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Research Note

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

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ABSTRACT

Drawing on national forest visitor use data from 722 overnight use recreation sites across 27 National Forests with oil and gas development, this work examines whether the presence of oil and gas development within five kilometers of an overnight recreation site affects site visitation. Findings suggest that sites within five kilometers of oil and gas wells see less visitation, compared to sites farther away from wells. While this work does not attempt to speculate on the overall user experience, it does suggest that the presence of oil and gas development may have a significant enough effect on the user experience to motivate some users to recreate elsewhere. On average, each additional oil or gas well within a five-kilometer radius is related to a decline in six visits to the site, on an annual basis. Geographically Weighted Regression (GWR) model results suggest that the effect of oil and gas wells on overnight site visitation varies across the nation and is statistically significant in western states but not significant in eastern states, possibly due to differing expectations for pristine recreation settings.

Management implication:

- This research finds that overnight use recreation sites within five kilometers of oil and gas wells see less visitation, compared to sites farther away from wells.
- On average, each additional oil or gas well within a five-kilometer radius is related to a decline in six visits to the site, on an annual basis.
- Managers tasked with analyzing potential impacts of oil and gas development on recreational uses can apply these findings directly into social impact analyses by carefully considering the real potential for declines in visitation and the associated drop in recreation fees available to local district managers for recreation resource maintenance and stewardship

1. Introduction

The presence of oil and gas development on public lands has become the “new normal” in the United States. With hydraulic fracturing (fracking) technology advancing at breakneck speeds, and horizontal drilling capabilities spanning miles, not feet, the sub-surfaces of America's public lands are being quietly transformed. According to the Bureau of Land Management, the federal agency responsible for managing onshore leasing on federal lands, in 2017 there were approximately 94,000 oil and gas wells and 26 million acres under lease to developers (Bureau of Land Management BLM, 2018). Public land conservation advocates and recreationalists posit that the uptick in oil and gas development has negatively impacted recreation opportunities on public lands. Recently, portions of the Bears Ears National Monument, a congressionally designated area in Utah, was opened to oil and gas exploration (Lipton & Friedman, 2018). This decision was highly contested by recreationists, who made the case that oil and gas exploration will negatively impact the number of visitors to the monument, and result in negative economic impacts to local businesses, which are dependent on tourism and the recreation economy (The Wilderness Society TWS, 2017). While researchers have theorized that oil and gas development may adversely affect visitor use, there is a dearth of research empirically testing this hypothesis as well as uncertainty surrounding the magnitude of economic impacts of oil and gas development to local communities (Evensen & Stedman, 2017; Maniloff & Mastromonaco, 2017). Kellison, Bunds, Casper, and Newman (2017)

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find that recreational users of park lands expect oil and gas development close to parks to negatively impact their recreation experience. According to stated preference survey results, recreationalists believe that in the event that oil or gas development did occur in or near their preferred recreation area, they would choose to recreate elsewhere.

This work examines whether the presence of oil and gas development on public lands impacts visitor use. Relying on empirical observation, rather than stated preference, we draw on National Forest visitor use data from 722 overnight use recreation sites across 27 national forests with oil and gas development. Employing both cross-sectional Ordinary Least Squares (OLS) regression and Geographically Weighted Regression (GWR) models which control for geographical location, site capacity, site type (e.g. hotel, cabin or campground), development level (i.e. amenities available), size of nearby human populations, and distance between the site and the nearest well, this work adds to the discussion of trade-offs between natural resource extraction and recreational uses of public lands.

2. Literature review

Conflict between recreational use of public lands and natural resource use is a well-researched topic in the disciplines of recreation and leisure studies. Researchers find that visitors prefer to recreate in landscapes that do not contain visible signs of ecosystem degradation (e.g. trail erosion, dead trees) or technical infrastructure such as wind mills (Arnberger et al., 2018; Riper, Manning, Monz, & Goonan, 2011). Kellison et al. (2017) find that recreationalists in the Appalachian basin believe that oil and gas development on public lands will negatively impact their access to recreation opportunities and the quality of the experience, thus decreasing the likelihood that they would visit a public park where oil and gas development was taking place.

There is some work suggesting that synergistic relationships may exist when recreational and extractive uses occur on the same landscape simultaneously. For example, research from Australia suggests that observing commercial fishing may be an integral part of an overall coastal recreation and tourism experience (Voyer, Barclay, McIlgorm, & Mazur, 2017). Similarly, conflict scholars suggest that some conservation conflicts arise from value clashes or lack of transparency in decision-making processes, rather than environmental impacts on the ground (Baynham-Herd, Redpath, Bunnefeld, Molony, & Keane, 2018). Using conflict resolution support tools, which focus on identifying the underlying causes of the conflict, disparate stakeholders may be able to create mutual benefits by identifying and achieving common goals (Young et al., 2016).

However, there is a dearth of evidence suggesting potential benefits of oil and gas exploration on the recreational experience. To the contrary, the research on the environmental impacts of oil and gas development suggest negative impacts to recreationalists stemming from impacts to air and water quality (Field, Soltis, & Murphy, 2014; Colborn, Kwiatkowski, Schultz, & Bachran, 2011; McKenzie, Witter, Newman, & Adgate, 2012). Additionally, sociologists have noted social impacts such as noise and light pollution, as well as impacts to one's sense of place and the aesthetic quality of an area, all of which have the potential to negatively impact an outdoor recreation experience (Brasier et al., 2011; Sangaramoorthy et al., 2016).

Ruiz, Marrero, and Hernández (2017) demonstrate that people tend to have a negative emotional response to oil and gas development based on fear, rather than stemming from empirical evidence of likely impacts. Similar to studies on crowding, researchers find that people often perceive an issue as a problem when it is presented as such by the researcher. When visitor behaviors are examined with a revealed preference model, rather than in a stated preference model, findings suggest that most visitors' stated preferences do not align with their behaviors. In the case of crowding, while visitors express that they would stop recreating in an area were it to become crowded, researchers find that recreationalists rarely employ complete inter-site displacement i.e. recreating elsewhere.

Instead, recreationalists tend to use a mix of behavioral and cognitive coping mechanisms, such as temporal displacement (i.e. visiting at less crowded times of the day or on less crowded days of the week), rationalization, or even product shift, where they adjust their expectations for the experience to fall in line with the new reality of a more crowded area (Manning & Valliere, 2001). The recreation research literature is ripe with case studies demonstrating how recreationalists cope with adverse recreation conditions. The bulk of this work, however, is focused on how recreationalists manage crowding or navigate conflicts among equestrians and, motorized (e.g. snowmobiler), mechanized (e.g. mountain biker), and non-motorized (hiker) recreationalists (Miller, Vaske, Squires, Olson, & Roberts, 2017; Wolf, Brown, & Wohlfart, 2018). Neither of these conditions directly apply to the case of oil and gas development near recreation sites.

Recreation research focused on preferences for recreation settings provides relevant insight into the question at hand as it is the recreation setting that is most likely to be affected by oil and gas development. Parry and Gollob (2018) demonstrate that recreationalists may be flexible in their preference for recreation settings. They find that the ability to participate in an activity is more important to a recreationalist than an ideal activity setting. Kellison et al. (2017) suggest that additional empirical research is needed to better understand the link between oil and gas development and visitation. This research effort heeds their call by providing an empirical examination of visitor use in the face of oil and gas development.

A primary hypothesis of this research is:

H1. The presence of oil and gas wells near recreation sites negatively impacts visitation to those sites.

Recreation settings and opportunities on national forests differ considerably across the United States. Western recreation settings are characterized by large, iconic, mountainous landscapes and wilderness lands. Eastern recreation settings tend to be located on smaller national forest units with rolling hills. While hiking and viewing natural features are the most popular activities across the nation, the primary activities that visitors engage in differ across the country. For example, in the eastern regions, seventeen percent of visits are primarily for hunting or fishing. In the western regions, hunting or fishing is only a primary activity in eight percent of visits (USDA Forest Service, 2016).

Expectations of recreation settings also vary by region. In the more densely populated eastern regions of the country, there are fewer expectations for solitude and pristine landscapes (Manning & Valliere, 2001; Whiting, Larson, Green, & Kralowec, 2017). Conversely, western landscapes are conceptualized as wild places, with vast areas of undeveloped landscapes and copious opportunities for solitude and untouched vistas (Blake, 1995). While the recent migration to western cities has increased development close to national forests in recent years, the myth of the unspoiled, American West still endures in popular culture, and western mountain towns often brand themselves as tourist destinations at the foot of pristine, natural areas. It is plausible that visitation to recreation sites in eastern areas, where there is an expectation for some level of development at a recreation site, may be less impacted by nearby oil and gas development, compared to western sites.

A secondary hypothesis is:

H2. The relationship between oil or gas wells and visitation to nearby recreation sites varies by geographic region. The relationship is strongest in western regions and weakest in eastern regions.

3. Methods

To test our hypothesis of whether or not the presence of oil and gas wells affects visitation to nearby recreation sites, we use both Ordinary Least Squares (OLS) and Geographically Weighted Regression (GWR)

models and combine four distinct, spatial datasets: Forest Service visitor use data, Forest Service infrastructure data, US Census American Community Survey population data and data on the location of oil and gas well heads. These data were purchased from the Whitestar Corporation (https://www.whitestar.com/). At proxy location, a range of spatial buffers was compiled from 1 to 5 km in 1kilometer increments using ArcGIS 10.3. Within each buffer the number of oil and gas well heads was counted. In addition, the distance to the nearest well from each proxy location was computed using the "Near" function in ArcGIS 10.3 (ESRI, 2011).

3.1. Data

The National Visitor Use Monitoring (NVUM) program of the US Forest Service collects data on recreation visits to national forests using a variety of methods. On-site, visitor intercept surveys as well as fee envelopes, receipts, vehicle traffic counts and trail counters are used to approximate the annual number of visits to each national forest. Recreation site-specific visitor estimates are also available for sites with proxy data. Proxy data take several forms, including: daily use records collected by campground hosts, fee envelopes collected by vehicle, tickets sold at visitor centers, and registration forms. The NVUM program applies a conversion factor to the proxy count data to approximate annual estimates of visits to the given site.

For this analysis, we use the site-specific NVUM total visit counts calculated from proxy data (USDA Forest Service, 2016). We narrow the analysis to include only overnight recreation sites as these sites have more reliable proxy data, compared to day use sites. Only overnight recreation sites on national forests with oil and gas development are included. National forests vary in their use of proxy data, and not every forest or grassland with oil and gas wells collects proxy data for its overnight recreation sites. We use Round 3 of NVUM, the most current visitor use dataset available, which includes data collected between 2012 and 2016. Visit data are available for a total of 803 proxy sites across 27 forests with oil and gas development. While the NVUM data provide information on visitor characteristics, they do not include site characteristics.

Data for each recreation site, including site capacity, level of amenities offered, and site type (e.g. hotel, resort, campground, etc.), are housed in the Forest Service Infrastructure (INFRA) database (USDA Forest Service, 2018). Unfortunately the unique site identifiers are not consistent across the NVUM and INFRA datasets. To match NVUM site data to INFRA site data, we spatially join the data files in ArcGIS based on GIS coordinates and manually inspect each observation to ensure the spatial join performs correctly. In 93 cases, GIS coordinates are missing or sites are very close together, leading to an incorrect match. In these cases, the data are manually joined based on recreation site name. Site capacity data are missing for 79 sites and two NVUM sites are not included in the INFRA database. Ultimately, we are able to match 722 overnight recreation sites across 27 forests to both the NVUM and INFRA data.

The oil and gas dataset contained four attributes including the API number, latitude and longitude, permit date, spud date, completion date, and status. The spud date operationally refers to the time when drilling commences while the completion date refers to the final preparation of the hole. For a dry hole this is the date of abandonment while for a service well it is the date on which the well is equipped to perform intended services. The status is a code indicating what the present disposition of a well is (e.g. inactive, active, dry, etc). The data represent 4.2 million well heads in the coterminous US and Alaska but contained no data in Hawaii. The data include wells on both public and private lands.

3.2. Variables

To estimate effects of oil and gas wells, we created two variables: the total number of wells within five kilometers of the recreation site (wells within five kilometers) and the total distance from the centroid of the recreation site to the nearest well (distance to nearest well). The total number of wells were estimated by spatially intersecting the buffers around proxy sites and then summing the total number of wells. The total distance from a recreation site to the nearest well was computed using the "Near" function in ArcIS 10.3 which returns the distance (Euclidean distance) from the subject recreation site and nearest well within the 5 km buffer.

The first well measure, wells within five kilometers, is a proxy for the holistic impacts to the recreation experience. These impacts include increased traffic, air pollution and impacts to scenery, both at the site or when recreating nearby. The second measure, distance to the nearest well, is a proxy for scenery impacts and noise impacts that occur within the recreation site. The distance to the nearest well variable is top-coded to five kilometers, aligning with the assumption that the most significant impacts from wells would likely occur from wells located within a five-kilometer radius of the site. The result of top-coding, from a modelling perspective, is that there is no difference in the effect of a well located five kilometers away or ten kilometers away. However, wells farther away could conceivably still pose impacts to traffic or air quality. In the absence of site-specific data on traffic counts, well visibility and well production, we feel the conservative, five kilometer cutoff is justified. This is an admittedly conservative assumption, and as such, results may underestimate the impacts of wells located farther away from recreation sites. Approximately 70% of the wells under analysis are located on Forest Service lands and the remainder are located either on private lands or on lands under other federal ownership such as the Bureau of Land Management.

The dependent variable, total visits, is the total number of annual visits to each overnight recreation site. Of the recreation sites under analysis, 99.1% had fewer than 50,000 visits per year, according to the NVUM data. The total visits variable is top-coded to 50,000 to limit the effect of outliers.

To account for differences in visitation levels due to site attributes, we include three control variables: site type, site development level, and site capacity. Site type is a categorical variable and includes three sub-types: 1) hotel, lodge resort; 2) lookout, cabin; and 3) campground, group campground. In the regression models, two dummy variables are included for the hotel, lodge, resort type and the lookout, cabin type. Campgrounds is the largest category and used as the reference category. Site development level is a scale from one to five, where one indicates the fewest amenities provided at the site. Site capacity is the total number of people-at-one-time (PAOT) capacity for each overnight site.

We also include a control for neighboring populations as recreation sites closer to larger population centers may have higher visitor use (Bowker et al., 2006; Rasch & Hahn, 2018). To estimate the size of local populations we use US Census American Community Survey 2016 five-year county population estimates (United States Census Bureau, 2016). In ArcGIS we identify all counties within 50 miles of a recreation site and aggregate the population of each county within 50 miles to obtain the population within 50 miles control variable. As the majority of national forest visitors travel 50 miles or fewer to reach their recreation destination, 50 miles is a reasonable distance threshold (NVUM, 2016).

Descriptive statistics for all the variables in models are listed in Table 1. Fig. 1 displays the location of the overnight recreation sites under analysis and locations of oil or gas wells within five kilometers of the sites. The map displays close-ups of the Allegheny National Forest in Pennsylvania and the Uinta-Wasatch-Cache National Forest in Utah to highlight the significant density of oil and gas wells within five kilometers of some overnight recreation sites and the high level of visitor use those sites receive.

3.3. Models

Using STATA SE software package, we employ an Ordinary Least

Table 1
Descriptive statistics for variables in OLS and GWR models.

Variables	*N*	Mean	Std. dev.	Min	Max
Independent variables					
Total number of wells within 5 km of site	722	11.31	74.58	0.00	1249
Distance to nearest well (meters)	722	4299.82	1406.28	44.02	5000.00
Control variables					
Hotel, resort, lodge	722	0.02	0.16	0.00	1.00
Cabin, lookout	722	0.08	0.27	0.00	1.00
Level of site amenities	722	3.00	0.64	2.00	5.00
Site capacity	722	193	296.41	2.00	3036
Population within 50 miles	722	1131,321	2043,072	63,559	19,300,000
Dependent variables					
Total annual site visits	722	3839	6294	20	50,000

Squares (OLS) regression model to test whether wells have an effect on overnight recreation site visitation. The OLS regression is specified as follows:

Model 1. OLS Regression

$$Visits_i = \alpha + \beta_1(Wells5km)_i + \beta_2(Distance)_i + \beta_3(Hotel)_i + \beta_4(Cabin)_i + \beta_5(Amenities)_i + \beta_6(Capacity)_i + \beta_7(Pop)_i + \varepsilon$$

i refers to a given recreation site. *Visits* is total annual visits to the site. *Wells5km* is the total number of wells within a five-kilometer radius of the recreation site. *Distance* is the distance, in meters, between the centroid of the recreation site and the closest well, *Hotel* is a binary where one signifies the site is a hotel, lodge or resort. *Cabin* is a binary where one signifies the site is a cabin or lookout, *Amenities* is the rating on the five-point amenity scale, *Capacity* is the total PAOT site capacity. *Pop* is the total population of counties within 50 miles of the centroid of the recreation site.

As many recreation sites and wells are clustered close together in space, it is possible that the independent well variables may be spatially autocorrelated, resulting in biased OLS model estimates. We tested for multicollinearity in variables by examining the Variance Inflation Factor (VIF) values for each explanatory variable in the model. All values were below two, suggesting that multicollinearity is not an issue. Next, we tested for spatial autocorrelation, the degree to which neighboring well variable values are similar or dissimilar, by calculating the Global Moran's I test statistic, a common measure of spatial autocorrelation (Lloyd, 2010). For both the well variables, the Global Moran's I values had p values above 0.1, indicating a lack of spatial autocorrelation, and thus, negating the need to employ a spatial error model which would control for spatial autocorrelation in the independent variables.

To account for differences in recreation experiences and expectations across the country, we employed a Geographically Weighted Regression (GWR), a common method for modelling potential geographic variability in a hypothesized relationship (Lewandowska-Gwarda, 2018; Lloyd, 2010; Shoff & Yang, 2012; Yoo, 2012). We used a fixed bandwidth of 2000 km so that local regression estimates would be calculated based on observations located within the same geographic region. With GWR, local regression coefficients are calculated for each site, essentially allowing us to test whether the effects of wells on visitation varies by geographic region.

Model 2. Geographically Weighted Regressions: Bandwidth parameter 2000 km

$$Visits_i = \alpha_i + \beta_{1i}(Wells5km)_i + \beta_{2i}(Distance)_i + \beta_{3i}(Hotel)_i + \beta_{4i}(Cabin)_i + \beta_{5i}(Amenities)_i + \beta_{6i}(Capacity)_i + \beta_{7i}(Pop)_i + \varepsilon_i$$

4. Results

The OLS model explains a relatively high level of variance for social science research, with an adjusted R^2 value of 0.479. The OLS regression model shows a statistically significant, negative relationship between total number of wells within five kilometers (km) of an overnight

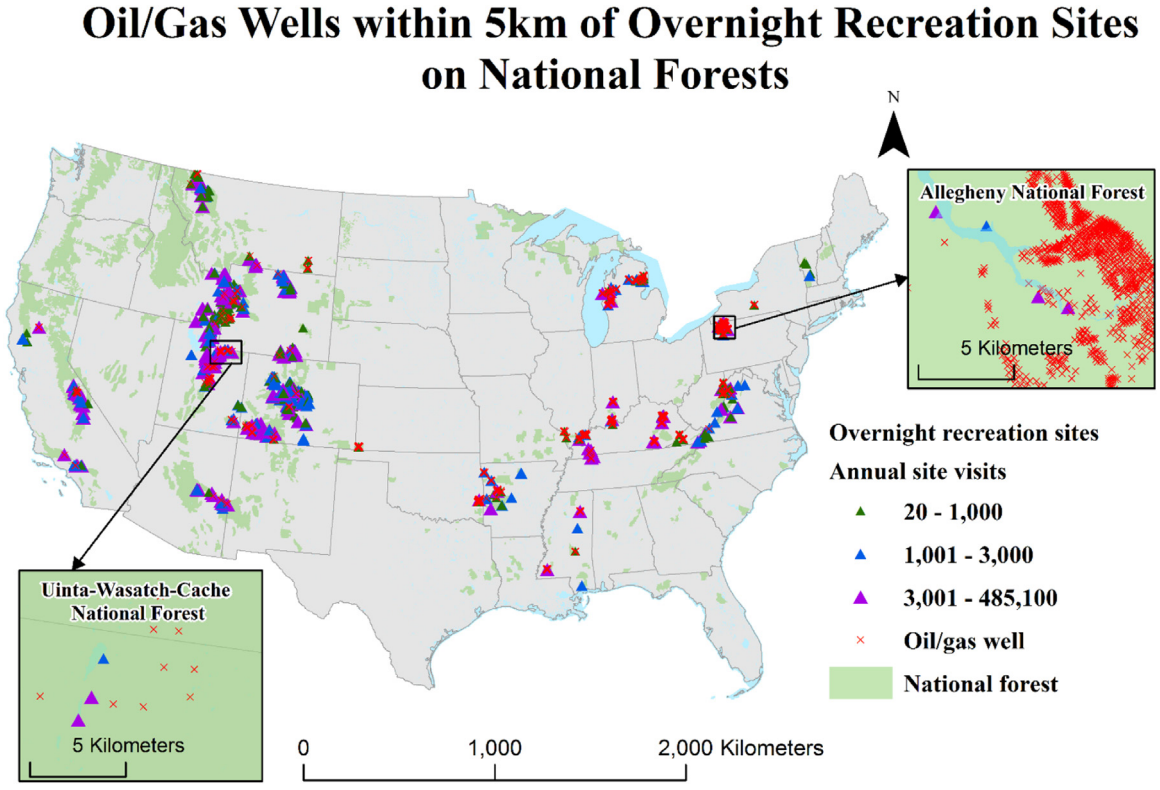

Fig. 1. Oil/gas wells within 5km of overnight recreation sites on national forests.

Table 2
OLS Regression model: determinants of overnight recreation site visits.

	Coef.	Std. Err.
Total number of wells within 5 km of site	− 5.608*	2.452
Distance to nearest well (m)	0.118	0.133
Hotel, resort, lodge	5873.438***	1118.334
Cabin, lookout	− 531.550	635.225
Level of site amenities	845.016**	305.197
Site capacity	13.784***	0.647
Population within 50 miles	3.60E−06	0.000
Constant	− 2272.687	1267.411
$n = 722$		

*** p < 0.001.
** p < 0.01.
* p < 0.05.

recreation site and total site visitation. These findings lend support to the hypothesis that the presence of oil and gas wells close to overnight recreation sites impacts visitation. The model predicts that for each well within a five-km radius of an overnight campground site with average amenities and capacity, visitation declines by 5.6 visits each year. The distance to nearest well variable is not significant, suggesting the proximity of the oil and gas wells to a given site within a five-kilometer radius does not significantly impact visitation.

The control variables in the models behave as expected. Hotels, resorts and lodges predict higher visitation, compared to campgrounds. Higher capacity and higher amenity sites both predict higher visitation levels. Nearby population size was not a significant predictor of visitation. Table 2 lists the OLS model output.

The results of the GWR model are listed in Table 3, alongside the OLS model fit statistics. The GWR proves a better fit for the data and explains more variance within the sample, compared to the OLS model. This is evidenced by the higher adjusted R^2 value of 0.524 and the lower AIC value of 14,156.2, compared to the AIC value of 14,217.7 for the global OLS model. Table 4 displays the minimum, median and maximum coefficient values for each predictor in the model. Interestingly, the coefficient for wells within five kilometers ranges from −6.7–2.06 across all local estimates. All local coefficients for the wells within five km variable that are above −4.67 are not statistically significant. Fig. 2 displays local coefficients for the wells within five km variable. While the relationship between wells and visitation is statistically significant in western states, the local models suggest that wells do not have a significant effect on visitation in the eastern regions or in California.

5. Discussion and conclusion

This work adds to the discourse of public land management by showcasing an empirical relationship between resource extraction and recreation use on public lands. Findings suggest that sites within five km of oil and gas wells see less visitation, compared to sites farther away from wells, in the western region of the United States. While this work does not attempt to speculate on the overall user experience, it does suggest that the presence of oil and gas development may have a significant *enough* effect on the user experience to motivate users to recreate elsewhere. These findings suggest that the observed environmental and social impacts of oil and gas development on communities

Table 3
Diagnostic statistics for local and global models.

	Local Model GWR	Global OLS Model
Coefficient determination R^2	0.532	0.484
Adjusted R^2	0.524	0.479
Akaike's Information Criterion (AIC)	14,156.234	14,217.710

Table 4
Regression coefficients in local and global models.

	Local Model GWR			Global Model
	Min	Median	Maximum	
Total number of wells within 5 km of site	− 6.656	− 6.403	2.060	− 5.608
Distance to nearest well (m)	− 0.362	− 0.021	0.315	0.118
Hotel, resort, lodge	1660.920	5279.056	6522.610	5873.438
Cabin, lookout	− 632.644	− 505.365	21.756	− 531.550
Level of site amenities	700.976	944.339	1089.840	845.016
Site capacity	11.927	14.902	16.722	13.784
Population within 50 miles	0.000	0.000	0.000	0.000
Constant	− 3415.379	− 1980.423	− 867.757	− 2272.687

*Not statistically significant denotes coefficients with a p value > 0.05.

may extend to recreational settings as well (Brasier et al., 2011; Colborn et al., 2011; Field et al., 2014; McKenzie et al., 2012; Sangaramoorthy et al., 2016). Additionally, these results extend the discussion of the effects of technical infrastructure on the recreation experience, suggesting that its presence may deter visitation to natural areas (Arnberger et al., 2018; Riper, van, Manning, Monz, & Goonan, 2011).

Interestingly, the data suggest that the presence of oil and gas development close to campgrounds in eastern regions does not result in declines in overnight site visits. Contrary to their stated preferences highlighted in previous research, recreationalists in eastern areas appear to be willing to recreate at sites close to oil and gas development (Kellison et al., 2017). These results support the notion that recreationalists in eastern areas and in California have a higher tolerance for developed recreational landscapes, compared to those recreating in the west (Manning & Valliere, 2001; Whiting et al., 2017).

These findings also lend support to the flexible recreationalist hypothesis (Parry & Gollob, 2018). Visitors may have adjusted their expectations for a pristine natural environment and are content to recreate alongside oil and gas development. Another possible explanation for the lack of relationship between oil and gas development and visitation is that the relationship is highly dependent on activity type, a variable we were unable to control for in the models. For example, in California, downhill skiing is the primary activity in the majority of visits (NVUM 2016). It is possible that while oil and gas development may impact the hiking experience, it has little impact on the downhill ski experience. Lastly, recreation sites in the eastern regions tend to be located in heavily wooded areas with dense vegetation, which may buffer impacts of wells on recreation settings.

Given the cross-sectional nature of the analysis, it is not possible to determine whether visits to eastern recreation sites close to oil and gas development are from long-term, traditional visitors or new visitors. It is possible that while oil and gas development has deterred recreationalists searching for a more pristine experience, visitor numbers to overnight recreation sites may still be high due to visitor displacement, i.e., new visitors with different expectations for their recreation experience are choosing to recreate in areas close to wells while traditional visitors are going elsewhere (Manning & Valliere, 2001). It is plausible that new migrants to the region, specifically oil and gas workers, may be displacing traditional recreationalists, as they may have a higher tolerance for oil and gas development within their recreation landscape. This situation highlights a potential synergistic relationship between oil and gas development and recreational use, as suggested by the conservation conflict research (Baynham-Herd et al., 2018; Young et al., 2016). Recreational use can stabilize or even increase in the face of energy development due to increased migration to an area.

Another limitation of this work is the possibility that oil and gas development may only be permitted in areas that are less desirable,

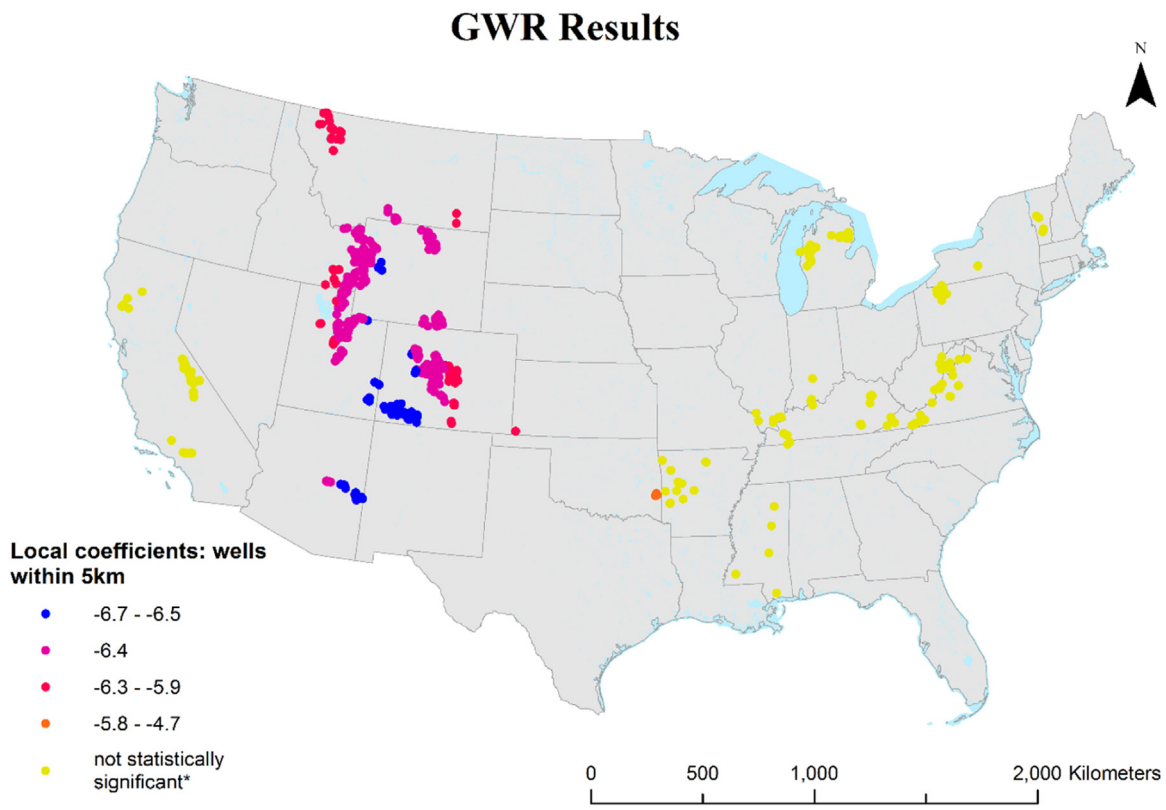

Fig. 2. Geographically weighted regression results.

from a recreation standpoint. Therefore, the observed relationships between wells and visits could be an artifact of where wells have been allowed to be placed, rather than an effect of the presence of wells on recreational visits. However, the wells in the dataset include wells of all ownerships and wells developed on private lands are not subject to review by the Forest Service. Additionally, the policies that guide permitting decisions and the National Environmental Policy Act (NEPA) decision process in the Forest Service are designed to mitigate the potential environmental effects of wells, not prohibit development of wells in the event that there may be recreational impacts. Forest managers in the Forest Service are directed to include provisions to mitigate potential effects, but not to deny permits, to oil and gas development in areas with high recreational values. This is due to the agency's multiple use mission, which supports natural resource extraction as a primary use of federal public lands. In most cases, the Forest Service can only deny well development within designated wilderness areas. Designated wilderness areas were not included in this analysis as developed recreation sites are not permitted within those areas. Wells exist in close proximity to some of the most popular recreation sites on many forests.

Visitor use is an admittedly crude measure of impacts to the visitor experience, but it does provide insight into visitor behavior and thus, lends a cursory insight into the larger debate regarding how oil and gas development impacts recreation on public lands. While this analysis proves an interesting snapshot of current visitor use patterns across the nation, further research is needed to determine how oil and gas development may be impacting the visitor experience, how those impacts vary by activity, and whether or not the effects on the visitation experience differ for traditional users, compared to new migrants.

Managers tasked with analyzing potential impacts of oil and gas development on recreational uses can employ these findings directly into National Environmental Policy Act social impact analyses. On average, an increase of one oil or gas well within five kilometers of an overnight site is related to a drop in only six visits to the site per year. Therefore, it is unlikely that small-scale oil and gas development will result in significant impacts to visitation at the forest-level or the local recreation economy. However, for western forest units with significant numbers of wells within close proximity to overnight sights, oil and gas development may be significantly affecting the district's ability to manage its recreation resources due to declines in visitation and the accompanying drop in income to the district from recreation fees. For example, a campground in Kansas with a capacity of 60 on the Cimarron and Comanche National Grasslands has 144 wells within five kilometers of the site, and an estimated 194 visits annually between 2012 and 2016. Given the capacity of the site and the amenities, our model suggests that visitation levels would be significantly higher, were it not for the site's close proximity to so many wells. Even applying the conservative global model coefficient of −5.6, our research suggests the wells could account for a loss of at least 807 visits to the site each year, an 81% loss in expected visits. When Forest Service specialists are analyzing the potential social and economic impacts of oil and gas development close to recreation sites, as part of the National Environmental Policy Act impact analysis process, this research suggests that they should carefully consider not only impacts to recreation settings and the visitor experience, but also the real potential for declines in visitation and the associated drop in recreation fees available to local district managers for recreation resource maintenance and stewardship.

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