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## Tradeoffs, balancing, and adaptation in the agriculture-oil and gas nexus: Insights from farmers and ranchers in the United States

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## ABSTRACT

This paper seeks to expand an emerging, multi-disciplinary body of work about tradeoffs in the agriculture-oil and gas nexus by offering evidence of the ways that farm and ranch operators experienced and negotiated costs and benefits of hosting oil and gas in three U.S. oil and gas plays. We report results of mail survey sent to landowners in four rural counties in three U.S. oil and gas regions (Marcellus, Powder River Basin and Bakken) and specifically data from farmers and ranchers about perceptions and experiences of the agriculture-oil and gas nexus ( $n = 96$ ). The data provided through closed- and open-ended questions suggest, from the perspective of those hosting energy infrastructure on farms and ranches, oil and gas development has enhanced agriculture operations and rural livelihoods but is not without negative impacts or tradeoffs. We introduce the balancing act as a useful framework for considering tradeoffs associated with hosting extractive industries as it allows space for the “balance” between economic activities to be impossible, aspirational or achievable. The study observes that mechanisms through which positive and negative effects operate vary according to agricultural context. Implications for research and practice in the agriculture-energy nexus are discussed.

## 1. Introduction

Approximately 35% of the total agricultural acreage in the United States is located in counties with shale development [1], making the scope of the overlay of onshore oil and gas and agricultural land uses vast. Oil and gas developers rely on agricultural lands to locate infrastructure. In return, farmers and ranchers experience a range of benefits and costs, both implicit and explicit, from energy development. However, the degree of alignment between agriculture and contemporary modes of oil and gas production as overlapping resource development strategies remains an open question in the literature [2,3]. Studies confirm economic benefits and mixed demographic outcomes in rural areas [4,5]. On the other hand, a growing body of evidence documents disruption of rural livelihoods, environments, and quality of life in the context of onshore unconventional oil and gas development booms [3,6–8].

That all energy systems imply tradeoffs between societal costs and

benefits is a standard trope of energy research [9–11]. And the notion of tradeoffs is certainly germane in the case of the farms and ranches that “host” oil and gas infrastructure. This paper seeks to expand an emerging, multi-disciplinary body of work about tradeoffs in the agriculture-oil and gas nexus by offering evidence of the ways that farm and ranch operators experienced and negotiated costs and benefits of hosting oil and gas in three U.S. oil and gas plays, with a particular interest in practical adaptations by farmers and ranchers. Focusing on farm business and on-farm activities, we conceptualize the agriculture-oil and gas nexus in terms of a balancing act: the idea, suggested by the literature and our research, that many farm and ranch operators pursue strategies that seek to maximize benefits and minimize costs of development and that the particulars of this balancing act vary in different geographic contexts. The paper has two linked objectives: 1) to provide scholarly audiences with descriptive and comparative data that can inform hypotheses and frameworks for further research about oil and gas development for farm and ranch operations; and 2) to inform regulators,

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policy makers, industry and advocates for agriculture about the range of experiences in the agriculture-oil and gas overlay in three distinct regions of the United States.

Specifically, we share data collected in a long-format mail survey sent to a random sample of 1000 rural landowners in four different U.S. counties with extensive oil and gas development activity (two in the Bakken, one in the Powder River Basin<sup>1</sup>, and one in the Marcellus). We organize our analysis around three concerns: What are the perceived positive and negative effects of oil and gas development on farms and ranches? How do they differ among distinct agriculture-oil and gas geographies? What strategies have farm and ranch operators used to respond and adapt to impacts from oil and gas activities?

The paper begins with a brief summary of the agriculture-oil and gas nexus grounded in recent scholarly literature. The next section describes our data collection and analysis approach. We then report findings in three general categories: observations of major geographic differences in the agriculture-oil and gas nexus, the impacts of unconventional oil and gas development on farm and ranch operators, and the adaptations they report having made in response.

## 2. The agriculture-unconventional oil and gas nexus

Beginning in the early 2000s, onshore gas and oil production in unconventional geologic formations (hereafter UOG) increased dramatically in response to multiple drivers including market signals and technological innovation [12]. Since agricultural operators own the majority of rural land in the United States [13], farmers and ranchers were primary local stakeholders in the surge of UOG development. Our study focuses on this agriculture-UOG nexus, which we define as the geographies in which agriculture and onshore oil and gas development (well pads and/or associated infrastructure) overlap as surface land uses.

Several different bodies of work contribute perspectives on experiences and outcomes of the agriculture-UOG nexus. These include statistical assessments of employment, income, and demographic outcomes in rural areas that draw on large datasets; environmental science studies focused on land, air and water impacts of UOG; survey and interview-based assessments of rural community experiences and impacts, often focused on explaining differences in outcomes or perspectives within and across social or stakeholder groups; and finally in-depth case study engagements with the concerns and issues emergent in specific agriculture-oil and gas landscapes.

Numerous statistical studies of economic and demographic effects of the UOG boom in rural areas that have asked whether rural communities are better or worse off for their participation in energy booms have produced mixed results. Taken together, the studies suggest that the oil and gas boom to date is neither an outright resource curse in rural areas [4,14–16], nor adequately dramatic to “reverse ...[the] long-run, structural problems” facing isolated rural economies ([17]: 235).

Economic studies also show that energy development has benefitted agriculture operations directly by providing supplemental income in the form of lease and/or surface-use, bonus, and royalty payments, albeit in a highly uneven pattern across the United States. In 2014, total private royalty payments in all U.S. shale plays were \$39 billion [18] and approximately 12% of farms in states with shale development

received payments from royalties and/or lease payments with an average amount of \$66,000 [1]. The average was substantially larger for agricultural operations in major shale plays: farms in North Dakota (Bakken shale play) received an average \$157,409 and Pennsylvania farms (Marcellus shale play) received an average \$157,070 [1]. Notably, not every landowner receives windfall payments. For landowners in areas that have had previous energy development and in areas of the West with public mineral ownership, estates are more likely to be “split,” meaning their mineral rights are separated from their surface rights, limiting their financial gains from energy development [13,19].

On the cost side of the equation, environmental and social science studies confirm that oil and gas development can impose costs on farm and ranch operators at both the property and the landscape scale. At the property scale, studies have documented topsoil and/or subsoil compaction [20,21], the introduction of invasive species [22,23], brine spills [24], and livestock losses [25]. Much of the emerging research on environmental impacts of UOG underscores an important feature of the industry in the United States: the tendency for regulatory approaches to follow, rather than pre-empt, the emergence of environmental problems and the science necessary to understand and mitigate them [26–29]. This policy environment puts farm and ranch operators on the frontlines of documenting and responding to novel or emerging forms of environmental damage associated with UOG [8].

An important group of studies explores the agriculture-oil and gas nexus from the perspective of rural landowners and farmers and ranchers through surveys and/or in-depth qualitative approaches. The closest parallel to the work described in this paper is McGranahan et al.’s [11] survey of rural residents in 6 counties in western North Dakota which focuses on documenting the range of perceived impacts and testing for their distribution and representation across stakeholder groups. Among farm and ranch operators, the study identifies concerns about impacts from dust on crop productivity and livestock well-being, a priority on soil conservation and effective reclamation using existing policies and practices, and costs to farm and ranch operators of time they invested in “babysitting” industry.

Survey work continually finds that perceived economic benefits and/or experience in or with extractive industries make rural residents more likely to tolerate oil and gas activity [30–35]. Research in the Northern Great Plains and Interior West points to a tendency for rural landowners to adopt a pragmatic and accommodating approach toward industry, as in the case of a low perception of risk from brine spills on Montana farmland [36] or farmers initiating a ‘troubleshooting’ rather than an oppositional approach to solving reclamation issues in North Dakota [8]. The dynamics underlying farmer accommodation of UOG impacts are likely far more complicated than survey work can address. A few in-depth case studies emphasize how structural political-economic inequalities leave landowners with little choice but to accommodate industry [3,37].

Studies of formal organization in response to UOG impacts by farmers and ranchers in the United States are few in number. Jacquet and Stedman [38] observe benefits of collective organizing among rural landowners in New York State in response to a flurry of leasing activity by landmen in a single geographic area. In contrast, Jacquet [39] points to a trend of “private participation” in which individual landowners and industry negotiate the siting and negotiation of energy facilities directly. Eaton and Kinchy [40] emphasize that failure to mobilize in rural areas should not be equated with consent, although they extrapolate from a very limited number of interviews. Smith and Haggerty [8] describe the tensions in a North Dakota landowners’ organization as they work to mitigate undesired impacts from development by employing an accommodating strategy with industry while continuing to advocate for landowners and avoid industry capture.

Taken together, the existing literature on the agriculture-UOG nexus clearly demonstrates several key trends upon which this study builds. First, other than those directly employed in UOG industry, few private parties experience the tradeoffs embodied in UOG development as

<sup>1</sup> The Powder River Basin experienced a boom in coalbed methane extraction between 1998 and 2008. Although coalbed methane does not meet standard geologic criteria for unconventional sources, the pace and scale of development and the extensive infrastructure necessary for development make a CBM boom very similar to an unconventional boom in terms of surface activities. The landowners of the PRB fit within this sample due to the reliance on agricultural activities, specifically livestock production, in the Basin and the region’s rural geography.

immediately as the farmers and ranchers that host energy development on their land. Their options and choices are in essence a microcosm of the broader environment-society-economy balancing act precipitated by the shale revolution. And while a few studies suggest different reasons and circumstances in which farmers and ranchers in the United States accommodate oil and gas development, the full range of the perspectives of agricultural operators on impacts and practical strategies for adapting to them is hard to decipher from the literature. It is also unclear under what circumstances UOG development enhances or detracts from farm and ranch operations. To this end, this paper provides a framework to start connecting impacts and adaptation strategies (the balancing act) and descriptive data about variations of the balancing act in different production regions.

### 3. Study design & dataset

This study analyzes data from a mail survey sent to landowners in four counties with unconventional energy development: Richland County, MT; McKenzie County, ND; Tioga County, PA; and Sheridan County, WY. These counties were selected to ensure rich comparisons based on their representation of three distinctive plays where UOG development targeted different hydrocarbons, specifically the Bakken (shale oil), Marcellus (shale gas), and Powder River Basin (coalbed methane). Additionally, the geographies were experiencing different phases of the boom-and-bust cycles at the time of the survey, and they have differing agriculture profiles (see Table 1 and Fig. 1). In addition, we relied on a project advisory board of local professionals familiar with community dynamics in the study areas in selecting study locations. We followed their advice to mail surveys in these counties in contrast to other areas that they considered over-studied and experiencing research fatigue.

As Fig. 1 suggests, while county-wide total net farm earnings were similar in the four counties until about 2005, farm earning performance diverged fairly dramatically in the two Bakken counties versus the Wyoming and Pennsylvania locations. These data do not isolate all UOG-related income on farms and ranches, but the charts suggest evidence that during the commodity price surge of 2010–2014, both high grain prices and miscellaneous farm income (including mineral income, see figure note) contributed to a more amplified cycle of expansion and contraction in farm earnings between 2008 and 2016 in the Bakken locations. All locations were experiencing a decline in farm earnings in 2016 when the survey was administered.

The survey instrument was designed to identify the perceptions of

**Table 1**  
Study County Profiles.

Sources: Number of farms (including ranches) as reported by U.S. Department of Commerce [45]. Total acres as reported by U.S. Geological Survey [46]. Total farm acres (including ranch acres) as reported by U.S. Department of Agriculture [47]. Well counts from state oil and gas commissions.

Geologic Region	Richland Co., MT Bakken	McKenzie Co., ND Bakken	Sheridan Co., WY Powder River Basin	Tioga Co., PA Marcellus
Total Acres	1,346,207	1,830,989	1,615,354	725,658
2013 Population	9,667	7377	29,376	42,267
# Farms (2012)	544	574	702	1,125
Farm Acres (%)	1,293,012 (96.9%)	1,064,191 (60.2%)	1,304,838 (80.8%)	205,158 (28.3%)
Boom Years	2004–2014	2007–2014	1998–2008	2009–2014
Well Count as of 2014	1665	2,523	4,892	873
Well Density (total acres divided by total wells)	776.6	421.8	266.7	235.0

costs and benefits that landowners and agriculture operators experienced due to oil and gas development, as well as the strategies that they used to capitalize on, manage, and/or mitigate impacts. The survey collected data through a mix of 24 multiple-part closed- and 10 open-ended questions. We pretested the survey with focus groups in each state to test for rigor and clarity prior to mailing. Survey design and administration followed Dillman et al. [41] best practices. Individuals had the choice to respond to the survey by mail or web. Selected individuals received a total of three mailings: an initial mailing of the survey, a follow-up postcard, and a subsequent second full mailing to non-respondents. Survey administration occurred in spring of 2016.

#### 3.1. Survey respondents and analysis

We selected 250 landowner addresses in each of four counties, for a total sample size of 1000 landowners using the following sampling approach. Using GIS data reported by state and local governments, the location of each unconventional oil or gas well in the counties was identified. A 1000 foot radius was drawn around the longitude-latitude location of each oil or gas well, and all private residential homes and family-run agricultural-related businesses within these radii were identified using county planning data. We deleted duplicate landowner names (landowners who own more than one parcel within the well radius) before we randomly selected our sample from this initial landowner set. Landowners were deleted from the sample frame if the agency records did not include complete address information or indicated the property was publicly-owned. Of the 1000 surveys delivered, 242 usable responses were received yielding an effective response rate of 24.2%. Response rates varied by state: 32% in Pennsylvania, 28% in Montana, 24% in North Dakota, and 22% in Wyoming. A non-response survey was not conducted due to budget limitations. The fact that the survey was sent by the Pennsylvania State University may have influenced higher response rates in that state.

The demographics of the survey respondents favored older males. Seventy-two percent of respondents were male. Seventeen percent of respondents were younger than 50; 34% were in the 50–64 year-old cohort, and 38 percent were older than 65. Nine percent of respondents reported having worked for the oil and gas industry at any time in the past. Among all respondents, 96 people (roughly 44% of total respondents) self-identified as farm and ranch agriculture operators; these responses are the subject of this paper. Distribution of agricultural operator respondents among the sampled locations is relatively even: McKenzie County, ND: 22; Richland County, MT: 28; Sheridan County, WY: 25; and Tioga County, PA: 22.

A range of types and sizes characterize the operations of agricultural respondents to the survey. Respondents' property holdings ranged from 10 acres (in Pennsylvania) to 38,000 acres (in Wyoming). On average, the western counties with energy development featured larger operations in terms of reported land acreage (Richland: 2307 acres; McKenzie: 1596 acres; Sheridan: 3322 acres). These operations were predominantly focused on cattle production and, in North Dakota and Montana, also on cash small grains. In contrast, in Pennsylvania the average agriculture operation was 267 acres, 87 to 92% smaller than the average operations in the western counties, and they were predominantly (41%) dairies. When asked to report their main agricultural products, Pennsylvania operations reported greater diversity than the western counties.

In sum, we are reporting on a small sample of farm and ranch operators from four rural counties where the dominant land use is agriculture and UOG activity surged in the 2000s. The sample includes a range of operational types and sizes, but privileges older male perspectives. While the survey did capture a range of diverse viewpoints, we cannot describe the representativeness of these viewpoints across the broader population. Due to the small sample size, the closed-ended data reported in this paper are used as descriptive measures and were not subjected to statistical analysis. Answers to the 11 open-ended

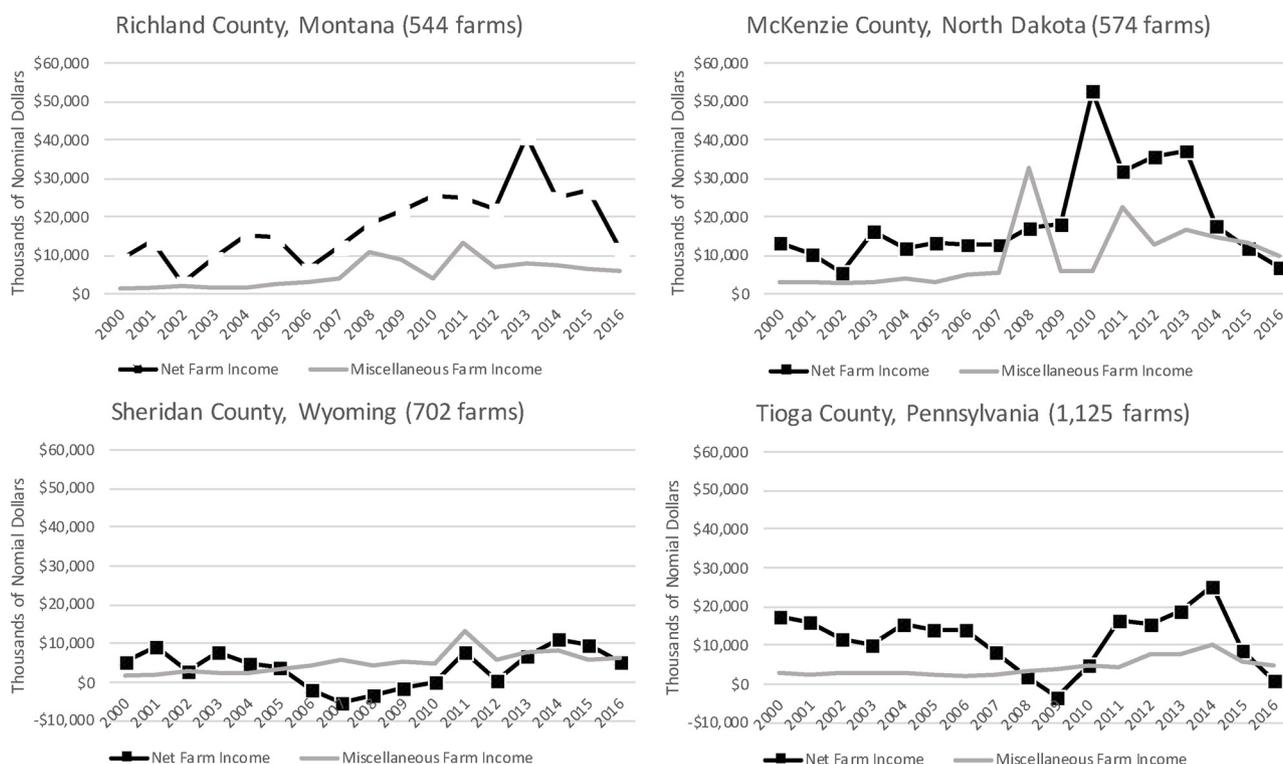


Fig. 1. Net Farm Earnings & Miscellaneous Farm Income by County, 2000–2016.

Sources: U.S. Department of Commerce, Bureau of Economic Analysis, Regional Economic Accounts, Table CA45 Farm Income (2018). Farm numbers from U.S. Department of Agriculture, Census of Agriculture, Table 8 (2012). Net Farm Proprietor Income and Earnings is derived from reported cash receipts, other income, production expenses, and inventory values. Miscellaneous income is defined as “the value of home consumption, and other farm related income components such as machine hire and custom work income, rental income and income from forest product royalties.” Upon inquiry, we learned from the BEA that rental income can include: “Mineral royalties if they are tied to the farm” and “Payments received for cell phone towers, underground pipelines, access roads, etc., in which the operation receives an ongoing payment for their presence on the farm.” (Baybrooks, M. U.S. Department of Commerce, Personal communication, 3-15-18).

questions were transcribed and uploaded into QSR Nvivo 10, a code and retrieve data analysis software. We systematically coded for common themes using a grounded theory approach [42].

#### 4. Findings: benefits, costs, and adaptations

We report findings in four categories: reported benefits to agriculture, reported costs, specific adaptations made to manage benefits and costs, and overall perceptions and assessments of UOG’s net outcomes.

##### 4.1. Reported benefits to agricultural operations & operators

Two questions asked about positive impacts from oil and gas development. In the first, 63 respondents (WY: 20; PA: 11; ND: 15; MT: 17) described the positive impacts of development to their farm or ranch in answers that ranged from one or two words to several paragraphs. Comments focused on income, off-farm benefits, and infrastructure improvements. Five respondents wrote either negative comments or ‘none’ with respect to major benefits to farming, despite having a separate place to comment on major negative impacts. In the second question, 53 respondents described how either they or someone in their household had personally benefited from oil and gas development. While answers aligned closely with the previous question, respondents also discussed new employment opportunities related to the oil and gas industry (e.g., “It has provided me with the majority of my income working for a[n] oilfield construction company” and “increase in business, we remove snow from [industry] sites with farm trailers”).

Over 60% of respondents who answered the first question about positive impacts mentioned the direct benefits of additional income to the farm or ranch business such as, “farm is paid off.” Many respondents

described a direct link between additional income and the ability to make on-farm improvements to the sustainability and productivity of their operations, as suggested by these answers: “The added income makes it much easier to farm and allows us better equipment, etc.,” “capital for farm improvements such as water development, fencing, weed control, and better farm machinery;” “money that allows for taking more risk in an effort to raise better crops;” and “provided extra cash to keep farm in top condition.”

Respondents’ answers about benefits suggest an influence of geography on how farms and ranches experience oil and gas development. Wyoming respondents, who generally had the most clearly positive orientation toward development, emphasized the positive effects that coalbed methane development had on expanding on-farm infrastructure, including roads and water systems. The link between ranch sustainability and productivity and infrastructure is made clear in these comments by one respondent from Wyoming:

The quality of road access to pastureland has improved. Installation of cattle guards at main fence crossings on roads eliminates the need to open gates. The most positive effect has been the installation of stock watering tanks along produced water pipelines<sup>2</sup> for the convenience of the landowner. [t]hese additional watering locations spreads the cattle and causes them to graze in areas they had previously received little grazing attention. These watering locations are only temporary, however, but grazing efficiency has improved during the time this water has been available.

The geographic context is important: Wyoming properties were on

<sup>2</sup> Produced water from shallow coal aquifers is often adequate for livestock consumption. Its utilization is a common practice in the Powder River Basin.

average the largest reported in the sample and ranch productivity in the region is water-limited. The county showed the lowest average net farm income among the four (Fig. 1, above), suggesting limited options for investing in farm infrastructure. Even minor changes in the ability of operators to move cattle and access parts of their large properties could have noticeable benefits. In North Dakota, one rancher respondent noted that new oil field roads “make it easier to get into rough country with pick-up and stock trailer with horses and dogs.” Perhaps not surprising given the smaller size of responding operations, by comparison, just one Pennsylvania farm operator indicated that oil and gas development had created beneficial on-farm infrastructure.

#### 4.2. Negative impacts on agricultural operations

Among the 57 answers (WY: 15, PA: 10; ND: 14; MT: 18) about major negative impacts of oil and gas operations on farms or ranches, concerns fell into multiple categories: issues with aesthetics, litter and dust; concerns about loss of privacy; lost productivity of farm and ranch operations; and the impacts of high truck traffic on personal safety and the functionality of local roads. These impacts varied in severity and concern. Dust for example, was a frequent problem for respondents in Montana, Wyoming and North Dakota, who reported health and agricultural productivity in comments noting “hindered plant development” and “dust pneumonia” in livestock, and “Dust!! Everything I have is covered in dirt most of the time. Sometimes it's hard to breathe...It's really awful and has impacted life more than anything else. Help!” In other cases, such as one Pennsylvania respondent, the issue was “unsightly” transmission lines. Impacts on farm productivity reported in these open-ended responses generally involved direct land lost to farming or grazing because of development; impacts to plant and animal growth from both dust and brine water spills, animals killed by trucks; and the impacts of weeds and un-reclaimed land.

A review of the comments by geography and category suggest that traffic and dust problems were experienced more often in the western states (n = 17) than in Pennsylvania (n = 1). While the sample is very small, it would appear that Pennsylvania operators have fewer complaints than western operators about lost productivity from oil and gas development as well. A related question asked respondents about costs that they or someone in their household have personally experienced. These answers (n = 53) reinforced some of the agricultural impacts described above and introduced new concerns and categories of impact including increases in cost of living, expenses associated with property taxes, legal fees, and the extra cost of remediating and reclaiming oil and gas impacted resources. Some impacts appear to have had significant personal toll such as having to sell off a cattle herd in Wyoming: “Gas and oil developer to create havoc [sic] on the land and fences so livestock had to be sold out.” From North Dakota, one wrote: “The highways will kill you and I have lost a lot of friends in this oil boom compared to the early 80's!!!!” Others reported no personal costs or noted that they were manageable, such as “tax, but it was very reasonable.” Two issues reported in all states involved increases in local cost of living and lost time and expense of interacting with oil and gas companies both in person and through lawyers.

#### 4.3. Adaptations by farm and ranch operators

When asked if survey respondents had changed their farm or land management practices in response to oil and gas development, 68% of respondents noted they made no changes to their operations compared to 32% noting they had changed practices (Table 2). Amongst the four states, Montana operators were most likely to make changes, while Pennsylvania operators were least likely. This observation reinforces geographic distinctions demonstrated elsewhere in responses to this survey, especially the tendency for more Montana respondents to mention that oil and gas had solely negative effects on their agricultural operations.

**Table 2**  
Farm and Land Management Response Amongst Agricultural Operators, by State.

County, State	Have you changed your farm or land management practices?		
	No	Yes	Total
McKenzie County, ND	16 (76)	5 (24)	21 (100)
Richland County, MT	15 (56)	12 (44)	27 (100)
Sheridan County, WY	17 (68)	8 (32)	25 (100)
Tioga County, PA	17 (77)	5 (22)	22 (100)
<b>Total</b>	<b>65 (68)</b>	<b>30 (32)</b>	<b>95 (100)</b>

Note: Row percentages in parentheses; may not equal 100 percent due to rounding.

An open-ended question probed the specific adaptations undertaken by farm and ranch operators. Responses fell into two categories: (1) operations and (2) remediation and reclamation. In terms of operations, farmer and ranchers reported changes to operating patterns (“split Pastures; rotation of cattle changed”); changes to having water and water access (“the installation of stock water tanks for watering livestock has...helped in utilizing areas that were not grazed because of the lack of stock water nearby.”); and managing machinery and farming to avoid oil and gas sites. Other adaptations responded to concerns about safety and security and overseeing activity on well sites. Respondents discussed only moving cattle “on back roads and on Sundays” because of traffic. Another stated having to “to have [a] paid person when gone,” while another person ‘lock[ed]’ everything up.” Others discussed the amount of time needed to manage the effects created by oil and gas development. As one Montana respondent wrote, “babysitting” was a negative impact for their operation:

Traffic - ensuring companies take care of well sites - pipelines for weed control. That is a never-ending job - always having to babysit each company to call few times a year as we have in our leases they have to control but we still need to call them - frustrating.

Despite various mandates to industry to undertake reclamation, one major adaptation farm and ranch operators engaged in was their own remediation and reclamation work. Several farm and ranch operators described having to rework lands to bring them back to productivity. One operator in North Dakota mentioned employing no-till practices to restore land, while another in Wyoming discussed re-using oil and gas facilities to expand their own infrastructure: “I have used the abandoned pipelines to provide irrigation to more land. Gas wells have been converted to water wells.” Operators in Montana and Wyoming noted that they adapted to unsatisfactory reclamation by conducting more intensive weed control. One agriculture operator described an “increase in money needed to spray for noxious weeds” and another operator “had to buy more weed spray as neighbor’s wells are not all kept up.” Other comments emphasized poor reclamation related to pipelines and well pads, as well as damaged fences and gates, that presumably led to adaptations, increased costs to agriculture operators, and/or additional demands on their time.

#### 4.4. Adaptation assistance and lessons learned

The survey asked respondents what, if any, assistance they utilized in adapting to oil and gas development. A list of possible sources with an option to write in a value for “other” was provided. Of the 56 respondents who answered the question, there was an even split between self-reliance and use of outside resources. Working alone was the most frequent answer, followed by family members. Beyond self and family, respondents used a variety of sources including lawyers, oil and gas industry representatives, financial managers, and various local entities.

Respondents were asked what type of assistance, such as training or

grants, would have been helpful for their operations. While there was no clear consensus from the respondents, many voiced concerns about the risk of being exploited by industry; the absence of effective state and federal oversight; and the importance of neighbor-to-neighbor communications. Comments addressing the uneven playing field between companies and landowners included: “[Company] took advantage of farmer and worked them for all they could” and “big oil and gas targets an area and takes advantage of landowners before government can react.” Westerners offered the most comments on ineffective regulation, such as: “The state should have tougher rules and enforce them with on-site inspectors” and “Oil and Gas Commission could be more concerned for the land long term.” Lastly, some respondents revealed their preference for educating themselves, both on their own and by talking to neighbors. A Pennsylvania respondent noted: “more meetings with farmers that had been through the experience [of hosting oil and gas development]” would have been helpful, adding poignantly: “If anyone would have listened.”

A similar question asked what respondents would do differently with regard to oil and gas development. Among the 67 respondents addressing this question, 27 wrote “nothing” or “none,” suggesting satisfaction with the nature of development. Among the 40 respondents (42% of the total sample) who stated they would have done something different, 13 expressed strong regrets about engaging with oil and gas at all, writing comments such as “TOLD THEM TO GO TO HELL” or “Not allowed [on] the site period.” The words of one Wyoming respondent are an important expression of the discontent of the 39% of Wyoming respondents who felt UOG development had negative effects on their farm/ranch operation:

We probably would not have allowed CBM natural gas development on our land... We had no choice [because of split estate]. We didn't feel that the loss of land value due to the disturbance of the land, and the [failure] of full reclamation, was worth the money we would receive with CBM development.

Beyond rejecting development completely, respondents noted the importance of taking a stronger position with industry as in “Been tougher on them – companies and the crap they get away with” and “Stood up stronger when industry failed to abide by the surface use agreement - left no topsoil, made larger roads, left noxious weeds, etc.” A few comments addressed the role of legal strategies specifically, such as working with a lawyer or being better educated about regulations.

#### 4.5. Overall perceptions of benefits and costs

Farmers and ranchers were asked to respond to two questions regarding their overall perceptions of the impacts of oil and gas development (Fig. 2) at the scale of households and counties. With the caveat that less than half of the farm and ranch operator survey respondents answered this question (it came at the end of a long survey), overwhelmingly those who did respond felt that oil and gas development had made their households and counties better off overall.

Operators were asked whether or not oil and gas development has had a positive or negative impact, or both, on their farm or ranch operation (Fig. 3). The results show that the majority of respondents perceived that oil and gas had either solely positive (47% of those reporting effects) or mixed effects (26% of those reporting effects), while slightly less than one-third perceived solely negative effects. Montana respondents were the most likely of the four states to indicate only negative effects, and Wyoming respondents were the most likely to observe only positive effects. The relatively high share of respondents noting mixed or solely negative impacts adds texture to the results reported above. While respondents recognized overall benefits to households and localities, these benefits accompanied perceived costs to farm and ranch operations.

#### 4.6. In their own final words: a risk, a boon, a balancing act

Our survey instrument contained a space to offer closing comments (“Please share any final comments you have related to oil and/or gas activities in your community”). At this point in a long survey, 45 of 96 respondents still chose to write in responses, 8 from PA; 12 from WY; 11 from MT; 14 from ND. Reading them, we were struck by the ways these final comments reflect a range of perspectives on the relationship of oil and gas to agriculture and rural livelihoods as an unacceptable risk, a boon, or as an imperfect, but manageable balancing act. They also hint at the different issues that have risen to the surface as consistent concerns in each geography. We take time and space here to share a few of the responses in full to help give voice to the participants in this survey, the farm and ranch operators who have accommodated oil and gas impacts, willingly or not.

Seventeen of these 45 responses focused on exclusively negative concerns that describe different kinds of risk and vulnerability being experienced in the agriculture and oil and gas nexus. Notably 7 of the 8 comments from Pennsylvanian respondents were negative and all focused on their perception of being mistreated and pushed around by uncaring or irresponsible companies. Examples of their statements are: “Big oil companies stop stealing money from the middle-class people. Stop deceiving people and having huge variations in the lease payments. The oil companies knew what the rights were worth and tricked many people.” “You can't win against the gas co. once you sign! Do more research.” “They are too pushy. Do and go where they want. Only interest in gas and not community or protecting land.”

Similar feelings of inequality were also expressed by respondents from Montana, Wyoming and North Dakota, but focused less on leasing *per se*. A Wyomingite wrote: “The oil and gas industry started out and developed an attitude that they could do no wrong, the same attitude that is common in the oil and gas industry. ... I personally wish they had never set foot in Sheridan County or Wyoming.” From North Dakota: “As I said – a complete NIGHTMARE. Crooks – thumb their noses at you as a land and mineral rights owner.” And in Montana: “Oil and gas industry gets 18-month tax holiday, while royalty owners get ZERO tax breaks. Oil and gas industry controls state [government] to big extent. Oil and gas industry largely dishonest. Oil and gas development ruins neighboring efforts.”

In the western states in particular, negative comments focused on the failure of the state to protect landowners and communities in their unequal position relative to the UOG industry. The concern focuses on two issues: on-site legacy issues (“trash, weeds, abandoned reclamation”) and impacts to local infrastructure (“our roads have been destroyed”). In the words of one Montana respondent:

This county has suffered thru 3 oil busts and we are tired of it. Mostly the messes left behind this included the sites left unmanaged, weedy and leaking. There are many in our county and surrounding counties. Yes, the county gets money for funding projects but who sees the mess us farmers have to deal with. I do have to admit the newer sites are so nice and well managed. ... All we want is a little consideration for afterlife of wells and pipelines.

Nine respondents chose to write in an explicitly positive final comment: 5 from Wyoming, 3 from North Dakota, 1 from Montana. The Wyoming comments tended toward the political, such as: “After the Democrats shut off our economy, we have lost 70% of value of oil and gas and 30% value of cattle. ... If we do not get [them] out we will be a 3rd world country.” And, “I feel that the more we develop our natural resources, the better. We need the jobs. Folks around here need their children to have the opportunity to work where they were raised. ... I feel that there's been a good balance in the way we've developed the gas field on my property. I have no regrets.” From North Dakota, one respondent wrote: “Not only did it give me a well-paying job, but it has allowed us to retire on time, buy what we want, and do what we want. The Lord has blessed us and we give him all the glory!!!” The lone

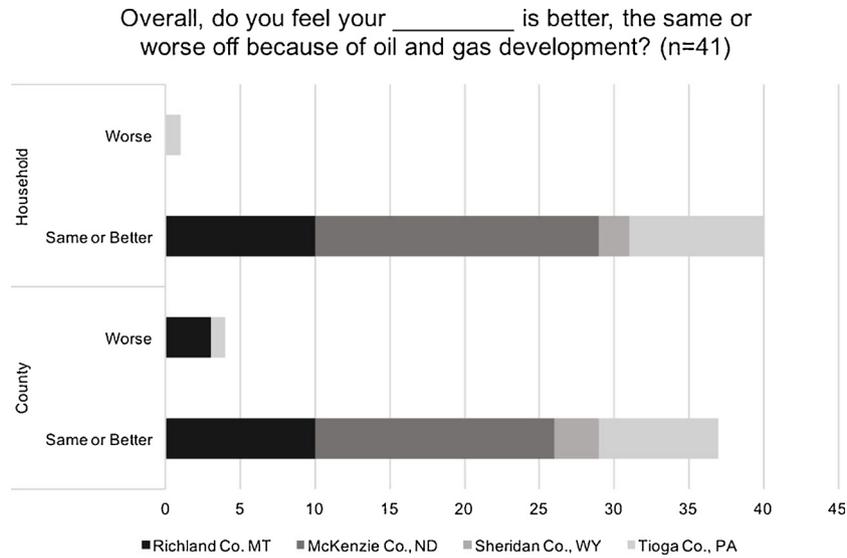


Fig. 2. General Assessment of Oil and Gas Impacts.

Montanan reporting positively focused on the community outcomes:

Oil and gas activities are so beneficial to all aspects of life, from better schools, our hometown owned stores are/were doing better than ever, increased community activities - from Rec. Center, walking paths, concerts in the new park pavilion, the list is endless. So please report this to the people that think they have a clue!!! Also, amazing health care improvements - **important**. [emphasis in original]

There were 12 closing comments that framed the experience of UOG in terms of tradeoffs. One North Dakotan’s answers were simple: “Some very good jobs in the community. Dust in our house every day. Churches and schools are better off due to the oil field money. General disrespect for landowners - litter and poor drivers.” Another’s comments were more reflective:

Any development in any area has both positive and negative effects. ‘Life is a see-saw’ – oil and gas development in our county has provided opportunities that we could never have imagined. If we use these financial rewards to develop new areas of opportunities for our land and people in the next generations we will have truly

succeeded. We have been given a huge gift - let’s hope we can deliver an even better land and community to those who follow.

A Wyoming landowner drew attention to how his/her personal capacity contributed to a positive experience: “Overall, it was good for us. However, I was a relatively sophisticated person used to negotiations. I found a good oil and gas attorney who was able to protect us with an excellent surface damage agreement and ‘keep the companies honest.’” Finally, we close with an observation by a Montana respondent we felt summed up the tolerance that many of our respondents demonstrated for the disruptive effects of oil and gas development, along with the optimism that persists among some about oil and gas development.

When I think about it, I would be very happy with all the development if the dust problem could be solved. People should be able to live in their homes and go outside and have air to breathe!!!! Other than that, the income was nice and hopefully will be again when things pick up again. Most of the people who have come in are really fine people.

What type of impact have the oil or gas development activities in your county had on your farming operation? Select all that apply. (n=78)

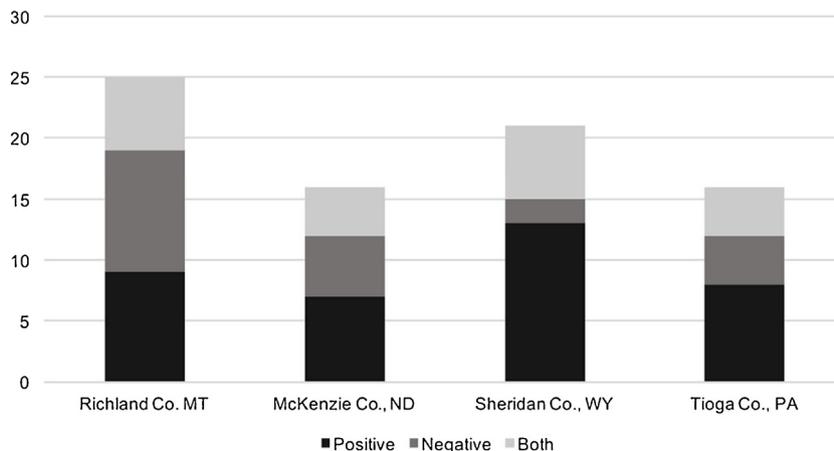


Fig. 3. Assessment of Oil and Gas Impacts on Farm or Ranch Operation.

## 5. Discussion: the balancing act as multi-dimensional & geographical

Our findings contribute to and expand a small body of literature on experiences of oil and gas by farmers and ranchers. The finding that—for the majority of a limited sample of agriculture operators—overall benefits at both the household and the community scale outweighed costs aligns with scholarship identifying an instrumental and economic rationale for the tolerance of oil and gas impacts in rural areas [31,35]. Support for this claim comes from the types of benefits identified in open-ended answers, which were primarily financial but also spoke directly to the specific benefits to agriculture. This study provides some evidence that farm and ranch operators used oil and gas income to invest in improving their operations. Open-ended answers speaking to broader community impacts appear to support the idea that “community values” helps to predict tolerance for energy development [7].

The extent to which oil and gas development specifically benefitted agriculture operations appears from this study to vary by geography. In particular, oil and gas development seemed to enhance some agriculture operations in Wyoming more directly than in the other counties. This is a somewhat striking finding with respect to the literature that suggests financial benefits encourage landowners to tolerate oil and gas: Wyoming ranch operators primarily operate in the context of split mineral estates, suggesting they might be the least likely to accommodate the negative impacts of oil and gas [19]. Yet in this study they had the greatest majority of respondents noting wholly positive benefits to agriculture and the most concrete and lengthy discussions of the specific ways their operations benefitted, primarily in terms of new road and water infrastructure.

The extent to which oil and gas development detracted from agricultural operations varied by geography. Not surprisingly, the responses from farm and ranch operators in the western counties were more similar to one another than to the Pennsylvania County. In the western counties, operators were quick to identify how energy infrastructure interferes with (or enhances) the work of agriculture as primary impacts. In North Dakota, where cattle and crop production dominate, the effects of pipelines and pipeline development on grazing and field access were key concerns. Respondents from Montana identified similar concerns about energy infrastructure’s interference with farming as in North Dakota, but also focused on issues such as traffic, dust, and the increased presence of people. Across the western counties, concerns focused on ineffective or abandoned reclamation of oil and gas facilities. In contrast, negative effects noted by Pennsylvanian farmers focused on dissatisfaction with leasing and the conduct of operators.

Taken together these findings emphasize the obvious, but as yet undocumented, point that the balancing act in the agriculture-oil and gas nexus is highly contingent on local circumstances—with respect to both agricultural operations and the types of UOG practices deployed in each location. Our research suggests the possibility that the large-scale cattle operations in Wyoming’s Sheridan County may be better suited to coexisting with UOG development than are agricultural land uses that mix cattle and small grains, or other types of agriculture. There, development involved extensive water infrastructure and some ranchers saw some value in utilizing this new water infrastructure. Another related possibility is that ranch cash flow is poor enough on Sheridan County ranches (see Fig. 1) to engender or coerce tolerance for oil and gas impacts in line with previous research on farm experiences with UOG [3]. Perhaps equally important in this argument is the small, but vocal minority in this study reporting no benefits or net costs to agriculture from oil and gas development, a cohort that was greatest in number (and percentage) in Richland County, Montana. This finding encourages for future research and adds a material aspect to the literature on the social tolerance of oil and gas development.

Farmers and ranchers employed adaptations and responses to the impacts of oil and gas development that were generally consistent

across the four states, from which a few important lessons can be drawn. Two-thirds of the respondents reported that they did not have to change their agricultural operation because of oil and gas activity. Those who did make changes pursued a variety of alterations ranging from shifting the location and timing of agricultural practices (such as moving livestock) to investing substantial time in engaging with and monitoring industry. Respondents used the same term “babysitting” noted by McGranahan et al. [11] in their report on perceived impacts among rural stakeholders in the Bakken. Other key adaptations by agriculture operators involved taking responsibility for regulatory and practical failures, particularly in reclamation. A takeaway suggested by this survey’s limited dataset is that the kinds of adaptations pursued here did require significant investment on the part of farm and ranch operators, but not the kind that can be easily monetized and as such, are hard to track in economic statistics. This takeaway reinforces the need for qualitative approaches that push past large datasets to explore the range of experiences in UOG development [39].

Perhaps the most important lesson from this survey is the observation that agriculture operators generally did not consult with others about adaptation strategies. When they did, they most often sought information from family members and lawyers. To a far lesser extent, they also consulted with the oil and gas industry and Extension specialists. This suggests that information available from professional service providers has been largely inaccessible, ineffective, or unused. It also reinforces the notion that the agriculture-oil and gas balancing act has been a highly individual enterprise [43]. This individualist tendency may be a liability in the sense of limiting the leverage of landowners in their negotiations with industry and may delay effective response to issues that extend beyond the farm gate, such as weeds or other common pool resource questions. This finding also suggests that a ripe area for inquiry is the influence of legal transactions on differential outcomes for farm and ranch operations that host oil and gas development, as noted by Bugden et al. [44].

## 6. Conclusion: implications for research and practice

Our findings have specific implications for three target audiences of this study: scholars, industry and policy makers, and outreach specialists with a mission of supporting agriculture such as extension, conservation districts, NGOs, and industry community liaisons. From the perspective of future research, these findings point to several fruitful spaces for interdisciplinary collaboration. In-depth qualitative studies might be coordinated with survey approaches with the goal of helping to advance clear models of ways that material, affective and social psychological practices that engender accommodation or rejection of UOG development. Furthermore, collaboration among social and physical environmental scientists of various types is important to establish a full accounting of costs and benefits. This study supports previous research findings that income and employment studies show only part of the picture. Additionally, we submit that the balancing act is a useful framework for considering tradeoffs associated with hosting extractive industries. As conceived, the concept allows for the “balance” to have many meanings depending on perspectives and experiences: imposed, impossible, aspirational or achievable.

Data collected in this survey remind researchers and practitioners about the consequences of research for residents in unconventional oil and gas plays. Several respondents noted being exhausted by requests to participate in surveys, interviews, research, and other outside investigations by government and non-profit organizations as a negative aspect of UOG development; this may help explain the survey’s poor response rate. While many researchers and investigators are doing this research in order to help, the subjects of this research may not see it as such. This is a good reminder that all findings and outcomes of research need to be translated into meaningful data and action in the areas being studied, lest research itself be considered nothing but an additional negative effect of UOG as a whole. On a related note, this study

reinforces the challenges in being effective in the provision of education and outreach intended to assist farm and ranch operators. Creative and innovative ways to generate and deliver relevant information need to attend to the reality suggested by these results—that the most information exchange happens within families and neighborhoods.

Regulators and industry representatives who have an interest in social license and public experiences with UOG development can take several points from this study. Truck traffic is one of the major sources of conflict with agriculture and rural livelihoods—managing the volume of traffic and road quality would mitigate this issue. Abandoned reclamation is a source of resentment and frustration by landowners that reinforces an impression that industry and/or regulators are careless. And finally, agents of industry and subcontractors that interact with farm and ranch operators have a substantial influence on its reputation. This paper offers an early window in the diverse experiences that have occurred at the UOG-agriculture nexus in recent episodes of development in the United States. Further research and practice should continue to expand knowledge of and practical responses to the points of alignment and conflict among these two important economic activities.

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