

The impacts of shale natural gas energy development on outdoor recreation: A statewide assessment of pennsylvanians



Michael D. Ferguson^{a,*}, Myles L. Lynch^b, Samantha L. Powers^c, Austin G. Barrett^d,
Darrick Evensen^e, Alan R. Graefe^f, Andrew J. Mowen^g

^a Recreation Management and Policy, 193 Hewitt Hall, University of New Hampshire, Durham, NH, 03823, USA

^b Department of Education, Morrill Hall, 62 College Road, University of New Hampshire, Durham, NH, 03824, USA

^c Parks, and Tourism Management, 813 Ford Building, The Pennsylvania State University, University Park, PA, 16802, USA

^d Independent Scholar, Greenville, SC, USA

^e Politics and International Relations, 22 George Square, Room B.2, University of Edinburgh, Edinburgh, Scotland, EH8 9LF, UK

^f Park, and Tourism Management, 701J Ford Building, The Pennsylvania State University, University Park, PA, 16802, USA

^g Parks, and Tourism Management, 704A Ford Building, The Pennsylvania State University, University Park, PA, 16802, USA

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ABSTRACT

This mixed-methods study examined the impacts of shale natural gas energy development (SGD) related activities upon outdoor recreation in Pennsylvania. Much of the ongoing and proposed SGD infrastructure in Pennsylvania is located either within or adjacent to public lands, waters, and protected areas, raising concerns about the potential environmental and social impacts upon recreation stakeholders. The extensive body of SGD research within the United States has suggested there are numerous positive and negative impacts upon the general public. Yet, the impact of SGD upon outdoor recreation users remains unclear. While SGD impacts are becoming progressively evident to both recreationists and natural resource managers, few studies have sought to specifically assess the extent to which SGD alters outdoor recreation behaviors, experiences, and activities. This statewide survey of Pennsylvanians ($n = 2240$) found that 23.4% of respondents had encountered SGD related activities while participating in outdoor recreation. Study findings also noted that 13.8% of respondents had changed their outdoor recreation behaviors or experiences as a result of encountering SGD related activities. Moreover, a sub-sample, representing 12.3% of respondents, identified specific SGD related impacts (e.g., aesthetic, environmental, infrastructure) upon their outdoor recreation behaviors, experience, and activities which sometimes resulted in substitution behaviors and/or a lack of perceived 'fit' between the energy development and the landscape and environment. From a policy and management standpoint, study findings highlight the specific and nuanced impacts of SGD upon certain sub-populations of outdoor recreationists as well as the importance of assessing and communicating recreation experience and use impacts to all recreationists when planning, developing, and managing SGD and related decisions in the United States.

Management Implications: This study found that only a small population of Pennsylvania outdoor recreationists were impacted by SGD related activities. In the regions of Pennsylvania where SGD was most prominent (e.g., North Central and Southwest), outdoor recreation impacts were considerably higher. Moreover, a sub-sample of respondents found that SGD impacted their outdoor recreation behaviors, their in situ recreation experiences, and/or the environmental setting and landscape in which they recreated. Study findings suggest a two-tiered communication approach, accounting for perceptions of both behavioral and/or landscape environmental quality impacts, may be the most comprehensive strategy for addressing and communicating the impacts of SGD upon outdoor recreationists.

1. Introduction

As the demand for energy production in the United States continues to increase, shale natural gas energy development (SGD) remains one of

the most viable and abundant domestic options (Loomis & Haeefe, 2017). In recent years, SGD has taken the United States by storm due largely to its economic feasibility and vast energy potential. Specifically, the Northeast region of the United States has seen the most

* Corresponding author.

E-mail addresses: Michael.Ferguson@unh.edu (M.D. Ferguson), Myles.Lynch@unh.edu (M.L. Lynch), slp408@psu.edu (S.L. Powers), AustinGordonBarrett@gmail.com (A.G. Barrett), darrick.evensen@ed.ac.uk (D. Evensen), gyu@psu.edu (A.R. Graefe), amowen@psu.edu (A.J. Mowen).

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dramatic increase in SGD, with the region expanding from a few negligible wells a decade ago, to one of the largest producers of natural gas in the world today (U.S. EIA, 2018). The Marcellus Shale of Pennsylvania has largely driven this development with more than 10,000 wells drilled in Pennsylvania between 2005 and 2017, producing more than 25 trillion cubic feet of natural gas (Exec, 2015). The influence of the Marcellus Shale and the levels of development in Pennsylvania are expected to steadily increase. Over the next 30 years, SGD is projected to more than double in production, with the majority of growth coming from the Northeast region of the United States (U.S. EIA, 2018).

Researchers, natural resource managers, and the general public have noted the effects of SGD upon local communities and landscapes. Studies have broadly found that individuals affected by SGD often reveal a host of negative social, environmental, and infrastructure impacts (Brasier et al., 2011; Lorig, 2016; Jacquet & Stedman, 2013a; Schafft & Biddle, 2015; Thomas et al., 2017; Weigle, 2010). Research has also shown the positive impacts of SGD which largely revolve around notions of economic prosperity and energy independence (Brasier et al., 2011; Kinnaman, 2011; Rahm, Fields, & Farmer, 2015; Thomas et al., 2017; Willits, Brasier, Ooms, Tracewski, & Stedman, 2008). While the majority of SGD research has broadly focused on environmental, economic, and social impacts, attention has also turned towards perceptions of SGD risks, benefits, and impacts across specific populations (Clough & Bell, 2016; Evensen, 2015).

SGD currently takes place on both public and private lands within the United States. Much of the current and proposed SGD infrastructure operates either within or adjacent to public lands, waters, and protected areas, raising concerns about the potential impacts upon outdoor recreation stakeholders. The literature has suggested that outdoor recreation may be impacted by SGD, but to date, no studies have specifically assessed this phenomenon amongst a statewide population sample. This study found that nearly one-quarter (23.4%) of Pennsylvania residents had encountered SGD related activities while participating in outdoor recreation and that 13.8% of residents had changed their outdoor recreation behaviors and experiences as a result of encountering SGD in Pennsylvania. Moreover, a sub-sample of study respondents qualitatively identified SGD related impacts upon their outdoor recreation behaviors, experience, and activities which often resulted in substitution behaviors and/or a lack of perceived 'fit' between the energy development and the landscape and environment. This study highlights the specific and nuanced impacts of SGD upon outdoor recreationists as well as the importance of assessing and communicating recreation experience and use impacts when planning, developing, and managing SGD and related decisions in the United States.

2. Literature review

2.1. Shale natural gas energy development

SGD is the largest energy sector in the United States, representing 31% of overall domestic energy production in 2017 (U.S. EIA, 2017b). Conventional shallow-well natural gas energy development has produced slow and consistent natural gas in the United States for over a century. However, recent technological advances have allowed for the efficient and cost effective extraction of shale natural gas reserves via unconventional hydraulic fracturing (Considine, Considine, & Watson, 2016; U.S. EIA, 2017a). Unconventional hydraulic fracturing (commonly referred to as 'fracking') utilizes the high-pressure injection of water, sand, and chemicals (e.g., 'frack fluids') into a wellbore to create cracks and fissures in deep-rock formations where natural gas and oil can flow more freely to the surface for collection (Rahm et al., 2015; Thomas et al., 2017). This intensely industrial process requires millions of gallons of freshwater, chemicals, and fuel as well as hundreds of skilled laborers (Cooley, Donnelly, Ross, & Luu, 2012). The scale, volume, and overall success of the SGD boom in the United States has

largely been attributed to the economic feasibility of unconventional hydraulic fracturing and its perceived ability to provide domestic energy independence from foreign providers (Lorig, 2016; Thomas et al., 2017).

There are numerous SGD regions within the United States, all of which vary in size, scale, scope, and levels of production and output. For instance, the Haynesville Shale of Eastern Texas, Louisiana, and Arkansas encompasses approximately 5.8 million acres and an estimated 75 trillion cubic feet of natural gas (Exec, 2015). The Barnett Shale of Central Texas contains an estimated 43 trillion cubic feet of natural gas and spans approximately 3.2 million acres (Exec, 2015). Additionally, the Fayetteville Shale of Arkansas and Oklahoma contains an estimated 32 trillion cubic feet of natural gas and spans approximately 3.7 million acres (Exec, 2015). The combined technological and geopolitical advances in SGD have allowed the United States to become the world's largest producer of natural gas, with Texas and Pennsylvania leading domestic production (Considine et al., 2016; Thomas et al., 2017; U.S. EIA, 2018).

2.2. Marcellus Shale natural gas energy development

The Marcellus Shale is a geological formation containing vast natural gas deposits below sections of five Northeastern states: Pennsylvania, New York, West Virginia, Ohio, and Maryland. This Marcellus Shale 'play' is one of the largest in the world, encompassing approximately 34 million acres and an estimated 500 trillion cubic feet of natural gas (Brasier et al., 2011; Considine et al., 2016). The combination of cost effective unconventional hydraulic fracturing, large scale capital investments, and increasing energy prices has led to a recent surge in SGD (Brasier et al., 2011; Considine et al., 2016). The majority of this SGD has occurred on the public and private lands of Pennsylvania where the "open for business" political mentality has led to the permitting of more than 16,000 wells between 2004 and 2015 (Brasier et al., 2011; Considine et al., 2016; Lorig, 2016; PA MCOR, 2018).

The Pennsylvania portion of the Marcellus Shale lies beneath approximately 1.5 million acres of the 2.2-million-acre Pennsylvania State Forest system (PA DCNR, 2017). This public lands system is managed by the Pennsylvania Department of Conservation and Natural Resources, 2017, 2019 (DCNR) who owns approximately 80% of the sub-surface rights below the State Forests system (PA DCNR, 2017; Rohrs, 2017). Since 2008, the DCNR has approved 1026 SGD wells on Pennsylvania State Forest lands, of which 646 have been drilled; generating approximately \$545 million in royalty revenue (PA DCNR, 2017). In response to mounting political pressure, Pennsylvania Governor Tom Wolf issued an executive order in 2015 that established a moratorium on new SGD leases within Pennsylvania public lands. Among other things, executive order 2015-03 referenced the presence of substantial recreation impacts on public lands including the clearing of forests, the loss of scenic vistas, noise pollution, heavy truck traffic, hiking and snowmobile trail conflicts, and overall intrusions and degradation upon the outdoor recreation experience (Executive Order No. 2015-03, 2015).

While unconventional hydraulic fracturing has been a relatively recent natural resource extraction advancement, Pennsylvania has a rich and thorough history of extractive industries (PA DCNR, 2019). Over the past two centuries, Pennsylvania has been a leader in surface and underground coal mining, stone quarry extraction, and shallow well natural gas extraction (PA DCNR, 2019; Pennsylvania Independent Oil and Gas Association, 2019). In fact, in 1859, the world's first commercial oil well was established in Venango County Pennsylvania (PA DCNR, 2019). Moreover, since its permitting in 1947, a significant portion of oil and natural gas development has occurred within Pennsylvania State Forests (PA DCNR, 2019). Thus, Pennsylvania's abundant sub-surface natural resources, complex land ownership policies, and landscape ethic have resulted in significant resource extraction over the

past century.

2.3. Perceived positive impacts of shale natural gas energy development

Research has found that perceptions of SGD can vary markedly based on factors such as social class, age, gender, population density, exposure, proximity, political orientation, direct benefit, and knowledge (Brasier et al., 2011; Ladd, 2013; Theodori, 2009; Thomas et al., 2017; Willits et al., 2008). Studies have also suggested that the primary positive impacts of SGD in Pennsylvania often stem from the concepts of economic prosperity and energy independence (Brasier et al., 2011; Thomas et al., 2017; Willits et al., 2008). For example, Willits et al. (2008) found that 84% of Pennsylvania residents felt SGD was essential to their state's economy. Brown et al. (2013) suggested that economic stimulus and the concept of energy independence from foreign sources were viewed as the primary positive benefits of SGD amongst Pennsylvanians. Thus, research has demonstrated that SGD has in many instances enhanced local economies and provided substantial domestic energy production, both of which have been perceived positively by the general public (Brasier et al., 2011; Theodori, 2009; Thomas et al., 2017; Willits et al., 2008; U.S. Exec, 2015).

2.4. Perceived negative impacts of shale natural gas energy development

Research has suggested there are numerous negative social, environmental, and infrastructure, impacts associated with SGD. For instance, social impacts related to safety, crime, stress, and individual and overall community health are frequently cited within the SGD literature (Brasier et al., 2011; Ferrar et al., 2013; Junod, Jacquet, Fernando, & Flage, 2018; Theodori, 2009; Thomas et al., 2017). Environmental impacts such as water, noise, light, and air pollution, forest clearing, wildlife habitat fragmentation, spills, leaks, and large scale water consumption are also commonly cited within SGD research (Considine et al., 2016; Cooley et al., 2012; Lorig, 2016; Schafft & Biddle, 2015; Thomas et al., 2017; Weigle, 2010). Additionally, infrastructure impacts such as heavy truck traffic, road degradation, vehicular accidents, traffic safety, and strained public services as well as the creation of well pads, access roads, and pipeline corridors are also common within the SGD process (Brasier et al., 2011; Jacquet & Stedman, 2013a; Schafft & Biddle, 2015; Theodori, 2009; Thomas et al., 2017). Thus, studies have demonstrated that numerous social, environmental, and infrastructure impacts may negatively influence perceptions of SGD (Brasier et al., 2011; Considine et al., 2016; Ferrar et al., 2013; Junod et al., 2018; Theodori, 2009; Thomas et al., 2017).

2.5. Recreationists' perceived impacts of shale natural gas energy development

Much of the ongoing and proposed SGD infrastructure in Pennsylvania is located either within or adjacent to public lands, waters, and protected areas, raising concerns about the potential social, environmental, and infrastructure impacts upon recreation stakeholders. These perceived impacts are of paramount concern for recreationists within the Pennsylvania public land systems. Research has suggested that outdoor recreationists may be predisposed to pro-environmental values and that these values may lead recreationists to avoid or substitute areas within or adjacent to industrialized energy development and/or perceive a lack of 'fit' between the energy development and the landscape and environment (Brownlee et al., 2015; Ferguson et al., 2018b; Jacquet & Stedman, 2013b; Kellison, Bunds, Casper, & Newman, 2017; Rasch, Reeves, & Sorenson, 2018; Stedman, 2002; 2003). Further, many of the rural economies within Pennsylvania are dependent upon recreation and tourism expenditures, and SGD may negatively affect the scale and volume of visitors to these rural areas (Rasch et al., 2018; Weigle, 2010). For instance, research has suggested hunting and fishing difficulties due to wildlife dispersion, strains on

camping, hotels, and accommodation availability due to the influx of SGD workers, and alterations to natural landscapes negatively influencing recreationists decisions to visit Pennsylvania public lands (Brasier et al., 2011; Evensen & Stedman, 2017; Ladd, 2013; Rasch et al., 2018; Rumbach, 2011; Weigle, 2010).

As demonstrated, a multitude of research has examined the general public's perceptions of SGD. Within these studies, outdoor recreation and recreationists' perceptions of SGD are often treated as a secondary pursuit or afterthought. Yet, numerous studies have suggested the importance of understanding the perceptions of SGD impacts upon outdoor recreation populations and their associated activities (Evensen & Stedman, 2017; Kellison et al., 2017; Stedman et al., 2012; Weigle, 2010). Research has proposed that SGD may impact the overall experience for outdoor recreationists and that it may alter outdoor recreation behaviors (Evensen & Stedman, 2017; Kellison et al., 2017; Rasch et al., 2018; Stedman et al., 2012; Weigle, 2010). While this concept garners intuitive appeal, it lacks empirical evidence. Outdoor recreationists are unique community stakeholders within the SGD process due to their potential firsthand interaction with this form of energy development. While the literature has suggested that outdoor recreation may be impacted by SGD, no studies have directly examined this phenomenon amongst a statewide population sample. A better understanding of these relationships may help to shape strategies to communicate and engage outdoor recreationists in the SGD process.

3. Methods

3.1. Research questions

- R1 To what extent have outdoor recreationists encountered SGD while recreating in Pennsylvania, and how does this vary across regions within the state?
- R2 To what extent have outdoor recreationists altered their outdoor recreation behaviors and experiences as a result of encountering SGD while recreating in Pennsylvania, and how does this vary across regions within the state?
- R3 How have outdoor recreationists been impacted by SGD while recreating in Pennsylvania?

3.2. Study context – Pennsylvania and the statewide comprehensive outdoor recreation plan

The state of Pennsylvania is home to a multitude of public parks and protected areas that provide abundant outdoor recreation access and recreational opportunities. A substantial portion of these public protected areas are managed by the Pennsylvania Department of Conservation and Natural Resources, 2017, 2019 (DCNR) who presides over 121 State Parks and 20 State Forests, encompassing approximately 2.5 million acres of public land (PA DCNR, 2017). A key element of both the State Park and State Forest systems is to provide a variety of outdoor recreation activities and opportunities for the citizens of the commonwealth (PA DCNR, 2017). Within Pennsylvania, outdoor recreation has become an increasingly critical component of the economy, often displacing the prominence of boom and bust energy development cycles that have historically dominated the landscape (Rumbach, 2011; Theodore Roosevelt Conservation Partnership, 2018; Weigle, 2010). The combination of biological and geological diversity, high quality and informed natural resource management, in addition to an abundance of public access, makes the Pennsylvania public lands system extremely attractive to a wide range of local, regional, and international outdoor recreationists.

This study was conducted as part of the Pennsylvania Statewide Comprehensive Outdoor Recreation Plan (SCORP). Every five years, the United State Department of the Interior, National Park Service, requires states to update their SCORP in order to qualify for grants and funding via the Federal Land and Water Conservation Fund Act of 1965 (Public

Law 88–578). Part of the planning process included the collection of public input from Pennsylvania residents regarding their outdoor recreation participation patterns, attitudes, perceptions, and opinions. For over half a century, the Pennsylvania SCORP has offered insights and solutions to effectively and proactively manage Pennsylvania's outdoor recreation future. In 2014, the Pennsylvania DCNR partnered with researchers at The Pennsylvania State University to conduct a statewide comprehensive study of Pennsylvania residents. Data from this study were used to inform the SCORP, as well form the basis of this research.

3.3. Data collection

Mail and online surveys were used to gather data from the Pennsylvania population from January to March of 2014. To gather a diverse and representative statewide sample, a systematic sampling plan was developed in consultation with natural resource managers and researchers. First, a random statewide sample of 12,000 Pennsylvania residents was purchased from a premiere market research firm. The statewide sample was stratified to reflect the six SCORP planning regions (Fig. 1) as well as the two prominent urban areas of Philadelphia and Pittsburgh. Next, 1500 random Pennsylvania residents were surveyed in each of the eight SCORP planning regions by the market research firm using a combined online and mail back survey protocol following the Dillman Tailored Design Method (Dillman, 2011). This multi-wave survey protocol was intended to achieve the highest possible response rate and was consistent with best practice methods used in similar statewide assessments (Dillman, 2011). Overall, a maximum of four contacts were made with potential study participants, yielding a total of 2240 completed surveys, representing a 20% response rate after adjusting for undeliverable addresses. The highest response rates were from the North Central (25.4%) and South Central (25.0%) regions of Pennsylvania. The lowest response rates were from more urban proximate areas such as Pittsburgh (16.8%) and Philadelphia (10.0%). Only consenting adults (18 years of age or older) were eligible to participate in the survey.

The 11-page Pennsylvania SCORP survey instrument was based upon previous iterations and included a vast number of outdoor recreation variables pertaining to participation levels, facility needs, recreation and conservation opinions, and sociodemographic characteristics (Graefe, Mowen, Trauntvein, & Covelli, 2009). It should be noted

that the data analyzed in this study represented a specific sub-set of quantitative and qualitative questions from the Pennsylvania SCORP survey instrument that were relevant and applicable to the study needs. The pertinent quantitative variables within the first portion of the survey included sociodemographic characteristics and regional residency characteristics. Next, respondents were asked two dichotomous questions (e.g., yes or no) pertaining to SGD in Pennsylvania and its potential effects on outdoor recreation: whether or not they had encountered SGD related activities when participating in outdoor recreation in Pennsylvania, and whether or not SGD related activities in Pennsylvania had changed their outdoor recreation behaviors or experiences. Finally, qualitative data were collected via an open-ended follow up question that prompted respondents to further explain, in their own words, their 'yes' or 'no' response regarding how SGD related activities in Pennsylvania had changed their outdoor recreation behaviors or experiences. The qualitative results presented in this study are based on the responses from those respondents who replied 'yes' to this open-ended follow-up question. Based on these various data segmentations, it is important to note that numerous sub-samples within the overall study population were represented and thus, study findings should not be generalized.

4. Theory

This study sought to add to the growing body of SGD research by specifically considering recreationists' perceptions' of impact. Several studies have advanced theory that many of the perceived negative impacts of SGD often stem from a lack of 'fit' between the energy development and the values that people assign to both the community and the landscape (Jacquet & Stedman, 2013b; Stedman, 2002; 2003). 'Fit' refers to how an energy development project is interpreted within the symbolic meaning of a landscape, community, or location (Ferguson et al., 2018b; Stedman, 2002; 2003). For example, research has suggested that the industrial aspect of some SGD sites can be perceived negatively among community stakeholders who see SGD as disrupting the place meanings that value natural beauty and the recreation potential of the area (Jacquet & Stedman, 2013b; Stedman, 2002; 2003).

Moreover, recreationists have been shown to exhibit substitution behaviors such as activity substitution, resource substitution, and displacement in response to environmental impacts within outdoor recreation settings (Ferguson, Mueller, Graefe, & Mowen, 2018a; Miller &

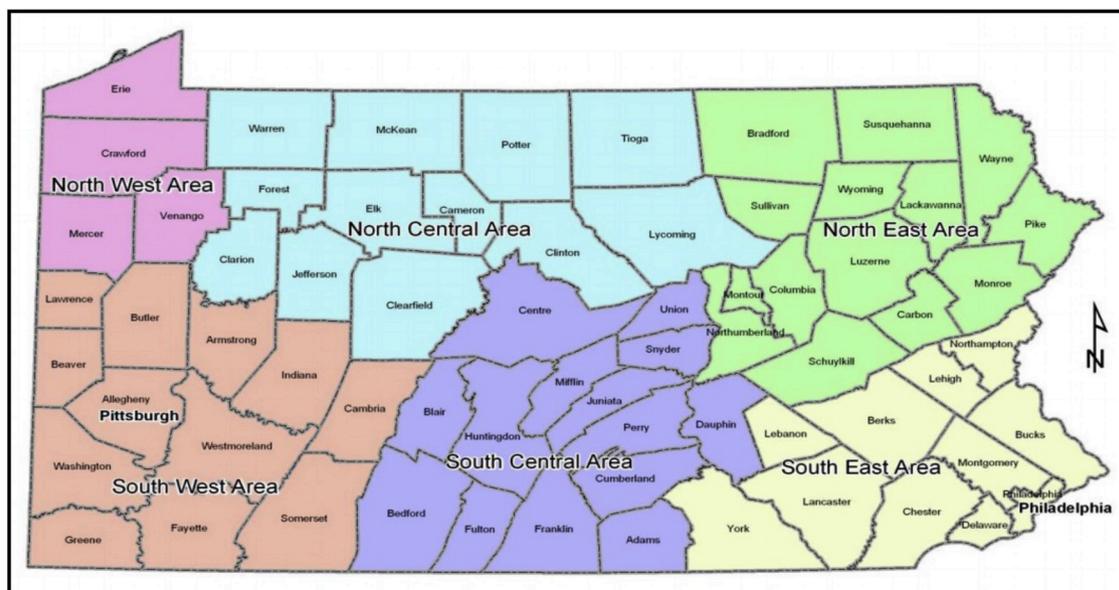


Fig. 1. Pennsylvania SCORP planning regions.

McCool, 2003; Rasch et al., 2018; Shelby & Vaske, 1991). This substitution typology allows impacted recreationists alterations to their recreation activities, settings, or both (e.g., displacement), in an effort to maintain experience quality (Ferguson et al., 2018a; Miller & McCool, 2003; Rasch et al., 2018; Shelby & Vaske, 1991). Certain recreation sub-populations have been shown to be generally opposed to industrial development, as they often view the recreation location as a place to escape areas that host economic production and industrialization (Jacquet & Stedman, 2013b; Stedman, 2002, 2003; Weigle, 2010). This research sought to investigate these phenomena to explore the potential impacts that SGD might have upon recreationists in Pennsylvania.

5. Results

All data were analyzed using Statistical Package for the Social Sciences (SPSS) version 24.0. To address research question R1, frequencies, valid percentages, and cross-tabulation procedures in conjunction with Pearson's Chi-Square analysis was used. To address research question R2, frequencies, valid percentages, and cross-tabulation procedures in combination with Pearson's Chi-Square analysis was again applied. Finally, to address research question R3, constant comparative methods, inter-rater reliability, and multiple correspondence analysis (MCA) were used to assess the supplemental open-ended comments. MCA was selected as it can establish underlying structures, typologies, characteristics, and linkages between and within qualitative data (Husson & Josse, 2014).

5.1. Quantitative results

Of the 2240 survey respondents, approximately 66% identified as male and 34% as female. The average age for survey respondents was 59 years (Table 1). The sample was fairly homogenous by race, with nearly 94% of survey participants identifying as white. Income levels of respondents were relatively evenly distributed with the highest percentage of respondents (18.1%) identifying their income within the range of \$40,000-\$59,999. Nearly 31% of the sample had earned a high school diploma or less and more than half of the respondents (50.7%) noted they had attended some college (17.5%), a two-year college (9.6%), or a four-year college (23.6%). Respondents described where they lived as rural (34.5%), suburban (28.4%), town (20.1%), or city (16.9%). Study respondents were relatively evenly distributed across the state, with the highest percentage of respondents (16.1%) residing in the South Central region of Pennsylvania. As previously noted, the varying numbers of respondents in each region reflected the varying response rates from the different regions. These sociodemographic and residency characteristic statistics closely resembled other similar research in the study area (Graefe et al., 2009).

To assess encounter rates with SGD related activities, respondents were asked, 'Have you encountered Marcellus Shale related activity when participating in outdoor recreation in Pennsylvania?' (Table 2). This item was created based on previous SCORP survey iterations and conversations with natural resource managers and other relevant outdoor recreation stakeholders (Graefe et al., 2009). Of the 2240 survey respondents, nearly one-quarter (23.4%) indicated they had encountered SGD related activities when participating in outdoor recreation in Pennsylvania. To further assess differences in SGD encounters based on regional residency, a cross-tabulation procedure in combination with Pearson's Chi-Square analysis was conducted. Results found significant differences ($\chi^2 = 201.539$, $df: 7$, $p < .001$) by geographical region of residency in encounter rates with SGD related activities (Table 2). Respondents from the North Central region of Pennsylvania (52.0%) were the most likely to say they had encountered SGD related activities while recreating. Nearly one-third of Southwest region respondents (30.8%) said they had encountered SGD related activities while recreating. Conversely, respondents from the Philadelphia region

Table 1
Outdoor recreationists' sociodemographic and residency characteristics.

Variable	Valid % or Mean
Age	59 years
Gender	
Male	66.1
Female	33.9
Race/Ethnic Background	
White	93.8
Non-white	6.2
Income	
Under \$19,999	9.6
\$20,000-\$39,999	17.3
\$40,000-\$59,999	18.1
\$60,000-\$79,999	17.0
\$80,000-\$99,999	11.0
\$100,000 or more	15.9
Education	
High School Graduate or less	30.7
Some College	17.5
Two-year College	9.6
Four-year College	23.6
Graduate or Professional Degree	18.6
Residency Settlement Type	
Rural	34.5
Suburban	28.4
Town	20.1
City	16.9
Residency Region	
Northwest	14.8
Southwest	13.5
North Central	14.4
South Central	16.1
Northeast	12.9
Southeast	11.2
Pittsburgh	10.8
Philadelphia	6.3

Note. Percentages may not equal 100 because of rounding.

Table 2
Encounters with SGD related activities while recreating in Pennsylvania.

Residency Region ^a	Encounters with SGD Related Activities (Valid % Yes)
North Central	52.0
Southwest	30.8
Pittsburgh	21.3
Northeast	20.5
Southeast	16.1
Northwest	14.6
South Central	14.5
Philadelphia	6.7
Overall Sample	23.4

Note. Percentages may not equal 100 because of rounding.

^a Chi-Square: 201.539, $df: 7$, $p < .001$.

(6.7%) were the least likely to report they had encountered SGD related activities while recreating. These regional responses closely corresponded with the distribution of SGD across the Pennsylvania landscape.

To assess the extent to which SGD impacted recreationists behaviors or experiences, respondents were asked, 'Has Marcellus Shale-related activity in Pennsylvania changed your outdoor recreation behaviors or experiences?' (Table 3). This item was created based on previous SCORP survey iterations and conversations with natural resource managers and other relevant outdoor recreation stakeholders (Graefe et al., 2009). Of the 2240 survey respondents, nearly one in seven (13.8%) indicated they had changed their outdoor recreation behavior or experiences as a result of encountering SGD related activities in

Table 3
Impacts from SGD related activities while recreating in Pennsylvania.

Residency Region ^a	Impacts from SGD Related Activities (Valid % Yes)
North Central	29.6
Southwest	15.1
Pittsburgh	14.7
Northeast	12.2
Southeast	11.5
South Central	10.2
Philadelphia	8.5
Northwest	6.0
Overall Sample	13.8

^aChi-Square: 83.038, df: 7, $p < .001$.

Note. Percentages may not equal 100 because of rounding.

Pennsylvania. To further assess differences in SGD outdoor recreation behaviors or experience impacts based on regional residency, a cross-tabulation procedure in combination with Pearson's Chi-Square analysis was conducted. Results found significant differences ($\chi^2 = 83.038$, df: 7, $p < .001$) by geographical region of residency in outdoor recreation impacts with SGD related activities (Table 3). Respondents from the North Central region (29.6%) were the most likely to report that their outdoor recreation behaviors or experience were impacted by encounters with SGD related activities. About fifteen percent of Pittsburgh area (14.7%) and Southwest region (15.1%) respondents said they had been impacted by SGD activities while recreating. Conversely, respondents from Philadelphia (8.5%) and the Northwest region (6.0%) were the least likely to report they were impacted by SGD activities while recreating in Pennsylvania.

5.2. Qualitative results

The quantitative analyses demonstrated that certain recreationists both encountered and altered their recreation behaviors as a result of SGD activity. In an effort to further understand this phenomenon, qualitative data were collected via an open-ended follow up question that prompted respondents to explain, in their own words, their 'yes' or 'no' response regarding how SGD related activities in Pennsylvania had changed their outdoor recreation behaviors or experiences. This study and subsequent qualitative analyses only analyzed the open-ended follow-up responses from the sub-sample of respondents who replied 'yes' ($n = 275$ or 12.3%), inferring that SGD related activities in Pennsylvania had indeed changed their outdoor recreation behaviors or experiences. Open-ended responses were analyzed using the constant comparative method (Corbin & Strauss, 2014). The authors discussed the original codes, generated a codebook, and independently coded and broke down each of the original statements. This process was conducted three separate times in order to develop a total of 11 themes and 18 related sub-themes which represented 338 independent statements within the data. This constant comparative method ultimately achieved an acceptable inter-rater reliability statistic with 83.5% agreement (Table 4) (Miles & Huberman, 1994).

Overall, respondents in the impacted sub-sample identified and incorporated both recreational as well as broader impacts associated with SGD activity. Recreationists open-ended comments were categorized under the themes of aesthetic impacts (19.2%), environmental impacts (17.9%), traffic, vehicle, and road impacts (12.7%), general recreation impacts (11.9%), avoidance impacts (8.3%), safety impacts (7.5%), displacement impacts (7.3%), and restricted access impacts (4.1%) (Table 4). All of the sub-sample open-ended comments were negative and/or oppositional towards SGD related activity and its impact upon outdoor recreation. These comments and their interpretation are discussed in further detail in the ensuing sections.

The theme of *aesthetic impacts* received the most comments ($n = 74$ or 21.9%). The aesthetic impact theme contained the sub-themes of

Table 4
Frequency of SGD impact themes and sub-themes.

Themes and Sub-Themes	N	Valid %
Total Aesthetic Impacts	74	21.9
Visual Impacts	38	51.4
Sound Impacts	27	36.5
Smell Impacts	7	9.5
Other Aesthetic Impacts	2	2.7
Total Environmental Impacts	69	20.4
Land/Forest Impacts	21	30.4
Water Impacts	16	23.2
Wildlife Impacts	15	21.7
Generic Environmental Impacts	15	21.7
Air Impacts	2	2.9
Total Traffic/Vehicles/Road Impacts	49	14.4
Traffic Impacts	30	61.2
Infrastructure Impacts (roads)	19	38.8
Total General Recreation Impacts	46	13.6
General Recreation Impacts – Hunting	23	50.0
General Recreation Impacts – Other Activity	17	37.0
General Recreation Impacts – Water-based Activity	6	13.0
Total Avoidance Impacts	32	9.4
Total Safety Impacts	29	8.5
Personal Health and Safety Impacts	9	31.0
Traffic and Vehicle Safety Impacts	9	31.0
Water Safety Impacts	7	24.1
Other Safety Impacts	4	13.8
Total Displacement Impacts	25	7.3
Total Restricted Access Impacts	14	4.1
TOTAL	338	100

Note. Percentages may not equal 100 because of rounding.

visual impacts ($n = 38$), sound impacts ($n = 27$), smell impacts ($n = 7$), and other miscellaneous aesthetic impacts ($n = 2$). These respondents suggested that the numerous aesthetic impacts resulting from SGD may not have "fit" or were not "desirable" within their outdoor recreation experience or environment. For example, one respondent explained, "We were shocked at how many miles of beautiful scenery were torn up to lay a pipeline. The drilling rigs were an eye sore." Several respondents also suggested that the anthropogenic sounds associated with the SGD infrastructure was a substantial impact. For example, one respondent explained, "Loud sounds [from SGD] make the area less desirable to visit."

The theme of *environmental impacts* ($n = 69$ or 20.4%) received a substantial number of responses. Environmental impact sub-themes included land and forest impacts ($n = 21$), water impacts ($n = 16$), wildlife impacts ($n = 15$), generic environmental impacts ($n = 15$), and air impacts ($n = 2$). Respondents noted SGD related activity was "disrupting", "polluting", and "destroying" the natural land and forests within the SGD region. For example, one respondent explained, "Marcellus shale related activity has marred many areas around the state, destroying ecosystems as well as fragmenting forests." Respondents also noted impacts associated with water contamination stemming from "runoff" and "poor construction" related to SGD. One respondent observed, "The destruction of drinking water, streams, and rivers". Wildlife impacts related to "changing habits of deer" and other wildlife disruptions due to SGD related activity were also noted.

The theme of *traffic, vehicle, and road impacts* ($n = 49$ or 14.4%) was a notable concern. Traffic, vehicle, and road impacts included two sub-themes pertaining to overall traffic impacts ($n = 30$) and infrastructure impacts ($n = 19$) that largely focused on roads. Traffic and road impacts led to one respondent noting, "... scenic roads are almost dirt due to high volume truck traffic." Respondents indicated numerous impacts associated with roadways in the form of "increased traffic", "more congestion" and an overall lack of 'fit' with the natural and scenic setting of Pennsylvania public lands. One respondent wrote, "The experience of driving through areas advertised to be 'wild and scenic' was dampened by encountering heavy-duty gas truck traffic."

Various *general recreation impacts* ($n = 46$ or 13.6%) associated with SGD activities were recounted. General recreation impacts were sub-categorized as hunting activity impacts ($n = 23$), other activity impacts ($n = 17$), and water-based activity impacts ($n = 6$). Hunting impacts were commonly associated with the disruption of “traditional hunting lands” as a result of “too many gas wells where I hunt” due to vast SGD infrastructure. One respondent noted, “[SGD] has impacted areas that I’ve hunted for years. It has also brought outsiders into the area that are disrespectful to our traditions and the outdoors.” Hunting impacts related to “fragmenting habitats” and “hurting hunting spots” were also highlighted. One respondent summarized, “Some of the hunting areas, especially for deer, have been affected and have changed the deer’s habits in my area.” Other general recreation activity impacts associated with “snowmobile trail detours” and concerns of, “... hiking only to come upon private industrial activity” were noted. One respondent explained, “It has ruined the Indian Pipe Trail for mountain biking. They cut down a lot of trees, rerouted the mountain bike path and made it wider for trucks and drilling rigs to drive up and down for oil and Marcellus drilling.” General water-based recreation activity impacts included concerns due to perceptions of “tainted water” and “less trust in swimming areas.” One respondent wrote, “My family no longer swims in the Youghiogheny River because we are concerned about what local shale fracking development is putting into the beautiful river.”

Certain respondents indicated *avoidance impacts* ($n = 32$ or 9.4%) related to SGD. Some noted, “... [SGD] drove us away from places” as well as, “We have traveled to other places because of the gas development”. One respondents noted, “I have avoided certain areas because I do not want to encounter drilling activity.” The theme of *safety impacts* ($n = 29$ or 8.5%) was also noted among recreationists. Safety impacts included the sub-themes of personal health and safety impacts ($n = 9$), traffic and vehicle safety impacts ($n = 9$), water safety impacts ($n = 7$), and other miscellaneous safety impacts ($n = 4$). Regarding safety impacts, respondents noted, “I do not think it is safe to be around fracking” and concerns related to “environmental effects [of SGD] on my health.” Traffic and vehicle safety impact concerns often referenced “speeding” and “dangerous” roadways, as well as not having enough space due to trucks “sharing” the road with regular vehicles. One respondent explained, “Speeding water trucks make travel on rural roads dangerous and menacing to those that share the roadway.” Water safety impacts included outdoor recreationists feeling “unsafe” and “concerned” regarding the potability and consumption of water near SGD sites. One respondent noted, “It makes me cautious and more alert towards the safety of potable drinking water at campsites.”

The theme of *displacement impacts* ($n = 25$ or 7.3%) was also mentioned. One respondent noted, “We have traveled to other states to vacation in lieu of going to areas in Pennsylvania that we have always gone to previously because of the Marcellus Shale activity.” The final theme of *restricted access impacts* ($n = 14$ or 4.1%) was the least frequently mentioned theme. Respondents suggested restricted access impacts resulting from SGD related to the land being “off-limits” and “changing”. Respondents said that roads were now being “guarded and gated” and therefore perceived the recreation settings as being “less accessible”. One respondent noted, “There are areas that I have always hunted and fished and access to those areas is changing.”

5.3. Multiple correspondence analysis results

Multiple correspondence analysis (MCA) was used to further explore the relationship between open-ended responses within the impacted sub-sample. MCA was selected as it establishes underlying structures, typologies, characteristics, and linkages between and within qualitative data. This was done by examining whether any relationships were manifested across the sample in the presence and absence of eight impact themes: 1) aesthetic impacts, 2) environmental impacts, 3) traffic, vehicle, and road impacts, 4) general recreation impact, 5) avoidance impacts, 6) safety impacts, 7) displacement impacts, and 8)

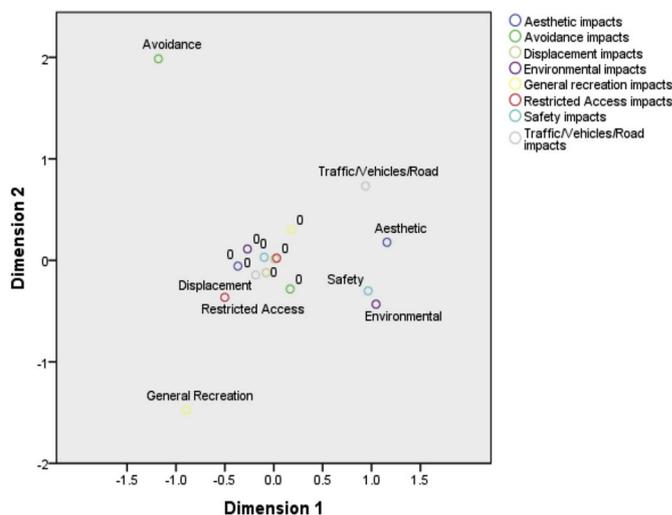


Fig. 2. Multiple correspondence analysis of qualitative themes.

restricted access impacts. MCA can be understood as a form of principal component analysis where the variables are categorical (Abdi & Valentin, 2007). MCA was used in this study to understand whether categories or typologies of respondents could be determined based on their sub-sample open-ended explanations of how SGD related activity in Pennsylvania changed their outdoor recreation behaviors or experiences.

Fig. 2 displays the results of the MCA. Similar to a factor analysis, the variables separated across multiple dimensions. The closer the value of variables on each of the dimensions, the more overlap there was in the themes expressed by individual respondents. The variables closer together are more closely related conceptually. All instances in which a theme was absent (denoted by ‘0’ in Fig. 2) pooled together, due to each theme being absent from a majority of the survey responses. Regarding the themes that *were* mentioned, however, notable groupings occurred. In the first grouping, themes related to displacement impacts and restricted access impacts pooled together. In the second grouping, themes related to environmental impacts; traffic, vehicle, and road impacts; safety impacts; and aesthetic impacts pooled together. Finally, themes related to general recreation impacts and avoidance impacts did not group with any other themes.

These findings suggest that respondents within the impacted sub-sample represented two general types of recreationists, those who focused on behavioral or experiential impacts and those focused on landscape environmental quality or ‘fit’ impacts. The behavioral impact respondents were likely to mention more recreation-behavior or experiential related SGD impacts (e.g., displacement impacts and restricted access impacts). On the other hand, respondents impacted by landscape environmental quality impacts were likely to mention any number of landscape ‘fit’ or recreation setting quality related SGD impacts (e.g., aesthetic impacts, safety impacts, traffic, vehicle, and road impacts, and environmental impacts). These findings suggest that respondents in the behavioral impact grouping may think more specifically about how SGD impacts their personal recreation experiences and that respondents within the landscape environmental quality impact grouping may think more broadly about how SGD impacts both their in situ recreation experiences as well as the environmental setting and landscape in which they recreate.

6. Discussion

SGD has expanded rapidly in the United States for various technological, economic, and geopolitical reasons, with production expected to more than double by 2050 (U.S. Exec, 2015). A majority of the SGD infrastructure in Pennsylvania is either within or adjacent to public

lands, waters, and protected areas, raising concerns about the impact on outdoor recreation stakeholders. The literature has suggested that outdoor recreation may be impacted by SGD, but to date, no studies have specifically assessed this phenomenon amongst a statewide population sample. This study found that nearly one-quarter of respondents (23.4%) had encountered SGD related activities while participating in outdoor recreation and that 13.8% of respondents had changed their outdoor recreation behaviors or experiences as a result of encountering SGD related activities. When considering regional respondent locations, SGD encounters and impacts closely corresponded with the distribution of SGD across the Pennsylvania landscape (MCOR, 2018). That is to say, recreationists residing and recreating within the most highly developed SGD regions of Pennsylvania (e.g., North Central and Southwest) were the most likely to report they had encountered and been impacted by SGD related activities while recreating in the outdoors.

While the perceived impact of SGD was notable, the deeper discussion revolves around the nuanced interpretation of these impacts upon a sub-sample within the study. This sub-sample, representing 12.3% of study respondents, identified numerous ways that the presence of SGD impacted outdoor recreation behaviors, experiences, and activities. These various social, environmental, and infrastructure related impacts often disrupted the recreation experience and led many recreationists within the sub-sample to exhibit substitution behaviors or perceive a lack of 'fit'. When integrating the open-ended comments, recreationists within the impacted sub-sample seemed to identify and incorporate both recreation-behavior impacts as well as the broader landscape environmental quality or 'fit' impacts of SGD. For instance, the majority of open-ended comments were related to the topics of aesthetic impacts, environmental impacts, and traffic, vehicle, and road impacts in addition to general recreation impacts. These respondents noted specific in situ recreation impacts such as, "disruption of traditional hunting lands" and, "rerouting mountain bike paths", but they also noted larger scale community, location, and landscape environmental quality or 'fit' impacts such as, "area advertised to be 'wild and scenic' was dampened by encountering heavy-duty gas truck traffic", going on to say, "... to give up such beauty is not worth any amount of money."

These findings corroborated the literature and suggested the recreation stakeholders within the impacted sub-sample may not have perceived the 'fit' of SGD amongst their community and landscape (Jacquet & Stedman, 2013b; Stedman, 2002; 2003). Furthermore, prior research has suggested that many of the perceived negative impacts of SGD often stem from a lack of 'fit' between the energy development and the values that people assign to both the community and the landscape (Jacquet & Stedman, 2013b; Stedman, 2002; 2003). The impacted sub-sample in this study expressed an understanding of not only the specific or behavioral recreation impacts of SGD, but also the landscape environmental quality or 'fit' impacts of SGD upon their natural resources and region. Thus, it appeared that respondents within this impacted sub-sample may have perceived a disruption of their recreation activities, communities, and settings rather than an enhancement. This concept is notable as respondents were likely aware of and familiar with Pennsylvania's significant resource extraction history (e.g., deep coal mining, surface coal mining, stone quarries). These findings further validate the literature and are similar to previous studies as certain sub-populations of outdoor recreationists have been shown to be impacted by industrialization and energy development within otherwise natural outdoor recreation settings (Brownlee et al., 2015; Jacquet & Stedman, 2013b; Stedman, 2002, 2003; Weigle, 2010).

Further, the MCA suggested that respondents within the impacted sub-sample likely represented two general types of recreationists, those focused on behavioral- or experiential-related SGD impacts and those focused on landscape environmental quality- or 'fit'-related SGD impacts. These behaviorally impacted respondents may think or act more specifically about the impacts of SGD upon their outdoor recreation

experiences. In this study, these behaviorally-impacted recreationists sometimes noted the employment of substitution behaviors such as avoidance and displacement. For example, "We have traveled to other states to vacation in lieu of going to areas in Pennsylvania that we have always gone to previously because of the Marcellus Shale activity". The landscape environmental quality-impacted respondents may think more broadly or holistically about how SGD impacts both their in situ recreation experiences as well as the environmental setting and landscape in which they recreate. The landscape environmental quality-impacted individuals within the sub-sample often made broad comments related to the concept of 'fit' (or a lack thereof) between SGD and the community and landscape. For instance, "The Marcellus Shale related activity has disrupted the natural environment and its setting", and, "[SGD] does nothing for the enhancement of an otherwise natural setting."

These behavioral and landscape environmental quality groupings suggest a two-pronged approach to communicating and managing the impacts of SGD upon outdoor recreation in Pennsylvania. While study findings suggest that SGD was not a major impact on the state level, regional impact responses closely corresponded with the distribution of SGD intensity across the Pennsylvania landscape. Natural resource managers on the local, regional, and state level should prioritize communication and stakeholder engagement based on a two-tiered communication approach, particularly in areas of intensive SGD. The first aspect of messaging could focus on how SGD impacts affect specific recreation behaviors and experiences. The second aspect of messaging could focus on how SGD impacts affect the broader communities, landscapes, environmental quality, and settings which cater to outdoor recreation. Each of these communication strategies would aim to increase the transparency of information within the SGD process and collaboratively mitigate impacts between natural resource managers, recreationists, and industry representatives. For example, informational campaigns (e.g., press releases and signage) could convey specific timelines and locations of SGD, temporary alternative recreation locations, as well as the positive and negative short term and long term impacts of SGD upon both the recreation experience and the landscape environmental quality. Recognizing that outdoor recreation is an increasingly critical component of the Pennsylvania economy, lawmakers, natural resource managers, and industry representatives must recognize that recreationists are a legitimate and vocal stakeholder within the SGD process (Rumbach, 2011; Theodore Roosevelt Conservation Partnership, 2018; Weigle, 2010). Thus, from a policy perspective, each development phase of SGD in Pennsylvania (e.g., proposal, construction, operation, reclamation) warrants particular input from this important constituency.

It is important to note only a sub-sample of the overall study sample was represented in our analyses and that study finding should not be generalized. Only 275 respondents (12.3%) of the entire statewide sample ($n = 2240$) were qualitatively analyzed. This study did not analyze nor expand upon the 'no' responses to the open-ended question as this response inferred that SGD related activities in Pennsylvania had *not* changed their outdoor recreation behaviors or experiences. Further, given the study sample was over-represented by males, older adults, and whites compared to the Pennsylvania population, study findings should not be generalized to the statewide population. Implications for future research include examining the recreation impacts of energy development across multi-item constructs, segmenting recreationists by activity type, and examining both cross-sectional populations as well as general populations. This study employed two separate single-item indicators to measure recreationists' encounter rates and impacts from SGD. These single-item indicators were successful, but future research should consider including other multi-item recreation impact measures with various unidirectional scaling along with these variables in an effort to corroborate study findings. While the focus of the study was to assess Pennsylvania recreationists broadly, there is merit in examining differential effects for specific forms of recreation. Future studies should

consider segmenting and analyzing recreationists across more well-defined activity types or stakeholder groups. These segmentations and analyses could aid in further understanding SGD impacts among individual user segments. Future research should also consider assessing SGD projects throughout the various stages of development (e.g., proposal, construction, operation, reclamation). Finally, researchers must also recognize that recreationists are not the only relevant stakeholders within the SGD domain. Future research should assess not only recreation populations within an area, but also other population samples within the surrounding area for comparative purposes.

7. Conclusion

The results of this study found that only a sub-sample of Pennsylvania outdoor recreationists encountered and were indeed impacted by SGD; particularly in the regions where SGD was more widespread. Certain recreationists within this impacted sub-sample were able to identify not only the behavioral impacts of SGD upon their recreation experiences and activities, but also the landscape environmental quality or 'fit' impacts of SGD upon their communities and regions. These findings suggested that certain impacted recreationists may not have perceived a 'fit' between SGD and the communities and landscapes of Pennsylvania. Moreover, study findings suggested that SGD may only impact certain recreation sub-populations, as opposed to recreationists overall. As SGD continues to increase within Pennsylvania and the United States, it is important to understand how SGD affects a variety of recreationists and to involve this constituency in the SGD planning and policy process. This is especially true as SGD companies attempt to gain public support. This need for engagement and communication with recreation stakeholders will be critical to the continued success of SGD in the United States. This study corroborated previous energy research and highlighted the importance of considering and assessing recreation stakeholder impacts when planning, developing, and managing SGD and related policy in the United States.

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References

- Abdi, H., & Valentin, D. (2007). Multiple correspondence analysis. In N. J. Salkind (Ed.), *Encyclopedia of measurement and statistics* (651–657). Thousand Oaks, CA: Sage.
- Brasier, K. J., Filteau, M. R., McLaughlin, D. K., Jacquet, J., Stedman, R. C., Kelsey, T. W., et al. (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. *Journal of Rural Social Sciences*, 26(1), 32–61.
- Brown, E., Hartman, K., Borick, C. P., Rabe, B. G., & Ivacko, T. M. (2013). *The national surveys on energy and environment public opinion on fracking: Perspectives from Michigan and Pennsylvania*. <https://ssrn.com/abstract=2313276>, Accessed date: 1 November 2018.
- Brownlee, M. T., Hallo, J. C., Jodice, L. W., Moore, D. D., Powell, R. B., & Wright, B. A. (2015). Place attachment and marine recreationists' attitudes toward offshore wind energy development. *Journal of Leisure Research*, 47(2), 263–284.
- Clough, E., & Bell, D. (2016). Just fracking: A distributive environmental justice analysis of unconventional gas development in Pennsylvania, USA. *Environmental Research Letters*, 11(2), 1–9.
- Considine, T. J., Considine, N. B., & Watson, R. (2016). Economic and environmental impacts of fracking: A case study of the Marcellus shale. *International Review of Environmental and Resource Economics*, 9(3–4), 209–244.
- Cooley, H., Donnelly, K., Ross, N., & Luu, P. (2012). Hydraulic fracturing and water resources: Separating the frack from the fiction. http://pacinst.org/wpcontent/uploads/2013/02/full_report5.pdf, Accessed date: 1 November 2018.
- Corbin, J., & Strauss, A. L. (2014). *Basics of qualitative research*. Thousand Oaks, CA: Sage Publishing.
- Dillman, D. A. (2011). *Mail and internet surveys: The tailored design method-2007 update with new internet, visual, and mixed-mode guide*. New York, NY: John Wiley & Sons.
- Evensen, D. T. (2015). Policy decisions on shale gas development ('fracking'): The insufficiency of science and necessity of moral thought. *Environmental Values*, 24(4), 511–534.
- Evensen, D., & Stedman, R. (2017). Beliefs about impacts matter little for attitudes on shale gas development. *Energy Policy*, 109, 10–21.
- Exec (2015). *Order No. 2015-03, 3. C.F.R. 1-2*.
- Ferguson, M. D., Mueller, J. T., Graefe, A. R., & Mowen, A. J. (2018a). Coping with climate change: A study of great lakes water-based recreationists. *Journal of Park and Recreation Administration*, 36(2), 52–74.
- Ferguson, M. D., Powers, S. L., Trautwein, N., Jacquet, J. B., Graefe, A. R., & Mowen, A. J. (2018b). Winds of change- predicting water-based recreationists' support and opposition for offshore wind energy development in the great lakes. *Journal of Great Lakes Research*. <https://doi.org/10.1016/j.jglr.2018.10.006>.
- Ferrar, K. J., Kriesky, J., Christen, C. L., Marshall, L. P., Malone, S. L., Sharma, R. K., Michanowicz, D. R., & Goldstein, B. D. (2013). Assessment and longitudinal analysis of health impacts and stressors perceived to result from unconventional shale gas development in the Marcellus Shale region. *International Journal of Occupational and Environmental Health*, 19(2), 104–112.
- Graefe, A. R., Mowen, A. J., Trautwein, N. E., & Covelli, E. A. (2009). *Outdoor recreation in Pennsylvania: Resident survey*. http://paoutdoorrecplan.com/cs/groups/public/documents/document/d_002752.pdf, Accessed date: 1 November 2018.
- Husson, F., & Josse, J. (2014). Multiple correspondence analysis. In J. Blasius, & M. Greenacre (Eds.), *Visualization and verbalization of data* (165–184). Boca Raton, FL: CRC Press.
- Jacquet, J. B., & Stedman, R. C. (2013a). Perceived impacts from wind farm and natural gas development in northern Pennsylvania. *Rural Sociology*, 78(4), 450–472.
- Jacquet, J. B., & Stedman, R. C. (2013b). The risk of social-psychological disruption as an impact of energy development and environmental change. *Journal of Environmental Planning and Management*, 57(9), 1285–1304.
- 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. *Society & Natural Resources*, 31(2), 200–217.
- Kellison, T. B., Bunds, K. S., Casper, J. M., & Newman, J. I. (2017). Public parks usage near hydraulic fracturing operations. *Journal of Outdoor Recreation and Tourism*, 18, 75–80.
- Kinnaman, T. C. (2011). The economic impact of shale gas extraction: A review of existing studies. *Ecological Economics*, 70, 1243–1249.
- Ladd, A. E. (2013). Stakeholder perceptions of socioenvironmental impacts from unconventional natural gas development and hydraulic fracturing in the Haynesville Shale. *Journal of Rural Social Sciences*, 28(2), 56–89.
- Loomis, J., & Haeefe, M. (2017). Quantifying market and non-market benefits and costs of hydraulic fracturing in the United States: A summary of the literature. *Ecological Economics*, 138, 160–167.
- Lorig, R. (2016). Noise mapping: Modeling chronic natural gas compressor noise across Pennsylvania State Forests in the Marcellus Shale formation. https://gis.e-education.psu.edu/sites/default/files/capstone/Lorig_596B_20160601.pdf, Accessed date: 1 November 2018.
- Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook* (2nd ed.). Thousand Oaks, CA: Sage.
- Miller, T. A., & McCool, S. F. (2003). Coping with stress in outdoor recreational settings: An application of transactional stress theory. *Leisure Sciences*, 25(2–3), 257–275.
- Penn State Marcellus Center for Outreach and Research (2018). What is meant by "gas development unit?". <http://www.marcellus.psu.edu/resources-faq.html>, Accessed date: 1 November 2018.
- Pennsylvania Department of Conservation and Natural Resources (2017). Natural gas development and state forests: Shale gas leasing statistical summary. http://www.docs.dcnr.pa.gov/cs/groups/public/documents/document/dcnr_20029363.pdf,

- Accessed date: 1 November 2018.
- Pennsylvania Department of Conservation and Natural Resources (2019). *History of geologic economic resources in Pennsylvania*. <https://www.dcnr.pa.gov/Geology/GeologicEconomicResources/Pages/default.aspx>, Accessed date: 12 April 2019.
- Pennsylvania Independent Oil and Gas Association (2019). *Pennsylvania oil and gas*. <https://www.pioga.org/education/pa-oil-and-gas/>, Accessed date: 12 April 2019.
- Rahm, D., Fields, B., & Farmer, J. L. (2015). Transportation impacts of fracking in the Eagle Ford Shale development in rural south Texas: Perceptions of local government officials. *The Journal of Rural and Community Development*, 10(2), 78–99.
- Rasch, R., Reeves, M., & Sorenson, C. (2018). Does oil and gas development impact recreation visits to public lands? A cross-sectional analysis of overnight recreation site use at 27 national forests with oil and gas development. *Journal of Outdoor Recreation and Tourism*, 24, 45–51.
- Rohrs, A. (2017). *Energy development is happening on your state lands*. Pennsylvania <https://www.fractracker.org/2017/12/energy-development-state-lands-pa/>, Accessed date: 1 November 2018.
- Rumbach, A. (2011). *Natural gas drilling in the Marcellus shale: Potential impacts on the tourism economy of the southern tier*. http://www.greenchoices.cornell.edu/resources/publications/drilling/Impacts_on_Tourism_Economy.pdf, Accessed date: 1 November 2018.
- Schafft, K., & Biddle, C. (2015). Opportunity, ambivalence, and youth perspectives on community change in Pennsylvania's Marcellus Shale region. *Human Organization*, 74(1), 74–85.
- Shelby, B., & Vaske, J. J. (1991). Resource and activity substitutes for recreational salmon fishing in New Zealand. *Leisure Sciences*, 13(1), 21–32.
- Stedman, R. C. (2002). Toward a social psychology of place: Predicting behavior from place-based cognitions, attitude, and identity. *Environment and Behavior*, 34, 561–581.
- Stedman, R. C. (2003). Is it really just a social construction?: The contribution of the physical environment to sense of place. *Society & Natural Resources*, 16(8), 671–685.
- Stedman, R. C., Jacquet, J. B., Filteau, M. R., Willits, F. K., Brasier, K. J., & McLaughlin, D. K. (2012). Environmental reviews and case studies: Marcellus shale gas development and new boomtown research: Views of New York and Pennsylvania residents. *Environmental Practice*, 14(4), 382–393.
- Theodore Roosevelt Conservation Partnership (2018). *The power of outdoor recreation spending in Pennsylvania*. <http://www.trcp.org/wp-content/uploads/2018/12/TRCP-and-Southwick-PA-Economic-Analysis-12-6-18.pdf>, Accessed date: 1 November 2018.
- Theodori, G. L. (2009). Paradoxical perceptions of problems associated with unconventional natural gas development. *Southern Rural Sociology*, 24(3).
- Thomas, M., Pidgeon, N., Evensen, D., Partridge, T., Hasell, A., Enders, C., et al. (2017). Public perceptions of hydraulic fracturing for shale gas and oil in the United States and Canada. *Wiley Interdisciplinary Reviews: Climatic Change*, 8(3), e450.
- United States Energy Information Administration (2017a). Marcellus region: Drilling activity report. <https://www.eia.gov/petroleum/drilling/pdf/marcellus.pdf>, Accessed date: 1 November 2018.
- United States Energy Information Administration (2017b). *U.S. energy facts explained: Consumption and production*. https://www.eia.gov/energyexplained/?page=us_energy_home, Accessed date: 1 November 2018.
- United States Energy Information Administration (2018). Natural gas explained: Where our natural gas comes from. https://www.eia.gov/energyexplained/index.php?page=natural_gas_where, Accessed date: 1 November 2018.
- Weigle, J. L. (2010). *Resilience, community, and perceptions of Marcellus Shale development in the Pennsylvania wilds (doctoral dissertation)*. *Penn state electronic theses and dissertations for graduate school*, Accessed date: 1 November 2018.
- Willits, F. K., Brasier, K., Ooms, T., Tracewski, S., & Stedman, R. (2008). Pennsylvania residents' perceptions of natural gas development in the Marcellus Shale: Differences among residents in self-perceived knowledge and attitudes. <http://www.institutepa.org/PDF/Marcellus/brief3differences.pdf>, Accessed date: 1 November 2018.