E., Stedman, R.C., 2014b. A New York or Pennsylvania State of mind: social representations in newspaper coverage of gas development in the Marcellus Shale. J. Environ. Stud. Sci. 4 (1), 65–77.
Evensen, D., Stedman, R., Brown-Steiner, B., 2017. Resilient but not sustainable? Public perceptions of Shale gas development via hydraulic fracturing. Ecol. Soc. 22 (1), 8.
Fernando, F.N., Cooley, D.R., 2016. Socioeconomic system of the oil boom and rural community development in Western North Dakota. Rural Sociol. 81 (3), 407–444.
Ferrar, K.J., Kriesky, J., Christen, C.L., Marshall, L.P., Malone, S.L., Sharma, R.K., et al., 2013. Assessment and longitudinal analysis of health impacts and stressors perceived to result from unconventional Shale gas development in the Marcellus Shale region. Int. J. Occup. Environ. Health 19 (2), 104–112.
Fershee, J., 2012. The Oil and Gas Evolution: Learning from the Hydraulic Fracturing Experiences in North Dakota and West Virginia. Texas Wesley. Law Rev. 19 (1), 23–36.
Fershee, J., 2014. Facts, fiction, and perception in hydraulic fracturing: illuminating act 13 and robinson Township v. Commonwealth of Pennsylvania. West. Va. Law Rev. 116 (3), 819–863.
Fershee, J., 2015. How local Is local? A response to professor David B. Spence's the political economy of local vetoes. Tex. Law Rev. See Also 93, 61–74.
Filteau, M.R., 2014. Who are those guys? Constructing the oilfield's new dominant masculinity. Men Masculinities 17 (4), 396–416.
Filteau, M.R., 2015a. A localized masculine crisis: local men's subordination within the marcellus Shale region's masculine structure. Rural Sociol. 80 (4), 431–455.
Filteau, M.R., 2015b. Go back to Texas, gas bastards! How a newcomer population of itinerant energy workers manage dirty work stigma in the marcellus shale region. Soc. Nat. Resour. 28 (11), 1153–1167.
Finewood, M.H., Stroup, L.J., 2012. Fracking and neoliberalization of the hydro-social cycle in Pennsylvania's Marcellus Shale. J. Contemp. Water Res. Educ. 147, 72–79.
Finkel, M.L., Selegean, J., Hays, J., Kondamudi, N., 2013. Marcellus shale drilling's impact on the dairy industry in Pennsylvania: a descriptive report. New Solut. 23 (1), 189–201.
Fisher, M., Mayer, A., Vollet, K., Hill, E., Haynes, E., 2018. Psychosocial implications of unconventional natural gas development: quality of life in Ohio's guernsey and noble counties. J. Environ. Psychol. 55, 90–98.
Fox, J., 1999. Mountaintop removal in West Virginia: an environmental sacrifice zone. Organ. Environ. 12 (2), 163–183.
FracTracker Alliance. 2017. Oil & Gas Activity in Maryland. Available online: https://www.fractracker.org/map/us/maryland/. Accessed May 15th, 2018.
Frazier, R., 2018a. Pittsburgh Suburbs Decide as Fracking comes Near: Welcome It, or Resist? NPR StateImpact Pennsylvania, February 9. Accessed May 16, 2018. https://stateimpact.npr.org/pennsylvania/2018/02/09/pittsburgh-suburbs-decide-as-fracking-comes-near-welcome-it-or-resist/.
Frazier, R., 2018b. Penn Township Fracking Dispute Heads to Court, With State's Environmental Rights Amendment at Center of Lawsuit. NPR StateImpact Pennsylvania, April 9. Accessed May 16, 2018. https://stateimpact.npr.org/pennsylvania/2018/04/09/penn-township-fracking-dispute-heads-to-court-with-states-environmental-rights-amendment-at-center-of-lawsuit/.
Freudenburg, W.R., 1992. Addictive economies: extractive industries and vulnerable localities in a changing world economy. Rural Sociol. 57 (3), 305–332.
Freudenburg, W.R., Wilson, L.J., 2002. mining the data: analyzing the economic implications of mining for nonmetropolitan regions. Sociol. Inquiry 72 (4), 549–575.
Glenna, L., Babbie, K., Kelsey, T.W., DeLessio-Parson, A., 2014. Establishing a Baseline for Measuring Agricultural Changes Related to Marcellus Shale Development. Center for Rural Pennsylvania, Harrisburg, PA.
Goldstein, B.D., Kriesky, J., Pavliakova, B., 2012. Missing from the table: role of the environmental public health community in governmental advisory commissions related to Marcellus Shale drilling. Environ. Health Perspect. 120 (4), 483.
Grace, T., 2008. More than 1,500 sign gas leases. Dly. Star Published: August 01, 2008.
Graham, J., Irving, J., Tang, X., Sellers, S., Crisp, J., Horwitz, D., Muehlenbachs, L., Krupnick, A., Carey, D., 2015. Increased traffic accident rates associated with shale gas drilling in Pennsylvania. Accid. Anal. Prev. 74, 203–209.
Grann, D., 2017. Killers of the Flower Moon: The Osage Murders and the Birth of the FBI. Doubleday, New York.
Hagley, P., 2017. Empowerment, Uncertainty, and Perceived Impacts of Shale Energy Development in Eastern Ohio. M.S. Thesis. Environmental Science Graduate Program. The Ohio State University.
Hardy, K., Kelsey, T.W., 2015. Local income related to Marcellus Shale activity in Pennsylvania. Commun. Dev. 46 (4), 329–340.
Harper, J.A., 2008. The Marcellus Shale – an Old 'New' gas Reservoir in Pennsylvania. Pa. Geol. 38 (1), 2–13.
Heberlein, T., 2012. Navigating Environmental Attitudes. Oxford University Press, Oxford.
Hedding, K.J., 2017. Sources and framing of fracking: a content analysis of newspaper coverage in North Carolina, New York, and Pennsylvania. Environ. Commun. 11 (3), 370–385.
Heikkila, T., Weible, C., Pierce, J., 2014. Exploring the policy narratives and politics of hydraulic fracturing in New York. In: McBeth, M., Jones, M., Shanahan, E. (Eds.), The Science of Stories: Applications of the Narrative Policy Framework. Palgrave, New York, pp. 185–206.
Holifield, R., Day, M., 2017. A framework for a critical physical geography of 'sacrifice zones': physical landscapes and discursive spaces of frac sand mining in western Wisconsin. Geoforum 85, 269–279.
Hopey, D., 2017. Many allegheny County cities, municipalities unprepared for shale gas drilling rebound. Pittsburgh Post. Gazette May 29. Accessed May 16, 2018. http://www.post-gazette.com/local/region/2017/05/30/Marcellus-Shale-drilling-Allegheny-County-zoning-ordinance-pa/stories/201705240023.
Hoy, K.A., Xiarchos, I.M., Kelsey, T.W., Brasier, K.J., Glenna, L.L., 2018. Marcellus shale gas development and farming. Agric. Resour. Econ. Rev. 47, 1–31.
Jacquet, J.B., 2012. Landowner attitudes toward natural gas and wind farm development in northern Pennsylvania. Energy Policy 50, 677–688.
Jacquet, J.B., 2014. Review of Risks to Communities from Shale Energy Development. Environ. Sci. Technol. 48 (15), 8321–8333.
Jacquet, J.B., 2015. The rise of 'Private participation' in the planning of energy projects in the rural United States. Soc. Nat. Resour. 28 (3), 231–245.
Jacquet, J.B., Kay, D., 2014. The unconventional boomtown: updating the impact model to fit new spatial and temporal scales. J. Rural Community Development. 9 (1), 1–23.
Jacquet, J., Stedman, R.C., 2011. Natural gas landowner coalitions in New York State: emerging benefits of collective natural Resource management. J. Rural Soc. Sci. 26 (1), 62–91.
Jalbert, K., 2016. Building knowledge infrastructures for empowerment: a study of grassroots Water monitoring networks in the marcellus shale. Sci. Technol. Stud. 29 (2), 26–43.
Jalbert, K., 2017. In: Willow, A., Casagrande, D., Paladino, S. (Eds.), ExtrACTION: Impacts, Engagements, and Alternative Futures. Routledge, New York.
Jalbert, K., Kinchy, A., Perry, S., 2014. Civil society research and marcellus shale natural gas development: results of a survey of volunteer water monitoring organizations. J. Environ. Stud. Sci. 4 (1), 78–86.
Jalbert, K., Malone-Rubright, S., Edelstein, K., 2017. The civic informatics of FracTracker Alliance: working with communities to understand the unconventional oil and gas industry. Engaging Sci. Technol. Soc. 3 (0), 528–559.
Junod, A.N., Jacquet, J.B., Fernando, F., Flage, L., 2018. Life in the goldilocks zone: perceptions of place disruption on the periphery of the Bakken Shale. Soc. Nat. Resour. 31 (2), 200–217.
Kelly, S., 2018. Pennsylvania suspends mariner East 2 pipeline construction, citing sunoco's' egregious and willful' violations. Desmog January 3. Accessed May 16, 2018. https://www.desmogblog.com/2018/01/03/pennsylvania-suspends-mariner-east-ii-

fossil-fuel-pipeline-work-citing-egregious-and-willful-law-violations-sunoco.
Kelsey, T., Hartman, W., Schafft, K.A., Borlu, Y., Costanzo, C., 2012a. Marcellus Shale Gas Development and Pennsylvania School Districts: What Are the Implications for School Expendi tures and Tax Revenues? Penn State Cooperative Extension. Marcellus Education Fact Sheet. .
Kelsey, T.W., Metcalf, A., Salcedo, R., 2012b. Marcellus Shale: Land Ownership, Local Voice, and the Distribution of Lease and Royalty Dollars. Center for Economic and Community Development White Paper Series. Penn State University, University Park, PA.
Kenneally, M.E., Mathes, T.M., 2010. Natural gas production and municipal home rule in New York. New York Zoning Law Pract. Rep. 10 (4), 1–4.
Kennedy, A., Schafft, K.A., Howard, T., 2017. Taking away David's sling: environmental justice in land use conflicts over natural resource extraction in Australia's Mount thorley-Warkworth open-cut coal mine and Pennsylvania's Marcellus Shale gas fields. Local. Environ. 22 (8), 952–968. https://doi.org/10.1080/13549839.2017.1309369.
Kenwood, T., 2006. Town Gets More than Money in Energy Boom. USA Today Published March 13th, 2006.
Kinneman, T.C., 2011. The economic impact of Shale gas extraction: a review of existing studies. Ecol. Econ. 70 (7), 1243–1249.
Komarek, T., 2016. Labor market dynamics and the unconventional natural gas boom: evidence from the Marcellus Region. Resour. Energy Econ. 45 (8), 1–17.
Krupnick, A., Gordon, H., Olmstead, S.M., 2013. Pathways to Dialogue – What the Experts Say About the Environmental Risks of Shale Gas Development. Resources for the Future, Washington, DC.
Ladlee, J., Jacquet, J., 2011. The Implications of Multi-Well Pads in the Marcellus Shale. Research and Policy Brief Series. Issue 43. September. CARDI, Ithaca, NY.
Lave, R., Lutz, B., 2014. Hydraulic fracturing: a critical physical geography review. Geogr. Compass 8 (10), 739–754.
Leadbeater, D. (Ed.), 2014. Resources, Empire & Labour: Crises, Lessons & Alternatives. Fernwood Publishing, Halifax.
Lewis, R., 1993. Appalachian restructuring in historical perspective: coal, culture and social change in West Virginia. Urban Stud. 30 (2), 299–308.
Litvak, A., 2018. Residents ask whether the proposed Shell ethane pipeline is an acceptable risk. Pittsburgh Post. Gazette April 4. Accessed May 16, 2018. http://www.post-gazette.com/powersource/companies/2018/04/04/Shell-ethane-pipeline-risks-residents-debate-DEP-hearing-pennsylvania-beaver-county/stories/201804030194.
Lobao, L., Zhou, M., Partridge, M., Betz, M., 2016. Poverty, place, and coal employment across appalachia and the United States in a New economic era. Rural Sociol. 81 (3), 343–386.
Lutz, B.D., Lewis, A.N., Doyle, M.W., 2013. Generation, transport, and disposal of wastewater associated with marcellus shale gas development. Water Resour. Res. 49, 647–656. https://doi.org/10.1002/wrcr.20096.
Malone, S., Kelso, M., Michanowicz, D., Ferrar, K., Shields, K.N., Kriesky, J., 2012. FracTracker survey and case studies: application for participatory GIS in unconventional natural gas development. Environ. Pract. 14 (4), 342–351.
Maloney, K.O., Yoxtheimer, D.A., 2012. Production and disposal of waste and materials from gas and oil extraction from the Marcellus Shale play in Pennsylvania. Environ. Pract. 14 (4), 278–287.
Masur, D., Coffman, C., Lenker, B., Kelso, M., Malone, S., 2015. Danger Around the Bend: The Threat of Oil Trains in Pennsylvania. PennEnvironment Report. Accessed May 16, 2018. . http://www.fractracker.org/2015/03/danger-around-bend/.
Matz, J., Renfrew, D., 2015. Selling 'Fracking': energy in depth and the Marcellus Shale. Environ. Commun. 9 (3), 288–306.
Matz, J.R., Wylie, S., Kriesky, J., 2017. Participatory air monitoring in the midst of uncertainty: residents' experiences with the speck sensor. Eng. Sci. Technol. Soc. 3 (0), 464–498.
Mazur, A., 2016. How did the fracking controversy emerge in the period 2010-2012? Public Underst. Sci. 25 (2), 207–222.
McGraw, S., 2011. The End of Country. Random House, New York.
McHenry-Sorber, E., Schafft, K.A., Burfoot-Rochford, I., Hall, D., 2016. The masculinized work of energy development: unequal opportunities and risks for women in Pennsylvania shale gas boomtown communities. J. Rural Soc. Sci. 31 (1), 1–23.
McLaughlin, D., Rhubart, D., DeLessio-Parson, A., Brasier, K., Babbie, K., Leach, M., 2014. Population Change and Marcellus Shale Development. Center for Rural Pennsylvania, Harrisburg.
McLaughlin, D.K., Corra, J., Hagedorn, A.D., Wang, D., 2017. Does Marcellus Shale natural gas extraction affect how much youth in rural Pennsylvania like their Community? Rural Sociol. 82 (4), 772–799.
Metze, T., Dodge, J., 2016. Dynamic discourse coalitions on hydro-fracking in Europe and the United States. Environ. Commun. 10 (3), 365–379.
Meyers, D., Walker, E.M., Vollmer, M., 2017. Carrying Coal to Columbus: Mining the Hocking Valley. The History Press, Charleston.
Milici, R., The Coalprod Database: Historical Production Data For The Major Coal-Producing Regions Of The Conterminous United States. 1996. United States Geological Survey. 1997. Retrieved https://pubs.usgs.gov/of/1997/of97-447/Appalachian.htm on July 1st, 2018.
Molofsky, L.J., Connor, J.A., Wylie, A.S., Wagner, T., Farhat, S.K., 2013. Evaluation of Methance Sources in Groundwater in Northeastern Pennsylvania. Groundwater 51 (3), 333–349.
Monnat, S.M., Ely, D.M., Suchyta, M., Chandler, R.F., Hesse, A., 2017. Health Insurance Coverage, Health Care Utilization, and Health Outcomes within the Context of Marcellus Shale Development. Center for Rural Pennsylvania, Harrisburg, PA.
Munasib, A., Rickman, D., 2015. Regional economic impacts of the Shale gas and tight oil boom: a synthetic control analysis. Region. Sci. Urban Econ. 50 (1), 1–17.
Murtazashvili, I., 2015. Origins and consequences of State-level variation in shale regulation: the cases of Pennsylvania and New York. Economics of Unconventional Shale Gas Development, Natural Resource Management and Policy. Springer, Cham, pp. 179–201.
New York Department of Environmental Conservation (NY DEC), 2018. Division of Mineral Resources' Oil and Gas Well Permit Files. Retrieved from:. on March 9, 2018. https://www.dec.ny.gov/energy/30438.html.
Nobel, J., 2018. Pipeline protesters take to the trees. Rolling Stone Magazine May 14. Accessed May 16, 2018. https://www.rollingstone.com/politics/news/pipeline-protestors-trees-w520215.
Ogneva-Himmelberger, Y., Huang, L., 2015. Spatial distribution of unconventional gas wells and human populations in the Marcellus Shale in the United States: vulnerability analysis. Appl. Geogr. 60, 165–174.
Ohio Department of Natural Resources, 2015. 2015 Report on Mineral Industries: An Annual Summary of the State's Economic Geology. Retrieved from:. on January 10, 2018. http://geosurvey.ohiodnr.gov/portals/geosurvey/PDFs/Mineral_Industries_Reports/MinInd15.pdf.
Ohio Department of Natural Resources (ODNR), 2018. Division of Oil and Gas Well Locator. Retrieved from:. on March 9, 2018. https://gis.ohiodnr.gov/MapViewer/?config=oilgaswells.
Ohio Environmental Council, 2015. Fracking: What Is Fracking? Retrieved from:. http://www.theoec.org/Fracking.
Olmstead, S.M., Muehlenbachs, L.A., Shih, J., Chu, Z., Krupnick, A., 2013. Shale gas development impacts on surface water quality in Pennsylvania. Proc. Natl. Acad. Sci. 110 (13), 4962–4967.
Paredes, D., Komarek, T., Loveridge, S., 2015. Income and employment effects of Shale gas extraction windfalls: evidence from the Marcellus region. Energy Econ. 47 (1), 112–120.
Patterson, L.A., Maloney, K.O., 2016. Transport of hydraulic fracturing waste from Pennsylvania Wells: a County-level analysis of road use and associated road repair costs. J. Environ. Manage. 181, 353–362.
Paydar, N.H., Clark, A., Rupp, J.A., Graham, J.D., 2016. Fee disbursements and the local acceptance of unconventional gas development: insights from Pennsylvania. Energy Res. Soc. Sci. 20, 31–44.
Peck, A., Identity-Based Conflicts in Public Policy: Hydraulic Fracturing in Pennsylvania. University of Pittsburgh Law Review, Forthcoming.
Pennsylvania Department of Environmental Protection (PA DEP), 2018. Oil and Gas Reports. Retrieved from:. on March 9, 2018. http://www.depreportingservices.state.pa.us/ReportServer/Pages/ReportViewer.aspx?/Oil_Gas/Wells_Drilled_By_County.
Pennsylvania Public Utility Commission (PA PUC), 2017. Act 13. Retrieved from:. on May 10, 2018. https://www.act13-reporting.puc.pa.gov/Modules/PublicReporting/Overview.aspx.
Perdue, R.T., Pavela, G., 2012. Addictive Economies and Coal Dependency: Methods of Extraction and Socioeconomic Outcomes in West Virginia, 1997–2009. Organ. Environ. 25 (4), 368–384.
Perry, S., 2012. Development, land use, and collective trauma: the Marcellus Shale Gas Boom in Rural Pennsylvania. J. Cult. Agric. 34 (1), 81–92.
Platt, R.V., Manthos, D., Amos, J., 2018. Estimating the creation and removal date of fracking ponds using trend analysis of landsat imagery. Environ. Manag. 2. https://doi.org/10.1007/s00267-017-0983-4.
Purdy, J.S., 2011. Afterword: An American Sacrifice Zone. In: Morrone, M., Buckley, G.L., Davis, D.E., Purdy, J. (Eds.), Mountains of Injustice. Ohio University Press, Athens, OH.
Rabinowitz, P.M., Slizovskiy, I.B., Lamers, V., Trufan, S.J., Holford, T.R., Dziura, J.D., et al., 2015. Proximity to natural gas wells and reported health status: results of a household survey in Washington County, Pennsylvania. Environ. Health Perspect. 123 (1), 21.
Richardson, Nathan, Gottlieb, Madeline, Krupnick, Alan, Wiseman, Hannah, 2013. The State of State Shale Gas Regulation. Resources for the Future.
Rinfret, S., Cook, J.J., Pautz, M.C., 2014. Understanding State rulemaking processes: developing fracking rules in Colorado, New York, and Ohio. Rev. Policy Res. 31 (2), 88–104.
Ridlington, E., Richardson, R., Ferrar, K., 2016. Dangerous and Close: Fracking Puts the Nation's Most Vulnerable People at Risk. Environment Colorado, Denver. Retrieved from https://environmentcolorado.org/sites/environment/files/reports/CO_dangerous_scrn.pdf July 1st, 2018.
Rosa, E., Machlis, G., Keating, K., 1988. Energy and society. Annu. Rev. Sociol. 14, 149–172.
Ryser, L., Halseth, G., 2011. Housing costs in an oil and gas boom town: issues for low-income senior women living alone. J. Hous. For. Elder. 25 (3), 306–325.
Sangaramoorthy, T., Jamison, A., Boyle, M., Payne-Sturges, D., Sapkota, A., Milton, D., Wilson, S., 2016. Place-based perceptions of the impacts of fracking along the Marcellus Shale. Soc. Sci. Med. 151, 27–37.
Schafft, K.A., Biddle, C., 2013. Youth Perspectives on Marcellus Shale Gas Development: Community Change and Future Prospects. Report submitted to The Center for Rural Pennsylvania, Harrisburg, PA. .
Schafft, K.A., Glenna, L.L., Borlu, Y., Green, B., 2012. Marcellus Shale Gas Development: What Does It Mean for Pennsylvania Schools? Penn State Cooperative Extension. Marcellus Education Fact Sheet. .
Schafft, K.A., Kotok, S., Biddle, C., 2013a. Marcellus Shale Gas Development and the Impacts on Pennsylvania Schools and Education. Report submitted to The Center for Rural Pennsylvania, Harrisburg, PA. .
Schafft, K.A., Borlu, Y., Glenna, L.L., 2013b. The relationship between Marcellus Shale gas development in Pennsylvania and local perceptions of risk and opportunity. Rural Sociol. 78 (2), 143–166.
Schafft, K.A., McHenry-Sorber, E., Hall, D., Burfoot-Rochford, I., 2017. Busted amidst the boom: the creation of new insecurities and inequalities within Pennsylvania's shale

gas boomtowns. Rural Sociol. https://doi.org/10.1111/ruso.12196.
ShaleShock, 2008. Shaleshock.org. Website as of January 1st 2009. Retrieved 3.12.18 from. https://web.archive.org/web/20090101172842/http://www.shaleshock.org:80.
Simonelli, J., 2014. Home rule and natural gas development in New York: civil fracking rights. J. Political Ecol. 21 (1), 258–278.
Sneegas, G., 2016. Media representations of hydraulic fracturing and agriculture: a New York case study. The Extractive Industries Society 3 (1), 95–102.
Spence, D., 2015. The political economy of local vetoes. Tex. Law Rev. 93 (2), 351–413.
Spencer, J.A., Camp, M.J., 2008. Ohio Oil and Gas. Arcadia Publishing, Charleston.
Staub, J., 2015. The outlook for U.S. Natural gas: an uncertain outlook for U.S. and world. For the 2015 EIA Energy Conference. Retrieved from: https://www.eia.gov/conference/2015/pdf/presentations/staub.pdf on March 12, 2018.
Staggenborg, S., 2018. Mobilizing against Fracking: Marcellus Shale Protest in Pittsburgh. In: Ladd, A. (Ed.), Fractured Communities: Risk, Impacts, and Protest Against Hydraulic Fracturing in U.S. Shale Regions. Rutgers University Press, New Brunswick, pp. 107–127.
Stedman, R.C., Jacquet, J.B., Filteau, M.R., Willits, F.K., Brasier, K.J., McLaughlin, D.K., 2012. Marcellus Shale gas development and new boomtown research: views of New York and Pennsylvania residents. J. Environ. Pract. 14 (4), 287–298.
Thomas, A.R., Smith, P.J., 2009. Upstate Down: Thinking About New York and Its Discontents. University Press of America, Lantham, Maryland.
Thomas, M., Pidgeon, N., Evensen, D., Partridge, T., Hasell, A., Enders, C., Herr Harthorn, B., Bradshaw, M., 2017. Public perceptions of hydraulic fracturing for shale gas and oil in the United States and Canada. WIREs Clim. Change 8, e450. https://doi.org/10.1002/wcc.450.
Tickamyer, A.R., Duncan, C.M., 1990. Poverty and opportunity structure in rural America. Annu. Rev. Sociol. 16, 67–86.
Troutman, M.A., Shamer, S., Pribanic, J.B., Public Herald. Published January 23rd, 2017. Retrieved July 1st 2018. Retrieved from http://publicherald.org/hidden-data-suggests-fracking-created-widespread-systemic-impact-in-pennsylvania/.
U.S. Energy Information Administration, 2012. Annual Energy Outlook 2012 Early Release Overview. U.S. Department of Energy, Washington, D.C.
U.S. Energy Information Administration, 2014. High Value of Liquids Drives U.S. Producers to Target Wet Natural Gas Resources. Retrieved from:. on March 12, 2018. https://www.eia.gov/todayinenergy/detail.php?id=16191.
U.S. Energy Information Administration, 2017a. Utica Shale Play Geology Review. April. Retrieved from:. on January 7, 2018. https://www.eia.gov/maps/pdf/UticaShalePlayReport_April2017.pdf.
U.S. Energy Information Administration, 2017b. Ohio State Profile Energy Estimates. Retrieved from:. on January 16, 2018. https://www.eia.gov/state/analysis.php?sid=OH.
U.S. Energy Information Administration, 2017c. West Virginia State Profile Energy Estimates. Retrieved from:. on January 16, 2018. https://www.eia.gov/state/analysis.php?sid=WV#14.
U.S. Energy Information Administration, 2018a. Drilling Productivity Report Data. Retrieved from:. on March 12, 2018. https://www.eia.gov/petroleum/drilling/xls/dpr-data.xlsx.
U.S. Energy Information Administration, 2018b. Annual Energy Outlook. Retrieved from:. on March 12, 2018. https://www.eia.gov/outlooks/aeo/.
Vasi, I.B., 2018. This (gas) Land is your (truth) Land? Documentary films and cultural fracturing in prominent Shale communities. In: Ladd, Anthony E. (Ed.), Fractured Communities. Rutgers Uniersity Press, New Brunswick.
Vasi, I.B., Walker, E.T., Johnson, J.S., Tan, H.F., 2015. No fracking Way!' Documentary film, discursive opportunity, and local opposition against hydraulic fracturing in the United States, 2010 to 2013. Am. Sociol. Rev. 80 (5), 934–959.
Vidic, R.C., Brantley, S.L., Vandenbossche, J.M., Yoxtheimer, D., Abad, J.D., 2013. Impact of shale gas development on regional Water quality. Science 340 (6134), 826–835.
Walsh, B., 2012. How the Sierra club took millions from the natural gas industry—and why they stopped. Time February 2nd.
Waples, D.A., 2012. The Natural Gas Industry in Appalachia, 2nd ed. McFarland & Company. Inc., Jefferson, NC.
Weber, J.G., Hitaj, C., 2015. What can we learn about shale gas development from land values? Opportunities, challenges, and evidence from Texas and Pennsylvania. Agric. Resour. Econ. Rev. 44 (2), 40–58.
Weber, J.G., Burnett, J.W., Xiarchos, I.M., 2016. Broadening benefits from natural Resource extraction: housing values and taxation of natural gas wells as property. J. Policy Anal. Manage. 35 (3), 587–614.
Weible, C.M., Heikkila, T., 2016. Comparing the politics of hydraulic fracturing in New York, Colorado, and Texas. Rev. Policy Res. 33, 232–250. https://doi.org/10.1111/ropr.12170.
Weidner, K., 2013. Natural Gas Exploration: A Landowner's Guide to Leasing Land in Pennsylvania. Penn State Cooperative Extension. Marcellus Education Fact Sheet. .
Weinstein, B.L., Clower, T., 2009. Potential Economic and Fiscal Impacts from Natural Gas Production in Broome County: Preliminary Report for Broome County Legislators. Brome County, New York. .
Weinstein, A., Partridge, M., 2011. The Economic Value of Shale Natural Gas in Ohio: The Ohio State University Swank Program in Rural-Urban Policy Summary and Report. Retreived from:. Ohio Agricultural Research Center on January 11, 2018. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.431.2299&rep=rep1&type=pdf.
West Virginia Department of Environmental Protection (WV DEP), 2018. Office of Oil and Gas. Retreived from:. on March 9, 2018. https://tagis.dep.wv.gov/oog/.
Wilber, T., 2008. Landowners at Crossroads With Sudden Prosperity. Press & Sun Bulletin (New York) Sep 28, 2008.
Wilber, T., 2012. Under the Surface: Fracking, Fortunes, and the Fate of Marcellus Shale. Cornell University Press, Ithaca, NY.
Wildermuth, G., 2018. Marcellus Shale Landowner Coalitions: Form, Function, and Impact (Master'S Thesis). The Pennsylvania State University 2018.
Williamson, J., Kolb, B., 2011. Marcellus Natural Gas Development's Effect on Housing in Pennsylvania. Lycoming College Center for the Study of Community and the Economy, Williamsport, PA.
Willits, F.K., Brasier, K., Filteau, M., Jacquet, J., McLaughlin, D.K., Stedman, R., 2010. Community Satisfaction and Change: A Study of Communities in the Marcellus Shale Region. University Park, PA, Penn State. .
Willow, A.J., 2014. The new politics of environmental degradation: Un/expected landscapes of disempowerment and vulnerability. J. Political Ecol. 21, 237–257.
Willow, A.J., Wylie, S., 2014. Politics, ecology, and the new anthropology of energy: exploring the emerging frontiers of hydraulic fracking. J. Political Ecol. 21, 222–236.
Willow, A.J., Zak, R., Vilaplana, D., Sheeley, D., 2018. The contested landscape of unconventional energy development: a report from Ohio's Shale gas country. J. Environ. Stud. Sci. 4 (1), 56–64.
Wrenn, D.H., Kelsey, T.W., Jaenicke, E.C., 2015. Resident vs. Nonresident employment associated with marcellus shale development. Agric. Resour. Econ. Rev. 44 (2), 1–19.
Wylie, S., Schultz, K., Thomas, D., Kassotis, C., Nagel, S., 2016. Inspiring collaboration: the legacy of Theo Colborn's transdisciplinary research on fracking. New. Solutions A J. Environ. Occup. Health Policy 26 (3), 360–388.
Ziemkiewicz, P., Quaranta, J., McCawley, M., 2014. Practical measures for reducing the risk of environmental contamination in shale energy production. Environ. Sci. Processes Impacts 16, 1692–1699.
Zirogiannis, N., Alcorn, J., Rupp, J., Carley, S., Graham, J.D., 2016. State regulation of unconventional gas development in the U.S.: An empirical evaluation. Energy Res. Soc. Sci. 11, 142–154.