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Review article

Geographies of Impact and the Impacts of Geography: Unconventional Oil and Gas in the American West

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1. Introduction

Since oil wells first appeared in the territories of Colorado and California in the 1860s, oil and gas extraction has been an influential force in the American West. The modern western petroleum industry developed in surges of expansion and contraction during the 1920s, 1950s, and 1980s. Most recently, the so-called "Shale Revolution" of the 2000s ushered in waves of new and expanded production of dry and wet gas and oil, episodes that came shortly on the heels of a coalbed methane boom. There were 150,000 well completions in key petroleum-bearing geologic basins of the West and Northern Great Plains between 2000 and 2017; 40% were horizontally-drilled (IHS, 2018). From 2007 through 2017, unconventional oil and gas development (hereafter, UOG) in the West's Niobrara and Bakken formations (found across a number of discrete geologic basins[1]) contributed 28% of United States shale oil production and 14% of shale gas yields (US EIA, 2018). A similarly booming social science literature has documented that these subsurface activities generate a mix of social impacts and outcomes for the people who occupy the diverse subsurface spaces and places above them. The local outcomes of UOG development range from a North Dakota community that rebranded itself as "Boomtown, USA" to Colorado communities that have attempted to ban UOG activities. This essay endeavors to review and synthesize among these varied spaces, places, impacts, and outcomes.

The American West, defined here as the region of the United States located between the Pacific Coast mountain ranges and the 100th Meridian, features a number of distinguishing characteristics that enable and shape different patterns of energy development. The region is characterized by repeating patterns of high mountain ranges separating basins that contain thick sequences of sedimentary rocks. These strata host extensive reserves of oil and gas trapped in conventional and unconventional reservoirs and hold some of the largest coal reserves on Earth. This physiography controls climatic patterns responsible for solar and wind resources as well.

At the regional scale, the West is made unique by the aridity of the climate; its spatial expansiveness; a settlement pattern in which pockets of extensive urban and suburban land use juxtapose an interior of vast open spaces and rugged mountain systems; the vitality, diversity and presence of contemporary indigenous populations[2] along with the legacies of colonial conquest (Limerick, 1987; Reibsame and Robb, 2007; Wyckoff, 2014); the substantial amount of land and minerals owned and managed by the federal government; and the divergence of economic trends within the region (Gude et al., 2012). A set of persistent social issues emerges out of this setting and influences the local outcomes of energy development, such as: the importance and difficulty of accomplishing justice for Native Americans and other historically marginalized groups; the sensitive politics surrounding the allocation of scarce water resources; the challenge of protecting vulnerable ecosystems unique to the region; the challenges of distance or the social cost of space; and finally, the complications of accommodating conflicting social values about the region's natural resources and their appropriate use.

These distinguishing features and issues coalesce in unique patterns across the West to create distinct "impact geographies" that are the focus of this review essay. By impact geography we mean a spatially-bounded area that features a distinct constellation of historical, physiographic (including climate, geology and ecology), economic, and cultural factors that influence the nature of oil and gas development and the character and magnitude of its impacts on local people, ecologies and landscapes. We argue that given the great diversity in the targets, configurations, and processes of shale oil and gas development in the many places that host it in the American West (and beyond), the best way to organize a search for emerging patterns in its social impacts is to work with impact geographies as an organizing framework.

In this review essay, we explore the relationship between geographic context and social impacts of the recent shale boom to identify common and/or unique aspects of the experience of UOG development among the West's impact geographies. The essay begins with a brief

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[1] See section 3 for a detailed discussion of development patterns by basin and the importance of formations therein.

[2] One fifth of the land area of the Interior West is owned by Native American nations who occupy 135 different reservations (Travis et al. 2007).

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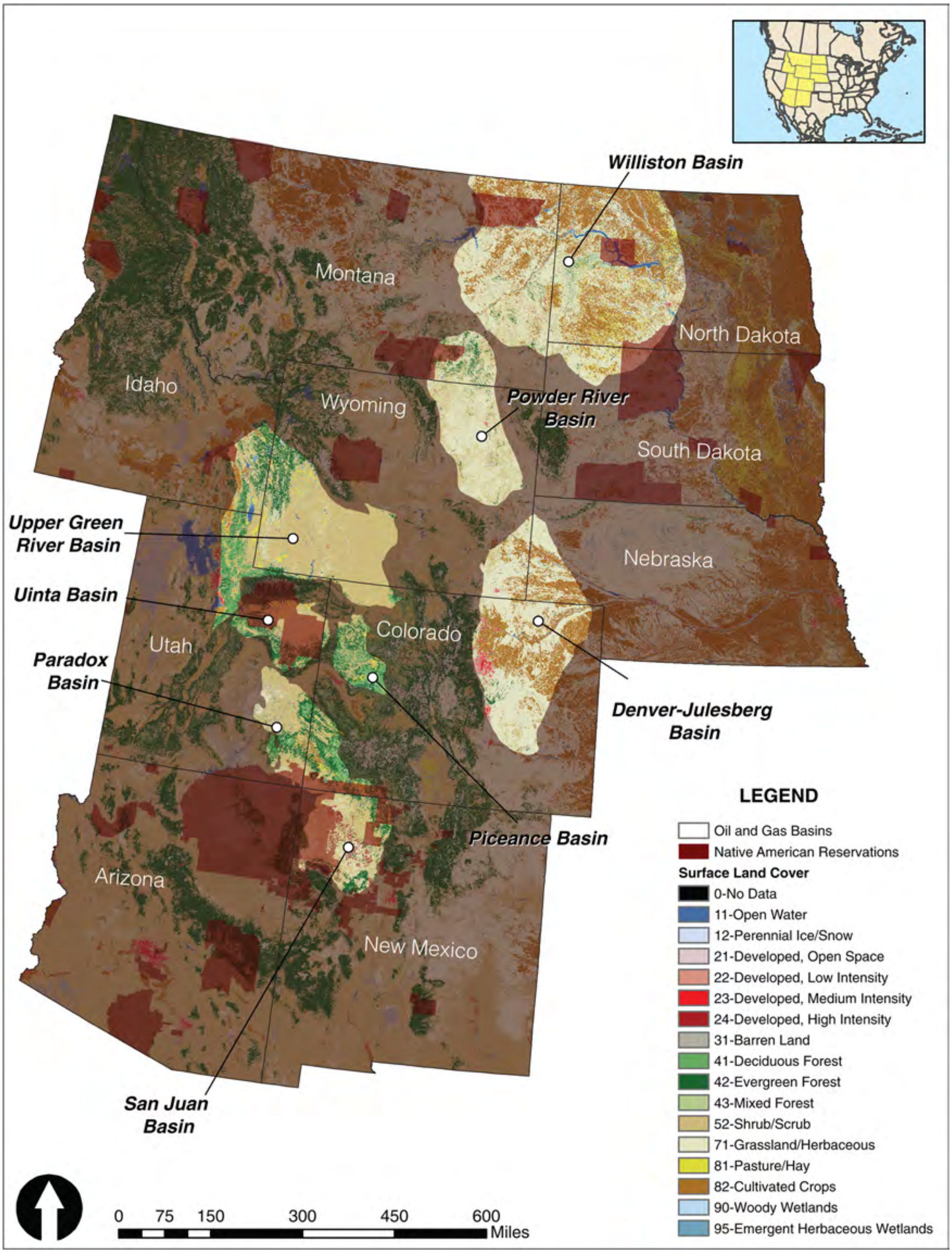

Map 1. Land Cover and the West's Major Shale-Bearing Geologic Basins.

summary that sets existing frameworks for assessing social impacts alongside a geographic perspective (Section 2). Section 3 provides a contextual overview of shale development in the West and sets the stage for Section 4, which describes important impact geographies of the American West and evaluates the nature of impacts specific to each, plus affected people and groups. Section 5 surveys key themes in how different actors and stakeholders across different shale geographies have experienced shale development in order to summarize the state of knowledge and chart a path forward for continued inquiry.

2. Social Impact Frameworks: All Welcome Here

The vast majority of literature on 'social' impacts of extractive industries uses the term social impacts as a shorthand for *local* impacts, meaning the impacts that accrue to people in and near places that host extractive industries and its infrastructure. Narrowly construed, social impacts might refer only to those effects of industrial development that play out in social composition, social interactions and social psychology, and are distinct from economic, health, and environmental effects. However, in his seminal review of risks to communities from shale development, Jacquet assesses the need for "a broad and multi-dimensional definition of risk that includes risks to social, psychological and economic assets that are valued at the community level" (2014a: 8321). Our review employs a similarly inclusive approach that focuses on the many different kinds of outcomes of UOG reported and experienced by people and social groups—in other words, the experiences of UOG development that matter to people in places where it happens. Here an impact can be experienced as a risk, a benefit, or a combination of both; in general, we seek a more neutral orientation than that conveyed by the use of the term "risk" alone.

Dominant conceptual frameworks for approaching social impacts reflect a similar focus on place-based experience, including the boom-bust-recovery and boomtown social disruption concepts (Brown et al., 2005); environmental hazards and justice frameworks focused on disparities in exposure and vulnerability to negative effects of industrial development (O'Rourke and Connolly 2003); explorations of impacts to 'sense of place' (Jacquet and Stedman 2013) and quality of life (Mayer 2017c); and even formal social impact assessment (Uhlmann et al., 2014). Other scholars adopt frameworks in political ecology and science and technology studies to evaluate experiences of UOG development with a particular focus on unevenness in social and political power (Bebbington, 2012) and knowledge production and technological change (Kinchy et al., 2018; Kroepsch, 2018a,b). All of these considerations, and others, have been brought to assessments and descriptions of UOG development in the American West. Our goal is to synthesize across the different social foci that orient these frameworks.

Toward this end, we can observe several basic concerns or questions that are compatible, if not common, across the approaches used in social impacts research. They include: (1) cataloging the range of local outcomes of UOG and measuring their frequency, magnitude, and duration; (2) assessing and explaining variability in the distribution of impacts and perceptions of impacts within and among human populations; and (3) understanding how and why impacts create either ephemeral or lasting change in key local capitals (Flora and Flora, 2013: 24), as well as how these local assets work to shape local experiences of, and responses to, UOG development. Common across social impact studies is a dedication to documenting UOG experiences that are not readily measured using publicly-available demographic and economic datasets, as well as those that are. For this reason, surveys, interviews, participant observation, and document analysis are key tools of the trade.

From these common considerations of the major conceptual frameworks for considering social impacts of industrial development we have developed four guiding questions to structure our review. What are the distinct impact geographies in the region, and what are their implications for stakeholder composition and social impacts? Across the West's diverse impact geographies, which, if any, people and places have experienced predicted psycho-social disruptions, such as changes to quality of life, sense of place, or place attachment? When, where and how has UOG development produced corrosive versus consensus community dynamics? And lastly, what patterns can we discern in how and why some groups resist or accommodate UOG development in the local context? We ask these questions of the current peer-reviewed UOG literature, which we supplement as necessary with white papers and media publications.

3. Situating UOG Development in the American West

Understanding the social impacts of UOG development in the American West requires first becoming familiar with the region's major oil and gas-bearing geologic formations, as well as the land cover, use, and ownership patterns that intersect them. Map 1 shows the vast surface areas and the wide variety of surface land uses featured in the West's UOG landscapes. Of note is the prevalence of the many Native American reservation boundaries within and around the borders of key geologic formations. The aridity of the landscape is made visible in the dominance of shrub and grasslands in the basins, interspersed with substantial areas of cropland, especially in eastern Colorado and North Dakota. And while the bright red of urban land use appears small in proportion to other features, it is a large component of the West's UOG conversation (Map 1).

Historically, conventional oil and gas exploration and development in the West followed boom-bust cycles shaped by the intersection of commodity prices, technological breakthroughs, depletion of exploration targets with time as prospects defined by current best technology are tested, and the natural decline of reservoirs through production of resources. Examples of these cycles can be seen in the progression of discoveries based on evolving technologies. Early oil and gas fields were found by drilling near oil seeps; later, additional fields were found by geologic surface mapping applied to the anticlinal theory of oil and gas trapping; this was followed by the application of gravity interpretation to explore for salt domes; then, the application of seismic refraction methods to delineate anticlines not mappable on the surface; next, seismic reflection methods found additional anticlines; new concepts in facies mapping located stratigraphic traps and then the application of seismic stratigraphy imaged these facies more accurately leading to additional discoveries; the development of seismic interpretation methods to image direct hydrocarbon indicators led to discoveries of more subtle traps; the development of three-dimensional seismic methods better imaged complex traps and reservoir geometries; more plays were identified using sequence stratigraphic techniques to explore for and develop oil and gas fields; and, with great processing power of computers through time, breakthroughs occurred in fields such as reservoir imaging, reservoir modeling, and the application of multi-component three-dimensional seismic methods. Connected to these technological innovations leading to cyclic increases in exploration success were commodity cycles that improved or inhibited cash flow available to industry for research and drilling, and the normal depletion of reservoirs through time. Thus, the economic viability of various energy development sites waxed and waned through time, shifting in space as new areas were developed and old areas depleted.

In a similar fashion, unconventional oil and gas exploration and development has experienced technological breakthroughs resulting in rapid paradigm shifts allowing development of new oil and gas resources but subject to the same commodity price cycles that have accelerated or diminished development of resources through time. Two major differences between conventional and unconventional (UOG) resource development are the more extensive scale of the energy development footprint of UOG, and the increased economic sensitivity of UOG projects to commodity price. These differences have a tremendous effect on the landscapes and communities that are impacted.

Unconventional plays have evolved through time in much the same way that conventional plays evolved with technological and conceptual advances, albeit on a compressed time scale. Many of these plays involve numerous low-volume reservoir compartments stacked over hundreds of vertical feet and require refined drilling and completion technologies, such as horizontal drilling techniques, deviated single-pad drilling, and multi-stage hydraulic fracturing (a.k.a., "fracking").

Unconventional resource plays are characterized by rich source rocks buried to depths sufficient to generate large volumes of oil and/or gas that have low permeability porosity networks near or within the source beds such that large volumes of generated hydrocarbons can be stored in the system without significant migration. The low permeability of these reservoirs means it takes extraordinary and expensive drilling and completion practices to develop them. Because the magnitude of investment to achieve production from unconventional wells is high and production declines are often rapid, UOG development is very sensitive to commodity price cycles. Favorable geologic conditions need to be met over significant areal extents and have sufficient thicknesses to store great enough volumes to warrant these large investments. These conditions correspond with large, spatially extensive infrastructure to support both the drilling and production stages of development.

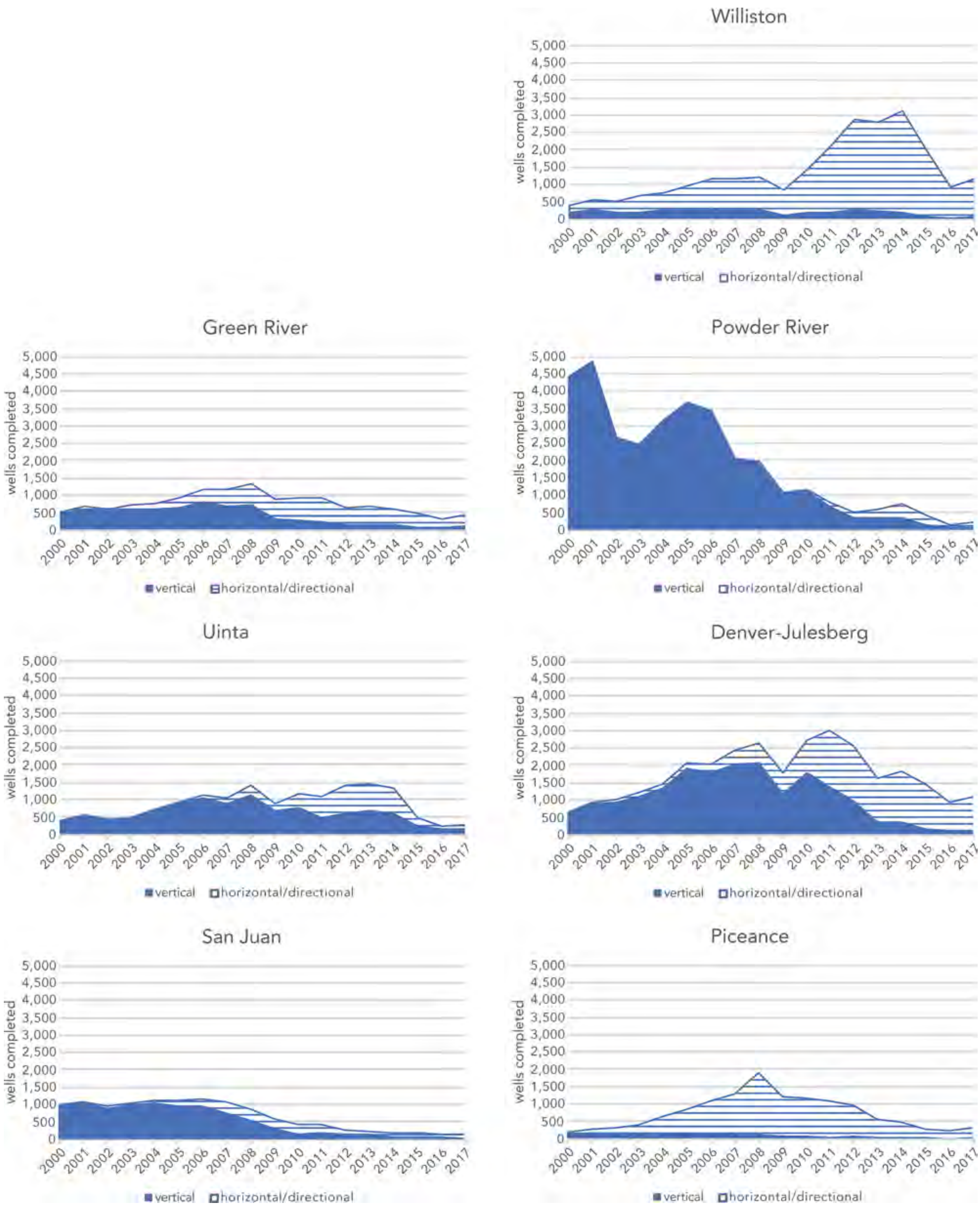

Fig. 1. Well Completions by Basin[3].
Source: IHS 2018.

Key to understanding the nature of UOG development from the perspective of people living in and around it is the high degree of variability in and between unconventional plays—and their implications for development cycles. UOG resources cover large areas but are often quite different between basins. Furthermore, unevenness in the geologic character across an entire producing region creates “sweet spots” within an unconventional play where producing characteristics are most favorable. As discussed above, unconventional resource plays

[3] Some basins shown in Map 1 are not charted here due to low drilling activity.

have become physically and economically possible with technological advances, but downturns in commodity prices can also quickly make them marginally economic or uneconomic. Because unconventional resource plays cover such large areas, drillable locations can be finely tuned to project economics. Drilling first turns on with rising prices in those plays with the most favorable economics and in the sweet spots within other plays. Fig. 1 shows drilling activity in the West's eight most active geologic basins and illustrates the variability in boom-bust cycles across the region. A close examination of drilling activity in each basin would show shifting development patterns in time and space, as production sweet spots evolve and recede in time (see discussion of Williston Basin below). Since the year 2000, most of the drilling in these basins has been in unconventional reservoirs. A short summary of the play types associated with each basin follows.

3.1. Williston Basin[4]

The dominant play in the Williston Basin has been in tight oil from the Bakken Formation. The Bakken play results from a lower and upper organic-rich shale (source rock) encasing a layer of low permeability dolomitic siltstone and silty dolomite (reservoir). The play limits are defined by the boundaries of thermal maturity of the source rocks. The play is no longer viable where the source rocks have not been buried deeply enough to generate oil. To achieve economic production from the Bakken in this basin, the reservoir layer is horizontally drilled and stimulated using multi-stage hydraulic fracturing (Sonnenberg, 2015). The first drilling cycle in the mid- to late-2000's reflects drilling of a sweet spot in eastern Montana (Elm Coulee Field) with a second cycle of drilling mostly in North Dakota starting in 2009 and ending in 2014 as drilling slowed with the commodity price crash in that year. Drilling is slowly recovering with rising commodity prices in the past two years (IHS, 2018).

3.2. Powder River Basin

Drilling in the Powder River Basin reflects the decline of vertical drilling in the mature Fort Union Formation coalbed methane play and increased horizontal drilling in several emerging Upper Cretaceous tight oil plays. The tight oil plays are in the Frontier Formation, Turner Formation, Niobrara Formation, Codell Formation, Shannon Formation, Sussex Formation, and Parkman Formation (US EIA, 2014). Each of these plays except the Niobrara Formation results from organic-rich shale source beds inter-bedded with reservoir units of siltstones and tight sandstones. The Niobrara is an organic-rich tight limestone that is both source rock and reservoir rock (USGS, 2016).

3.3. Green River Basin

Vertical drilling and directional wellbores account for all but 212 of the wells shown on Fig. 1 in the Green River Basin. The vertical and deviated wells were drilled for Cretaceous tight gas sandstone reservoirs that require multi-stage hydraulic fracturing to produce at economic rates (IHS, 2018). Most of the deviated wellbores were associated with pad drilling on Moxa Arch and Pinedale Anticline fields (Ibid). The horizontal wells represent drilling on emerging unconventional Cretaceous tight gas sandstone reservoirs, applying horizontal drilling and multi-stage hydraulic fracturing technology to maximize production rates (Ibid); and, drilling for unconventional tight oil reservoirs in the Niobrara Formation of the Sandwash Sub-basin of the Greater Green River Basin. The Niobrara here is a low-permeability fractured limestone play (Perry and Hutson, 2013).

3.4. Denver-Julesberg Basin

Two play types have dominated drilling in the Denver-Julesberg Basin since 2000. The principle vertical play has been in-fill development drilling of the tight gas resource in the structurally deepest part of the basin, mostly in and around Wattenberg Field. The main reservoirs targeted in this effort were the Dakota J, the Codell, and the Niobrara formations (Higley and Cox, 2007; IHS, 2018). A second play, the horizontally drilled wedge of completed wells shown in Fig. 1, is the tight oil play that has emerged in the Niobrara Formation. Tight chalk reservoirs are interbedded with organic-rich source rocks that are mature in the deeper regions of the basin and is a technology play that requires horizontal drilling with multi-stage hydraulic fracturing to produce (Sonnenberg, 2011). The play area overlaps the region occupied by the vertical tight gas play and is also coincident with the Front Range urban corridor in many areas.

3.5. San Juan Basin

Drilling in the San Juan Basin reflects diminishing vertical drilling in a mature coalbed methane play and increased vertical and horizontal drilling in an emerging unconventional tight oil and gas play in the Mancos Shale. In this play, almost all production and recent exploration is within the lowermost 400 ft of the Upper Mancos Shale (the Mancos C interval). The Upper Mancos shales are both the source rocks and the reservoirs. The reservoir intervals are organic-rich marine shales with laminations and very thin beds of very fine-grained sandstones and siltstones (Broadhead, 2015). Drilling in the play slowed with commodity price declines in 2014 and with competition for investment dollars with more economic unconventional plays in other parts of the United States.

3.6. Uinta Basin

Drilling in the Uinta Basin between 2000 and 2018 has been predominantly for vertically drilled wells and directional wells drilled developing tight gas reservoirs. The major reservoirs are low-permeability sandstones of the Dakota Sandstone, Mesaverde Formation, Green River Formation, and Wasatch Formation (IHS Energy, 2018). Additionally, vertical and deviated wells have been drilled for tight oil reservoirs in fractured limestones and dolomites of the Green River Formation. A horizontal unconventional play has also emerged in the Uinta Basin that targets the Uteland Butte Member of the Green River Formation. The Uteland Butte member is the basal carbonate of the Green River Formation, is present across much of the Uinta Basin, and is locally sourced from organic-rich beds within the Green River Formation (Anderson and Roesink, 2013).

3.7. Piceance Basin

Drilling in the Piceance Basin is dominated by directional wellbores for unconventional tight gas reserves in the Williams Fork Formation (Fig. 1). The reservoirs in the Williams Fork are thick stacks of low volume compartments allowing for 10-acre spacing of wellbores accomplished by drilling multiple directional wells from single well pads (Harpole, 2014). The number of wells drilled per year peaked in 2008 when natural gas prices also peaked. The drilling since has closely followed the decline of commodity prices. Drilling will most likely rise when commodity prices increase as many locations remain to be drilled in defined fields (ibid). A deeper emerging unconventional tight gas play is also being explored in the stratigraphically lower Mancos Shale. Horizontal drilling and multi-stage hydraulic fracturing is being utilized to test this source rock play (ibid).

[4] We use the terms Williston Basin and Bakken interchangeably in this paper. Despite the fact that the greater region affected by UOG of the Bakken shale might be best described as the Williston Basin, the term "the Bakken" is widely used by the media, local people and politicians to refer to the geography that has emerged from UOG drilling in the Bakken.

Each of these basins has had a long history of conventional reservoir development. The unconventional plays that have evolved and are now emerging in each of the basins reflect the application of new technologies to produce oil or gas at economic rates and volumes that could not be achieved through conventional means. Additionally, in areas of these basins where thick stacks of low-permeability sandstone reservoirs are present and require closely spaced wellbores though the pay intervals, deviated drilling of multiple wellbores from individual well pads has greatly diminished surface impacts. Drilling in each of these basins depends on economic success which is much more achievable during periods of higher commodity prices. Additionally, the tolerance for risk is much greater when commodity prices are higher, thus new play concepts are most likely to be tested during times of commodity price growth or stability at a high level.

4. Impact Geographies of the American West

In addition to the particular qualities emergent from the intersection of geology, technology and economics described above, dynamics above the surface are also influential on the kinds of impacts development creates. The local land use patterns and the economies that predate UOG development strongly affect the character, magnitude, and distribution of its local impacts. In this section, we describe the unique features of three prominent and discrete geographies in the American West's UOG economy: remote and rural resource regions, suburbs, and sovereign nations. We also highlight important sub-geographies (such as boomtowns, industrialized countrysides and petro-suburbs) and detail prevalent social impacts and stakeholders in each. We acknowledge that these impact geographies do not include public lands, which are a crucial jurisdiction for oil and gas development in the West, but have not been a central focus of recent UOG social impacts literature.

4.1. Remote and Rural Impact Geographies

The dry gas, coalbed methane, and shale oil booms in the Piceance, Uinta, Green River, San Juan, Powder River and Williston basins all occurred in mostly remote, isolated areas in western Colorado, eastern Utah, southwestern and northeastern Wyoming, northern New Mexico and eastern Montana and western North Dakota. In these remote, rural geographies, pockets of drilling activity punctuate vast areas in which farming and ranching are the dominant land uses. In addition to developing well pads, UOG extraction in these areas demands the construction of extensive connective infrastructure (roads, pipelines, power lines, and railways) as well as residential infrastructure (homes, water and sewer lines, etc.).

These are regions that economic geographers identify as least able to capitalize on the growth in the contemporary knowledge-based economy that drives the American West (Goetz et al., 2017; Rasker et al., 2009). With little to no sectoral diversification, remote rural economies stand to demonstrate the clearest short-term economic benefits of an energy boom yet are most exposed to the risks of over-specialization in an economic downturn (Haggerty et al., 2014; Haggerty and Haggerty, 2015).

The West's settlement and economic histories have two important implications for UOG development in remote and rural areas. First, the federal government (and state governments to a lesser extent) own large areas of the surface and many of the minerals in the region (Hoover, 2018; Jacquet et al., 2018). This makes public land law, federal management and the local and diverse non-local constituencies of public lands key components of some UOG landscapes of the American West (Harm Benson, 2009). Second, federal settlement policies encouraged a practice of split mineral and surface estates in the region. Because most remote energy regions have experienced episodic oil and/or gas development since the early to mid-20th century, private mineral rights are often severed from the surface title and held by parties unknown to the current surface owner (Walsh, 2017).

Other important—and interacting—characteristics of the West's remote and rural UOG regions are low population densities (lowest in the continental U.S.); residents who perform higher than average levels of volunteer service (Winchester, 2010); higher than average costs of public services; distances between population centers; sensitivity and brittleness of the soils and land cover; sensitivity of water management questions; limited formal planning capacity; historical familiarity with extractive industries; and a tendency toward political conservatism. These factors influence the nature of impacts and the character of local responses to these impacts in ways that are described here and in Section 5.

Finally, the remoteness of these geographies encourages a broader societal response to them as spectacle, socially and physically. The public fascination with Bakken development as a classic Western boomtown story is well documented (Cary, 2016). Consider also the viral dissemination of the NASA photograph of the Earth at night in 2013 that showed light from the flaring of Bakken wells shining as bright as major cities. As the photograph made the rounds in the media, one National Public Radio reporter opined: "Those lights are a sign that this region is now on fire … to a disturbing degree. Literally." (Krulwich, 2013; NASA, n.d.)

The following discussion explores documented impacts of UOG development in three distinct impact geographies in the rural and isolated Western places that host UOG: boomtowns, overlays of UOG and agriculture, and oilfield borderlands. We summarize key themes in recent published studies about these places with respect to the range of social impacts and the social groups and institutions affected by them.

4.1.1. Boomtowns

The American West is the original site of popular and academic understandings (and misconceptions) about boomtowns (Gilmore, 1976; Guilliford, 1989; Wilkinson et al., 1982). When small population centers in remote areas experience the sudden effects of the labor and service demands of large energy projects, population growth and increases in industrial activity result in what is now a frequently-documented set of follow-on social and economic impacts (Measham et al., 2016). Table 1 denotes the remote nature of the West's UOG

Table 1
Key Geographic and Demographic Features of Western Boomtowns.

	Travel Time to Urban Area (mins)	2000 population	Population Change at Peak Drilling	2016 population
Rifle, Colorado	61	7,014	28%	9,488
Sidney, Montana	212	5,135	15%	6,407
Dickinson, North Dakota	209	16,036	24%	21,985
Watford City, North Dakota	170	1,439	90%	4,596
Williston, North Dakota	219	12,550	58%	23,902
Vernal, Utah	156	7,771	13%	10,588
Pinedale, Wyoming	230	1,429	34%	2,044
Rock Springs, Wyoming	174	18,671	18%	23,967

Sources: U.S. Census ACS estimates 2014; 2018; U.S, Census Population Estimates 2000.

boomtowns and the volume of population growth experienced at the height of development. Small towns and cities added population at decadal rates ranging from 13 to as high as 90 percent in the formal census data (undercounting population in boomtowns is a documented phenomenon). Several of these population centers are located two or more hours of drive time from an urban area (*e.g.*, defined as a metropolitan statistical area by the U.S. Census). The geographic expanse of shale development patterns (as a function of the dispersed nature of geologic sweet spots described above) is reflected in the fact that in most remote shale plays, multiple boomtowns emerged.

In contrast to boomtowns organized around one major project with a single project manager (e.g., coal or hydroelectric power plants), UOG activities in recent Western boomtowns have attracted a much higher number of discrete private companies occupying different positions in the supply chain for upstream and midstream development activities. The complex industrial organization of UOG added to the chaos during frantic phase of boomtown activity as well as to the challenges of planning for and responding to growth-related impacts (Haggerty and McBride, 2016; Haggerty et al., 2017; Walsh and Haggerty, 2017).

Unsurprisingly, a series of serious challenges presented themselves in the boom phase of UOG development in boomtowns such as Pinedale and Rock Springs, Wyoming and the Bakken's three primary North Dakota hubs: Watford City, Dickinson and Williston. Many of these impacts are recorded in white papers and have been familiar since Gilmore's 1976 description of the "problem triangle" in *Science*, which describes the mismatch between extant local capacity and the pace and scale of population and economic expansion that characterizes the construction phase of major energy projects in remote regions, as well as the amplifying effect that ill-preparedness can have on the magnitude of local impacts. Specifically, places like Watford City, Williston, Pinedale, Dickinson and Rock Springs all experienced predictable housing shortages; rapid inflation of housing and other costs of living; increased crime; increases in traffic volumes; labor shortages; high construction costs; and the shortcomings of under-resourced local governments with respect to demand for public services such as schools, water and sewer, planning and permitting, public safety, and public health services (summary sources on impacts include: BBC Research and Consulting, 2013; Eastern Montana Impact Coalition, 2015; Ecosystem Research Group, 2008; Ruddell, 2017; VisionWest ND, 2017).

At the same time, the boomtown experience is one of rapid growth in economic activity that many residents welcome. As Fernando and Cooley (2016b) remind us, the context is critical: many isolated communities in the Northern Great Plains and Rocky Mountain West have experienced flat or declining rates of population and employment growth since the early 1980s (Gude et al., 2012). It is in these circumstances of population decline and economic contraction that the recent UOG boom transpired—particularly in the Bakken as well as in parts of Wyoming and Utah. While the benefits and outcomes of boomtime investments remain an important area of inquiry (cf. Haggerty and Haggerty, 2015; Smith, 2018), the boom did engender long-overdue investments in local infrastructure in boomtowns and surrounding regions that could benefit residents for years to come (Newell and Raimi, 2018). The specifics of economic impacts are beyond the scope of this review, but the existing econometric literature on UOG development has demonstrated net positive effects on local employment and personal income in the short-term and little evidence as of yet of marked vulnerability (e.g. lost human capital, over-specialization, or crowding out effects) (Mayer, 2016; Weber, 2014). Whether UOG will yield long-term structural change that improves remote economies for the long-term remains unclear (Haggerty et al., 2014; Mayer et al., 2017; Mayer et al., 2018). In energy boomtowns, economic issues often quickly become political and social issues as well—whether they involve changes in cost of living, inequality between boom beneficiaries and non-beneficiaries, or public spending on impact mitigation and local development (Becker, 2016). Lastly, these economic benefits are important as studies continue to emphasize economic rationale for positive or tolerant attitudes toward UOG development (see Section 5).

Primary stakeholders in the West's energy boomtowns include elected officials and staff, who are on the front lines of managing growth-related impacts (good and bad), and boomtown residents, who have been shown to vary widely in their experience of the boom based in large part on their ability to capitalize on the opportunities it creates versus their inability to mitigate its impacts on quality of life or cost of living. Also important are non-resident or temporary workers living in discrete facilities such as man camps and dedicated hotels, plus businesses based in boomtowns and their customers (often rural residents who come to town to shop).

4.1.2. The Industrial(ized) Countryside: the UOG-Agriculture Overlay

The extensive surface land use and infrastructure demands from UOG in rural areas predict a particular set of impacts for rural and agricultural properties that host wells, pipelines, and other UOG facilities. These impacts occur directly on farm and ranch properties and in rural landscape commons, where roads, transmission lines, and pipelines are sited. For this reason, Smith and Haggerty (2018) have found that, for many rural residents, the Bakken UOG boom was more appropriately called an "infrastructure boom." An industrial countryside emerges from this overlay of UOG activities on top of farming and ranching. This is not to suggest that many forms of agriculture are not heavily industrial already (many are, especially in the Williston Basin), but rather to emphasize the extent of industrial energy development occurring in agricultural contexts. The literature analyzing the social and geographic contours of this landscape is just beginning to emerge.

Studies suggest that positive benefits to farm and ranch businesses can be financial—in the form of direct payments from leases or other arrangements, or additional employment that helps the farm or ranch business overall. Upsides can also be operational. In some cases, UOG development contributed to the expansion or upgrade of water and road infrastructure directly on farms and ranches in Montana, North Dakota and Wyoming (Haggerty et al., In press). Beyond the farm gate, major investments in rural infrastructure, especially water supplies and roads, have accompanied UOG activities perhaps most noticeably in the Williston Basin. This infrastructure expansion can afford agricultural operators more flexibility in their use of individual properties and mitigates some of the social cost of living in remote areas (e.g. not having to haul water, safer roads) (Smith, 2018).

Challenges on farm and ranch properties reported in the Williston, Powder River and Green River basins include the following: the expense of 'babysitting' industry to minimize the disruptive effects of activity taking place on the farm/ranch; the troubles in interacting with industry at the leasing and development stage; perceived loss of privacy and safety; dangerous, ineffective, or non-existent reclamation; impacts of dust on crop and livestock health; other hazards for livestock including traffic, contaminated surface water, and abandoned infrastructure; and impacts of brine spills on soil health and water quality (Haggerty et al. in press; McGranahan et al., 2017; McEvoy et al., 2017; Smith and Haggerty, 2018; Walsh, 2018).

While many areas have eventually seen upgrades to roads, the upgrades have often followed a period of conflict between industrial and other uses of rural roads. Across the West, surface activity involving the trucking of water for hydraulic fracturing is one of UOG development's most noticeable disturbances. In rural areas, much of the traffic occurs on unpaved roads, causing unwanted and widespread dust problems. Concerns about personal safety risks also arise when local and industry traffic share rural roads (Rundquist et al., n.d.; McGranahan et al., 2017). Similarly, upgrades to rural water supplies involve complex negotiations between domestic, agricultural and industry water users. The distribution of costs and benefits of water infrastructure upgrades among diverse interests has posed tremendous challenges for UOG development throughout the Williston Basin (Smith, 2018; Zoanni, 2017).

In the energy-agriculture overlay in the American West, industry operators, non-agricultural rural residents, and farm and ranch owners and operators are primary stakeholders. This includes neighbors of properties that host development, who may experience off-site impacts, such as the deleterious effects of poorly-managed brine water disposal that produced a series of lawsuits in the Powder River Basin (Bleizeffer, 2008) and have created a chronic brine spill problem in the Williston Basin (Lauer et al. 2016). By extension, organizations representing agricultural interests (including resource councils, landowner and royalty owner organizations), conservation districts, and industry organizations influence responses to impacts in rural areas. In addition, critical but often invisible actors are non-local mineral owners whose actions influence development from afar. The prevalence of split estates in the rural West increases the number of stakeholders involved in energy projects and potential for conflicts (Kulander, 2009; Micheli, 2006; Walsh, 2017).

4.1.3. Borderlands

Some of the most intriguing new research on the recent impacts of UOG development in the West and Northern Great Plains involves geographies on the border of UOG development activity. The extensive surface footprint of development in places like the Williston or greater Green River basins creates a wide circumference that draws in small towns and rural residents who can notice development impacts but do not live in the heart of development activity. Junod et al. (2017) report on in-depth interviews with adults living in three communities on the border of the Bakken development zone in South Dakota. They find that periphery communities may have a Goldilocks experience that, as per the popular nursery tale, is "just right" because modest costs are balanced by modest benefits.

As Junod et al. suggest, a ripe area for explanation is the conditions under which energy borderlands are experienced as "just right" versus more strongly positive or negative. By contrast, in western Colorado during the dry gas rush of the mid-2000s, some local leaders and residents of border communities adjacent to UOG development—amenity and retirement destinations such as Glenwood Springs and Battlement Mesa—experienced the impacts of housing workers and providing public services as largely unwanted and unfunded mandates (Headwaters Economics, 2008).

4.2. (Sub)Urban Impact Geographies

The recent UOG boom has received significant public and scholarly attention in part because it has intensified extractive activities in and around relatively more populated areas, in addition to heightening drilling in the rural environs just discussed (Lave and Lutz, 2014). As of 2014, approximately 17.6 million people were living within one mile of an active oil and gas well in the U.S., for a total of 6% of the U.S. population (Czolowski et al., 2017). While the history of the Los Angeles Basin reminds us that the close proximity of people and intensive drilling operations is not an entirely new phenomenon in the United States (Cumming, 2018), the rise of UOG appears to have made it a more common one. In Colorado's Denver-Julesburg (DJ) Basin, for example, a total of 293,855 people (or 19% of the population) were living within one mile of an active oil or gas well as of 2012 (McKenzie et al., 2016). In the years between 2000 and 2012, the population living in very close proximity—within 500 feet—of an active oil and gas well doubled in size (from 3,793 to 8,922 people) as the basin's active well count doubled as well (from 10,922 to 21,044 wells) (McKenzie et al., 2016).

Western states do not have a monopoly on this burgeoning (sub) urban energy geography. In fact, Colorado ranks eighth among the top ten states with the most people living within one mile of an active oil or gas well. At 429,000 people in the one-mile range, Colorado sits far behind Texas (4.5 million people) and Ohio (2.8 million people) (Czolowski et al. 2017). Within the American West, however, Colorado's DJ Basin has become the primary regional example of the contemporary (sub)urban drilling geography both because the Front Range communities within it have been key sites for UOG governance debates (e.g., Erie, Greeley, Longmont, etc.) and because its proximity to several universities has made it the subject of a growing literature focused on the relationship between cities and the oil and gas industry. Media and NGOs have also made the DJ Basin a focus, recording and tracking the evolving extractive and residential land use patterns of the (sub)urban-energy overlay with maps searchable by home address (e.g., see Hamm, 2017; Earthworks, 2018).

In a sense, the DJ Basin has actually been the site of two spatially overlapping booms in the last decade: a boom in UOG production, due in part to the tapping of the Niobrara Formation, and a simultaneous boom in housing development, fueled by Colorado's economic and amenity draws (McKenzie et al., 2016). The corresponding social impacts challenges of the (sub)urban-energy overlay stem, arguably, from two related factors: (1) that these overlapping development booms caught a broad array of relevant stakeholders by surprise, and (2) that industrial and residential land uses are typically governed at a local level and zoned apart from each other in (sub)urban areas, which makes the state-level pre-emption and zoning exceptions provided for extractive industries a major source of local disruption and contention (Minor, 2014; Ryder and Hall, 2017; Kroepsch, 2018a,b). Indeed, many Front Range residents never expected or wanted to live so close to extractive activities and report mixed views on whether drilling belongs in neighborhoods and mixed estimations of associated risks and benefits (Kroepsch, 2016; Mayer, 2016). Front Range residents were not the only ones arriving in unfamiliar territory as (sub)urban development intensified in the DJ Basin after 2010. UOG operators, state regulators, and local governments also found themselves on a steep learning curve, particularly since the bulk of drilling and governance activities in the preceding decade had often focused on issues in relatively less populous and natural gas-rich areas in the state's Piceance, Raton, and San Juan basins (Oil and Gas Journal, 2009).

4.2.1. Petro-Suburbs and Focusing Sites

In more specific terms, the intermixing of oil and gas extraction with urban and suburban environs has been generating what Los Angeles Basin scholars have historically called "petro-suburbs": residential areas that house active drilling and/or producing well pads in their midst (Cumming, 2018). The Colorado Oil and Gas Conservation Commission (COGCC) refers to these areas as "Urban Mitigation Areas," defined as locations with at least 22 buildings or one high occupancy building within 1,000 feet of a well pad (Colorado Oil and Gas Conservation Commission (COGCC, 2018). While the actual spatiality, dynamics, and planning of petro-suburbs vary (see Fry et al., 2017 for examples from Dallas-Forth Worth), some commonalities can be identified. In the DJ Basin's petro-suburbs, oil and gas extraction is predominately conducted on private lands by smaller operators that have made (sub) urban drilling their business niche, typically via the leasing of many small mineral rights, with the majority of mineral rights (57%) split between different owners (Kroepsch, 2018a,b; McKenzie et al., 2016). As horizontal drilling has enabled operators to condense their surface footprints by co-locating more wells per site, (sub)urban well pads have been growing in size. Current (sub)urban DJ Basin drilling proposals are for as many as 40-56 wells per site (Arvesen, 2018; Rios, 2017). This consolidation has mitigated the impacts of extractive activities for some residents, while intensifying them for others (Kroepsch, 2016; Kroepsch, 2018a,b).

Stakeholders in the DJ Basin often engage with, and mobilize around, *individual sites* of extraction within petro-suburban areas, particularly well pads that are especially large and/or proposed near homes and schools. Similar dynamics have been recorded in Texas (Fry, 2013; Fry et al., 2015; Theodori, 2013). Here, we call these locations "focusing sites," adapting terminology from Kingdon's scholarship on the relationship between public policy change and "focusing events" (Kingdon, 2003). In the DJ Basin, oil and gas focusing sites have emerged for a host of reasons in addition to size and close proximity to homes and schools: because neighbors found them to be troublesome (Shaffer et al., 2016), because they appeared in unexpected places (Joyce, 2016), because they have become symbols of industry-community conflict and/or compromise (Silvy, 2014; Dunn, 2017a), or because they raise environmental justice concerns (Dunn, 2017b). Finally, and most importantly, some focusing sites have emerged because of an accident or disaster (Blair et al., 2017). Multiple fires and explosions have been lethal to workers in the DJ Basin, and an explosion in April 2017 killed two residents of the town of Firestone (Finley, 2017).

Despite these complex UOG dynamics, the social impacts literature appears to be much less developed for (sub)urban environs than for rural areas. This is perhaps because it is challenging to isolate the specific social impacts of UOG—positive and negative—in larger communities, which have more of everything: more people, more varied economies, more types of land uses, and more diverse populations. Statewide, Colorado residents report experiencing the typical industrial burdens that accompany UOG development, such as increased traffic, noise, light, and dust (Opsal and Shelley, 2014; Shaffer et al., 2016), and Colorado policy actors broadly agree that these impacts are problematic (Heikkila and Weible, 2015). Less tangible impacts, such as psychosocial and health effects, are far more contested (Jacquet, 2014b; Witter et al., 2013), but studies demonstrate growing evidence for concern (McKenzie et al., 2017; McKenzie et al., 2018). Analyses of DJ Basin home values as an indicator of negative social and environmental externalities from UOG have been inconclusive, with some researchers finding slight decreases in home values (Bennett and Loomis, 2015) and others finding none (He et al., 2017). Much clearer is the trend that more low-value homes are being built nearer to existing oil and gas wells than elsewhere in Colorado (McKenzie et al., 2016).

These circumstances have critical implications for stakeholder composition and challenges. Residents of the petro-suburbs are of mixed opinions on UOG development, with some convening grassroots groups to oppose or limit UOG, others favoring UOG, and still others remaining undecided or uninformed. Local governments also make up a spectrum of opinion on UOG development; some pursued bans on extractive activities in response to the DJ Basin UOG boom, while others did not (Fisk, 2016; Fisk et al. 2017). (In 2016, the Colorado Supreme Court overturned existing municipal bans due to state preemption.) The operators that have chosen to drill in (sub)urban areas tend to be smaller in size and locally headquartered, which can both assuage and intensify local drilling conflicts. Finally, several scholars have raised concerns about the impacts of vulnerable and politically under-represented community members in the petro-suburbs, including, but not limited to, residents who don't speak English, renters, and also rural stakeholders in outlying areas where regulations are not as strict (e.g., shorter setback distances) (Kroepsch, 2016; Kroepsch, 2018a,b; McKenzie et al., 2016; Zilliox & Smith, 2017a).

4.3. Sovereign and Sacred Impact Geographies

In the American West, sovereign indigenous nations maintain legal, economic, spiritual and cultural connections within and around many energy landscapes. Their experiences are key to gaining a full picture of the nature of social impacts of UOG development. Native American tribes are the third largest mineral rights holders in the United States and control 20% of oil and gas reserves, estimated at $1.5 trillion in value (Hoffman, 2017; Regan and Anderson, n.d.) Stakeholders in UOG development include a diverse mix of Native American people, spiritual leaders, and political leaders. Other key stakeholders include agents of relevant federal, state, and tribal governments.

The Blackfeet, Sioux and Assiniboine tribes of Fort Peck; the Mandan Arikara Hidatsa of Fort Berthold; the Shoshone and Arapahoe tribes of Wind River; and the Navajo, Northern Ute, Southern Ute, Ute Mountain Ute and Jicarilla Apache tribes of the Four Corners region all have substantial claims to shale resources and most have extensive experience with conventional energy development (Bur. Of Indian Affairs, n.d.). To date, UOG development has only really occurred at a substantial scale on Fort Berthold in the heart of the Williston Basin. A number of voices from Indian Country argue that greater authority for tribal nations to pursue and regulate energy development is critical, as it is one of a limited number of conventional economic development options to impoverished tribal nations in remote areas (Davis et al., 2016; Royster, 1994; Regan and Anderson, n.d.). From this perspective, the most important infrastructure upon which future UOG development rests is institutional—e.g., updating, refining and expanding laws and administrative structures.

At the same time, because the customary beliefs of Native American cultures frequently emphasize animism, pantheism and holism in their cosmologies, the likelihood that UOG development presents conflicts for and among many residents of Native American reservations is high (Ludvig, 2014). In addition, as Hoffman (2017) keenly observes, the extent of impact geographies extends beyond land allocated to reservations to include the many sacred cultural sites located beyond reservation boundaries. A series of prominent protests highlights the depth of resistance to the intrusion of new UOG development on sacred sites on the part of many Native Americans—including the protests against the Dakota Access Pipeline in 2015 and 2016, ongoing protests regarding the potential for UOG development in the Mancos shale of the San Juan Basin in and around prehistoric Puebloan cultural sites (Thompson 2018); and the contested exclusion of Bears Ears region from potential development (Hoffman 2017).

Fort Berthold Indian Reservation, home to three affiliated tribes that participate in a shared national government—the Mandan, Arikara and Hidatsa peoples—is located in the very heart of the Bakken shale play. Fort Berthold experienced a development explosion that proceeded at a dizzying pace between the onset of active leasing in the mid-2000s to the height of drilling activity—between 2008 and 2015, over 1300 leases were signed and daily oil production surged from less than 10,000 bbd to over 160,000 bbd (Tice 2016). The context is critical: social conditions going into the oil boom were marked by extreme levels of unemployment and a host of other indicators of social vulnerability. While the peer-reviewed literature on the boom's effects at Fort Berthold is sparse, a complicated picture has emerged from a few studies and media accounts (Crane Murdoch 2012; Sontag and McDonald 2014; Tice 2016). New revenue from development swelled tribal government funds—and distributions have been made to over 15,000 tribal members—while leases and business ventures made some individuals vast personal fortunes. But these benefits were accompanied not only by the boomtown phenomena described above, but also by revelations of systemic corruption and substantial social conflict. Of particular concern has been the boom's amplifying effect on existing domestic violence, sexual assault, and drug and sex trafficking public health crises (Purdon 2012).

While there are a number of important legal treatises that evaluate and reflect on oil and gas development on tribal lands (Cross, 2011; Ludvig 2014; Royster, 1994), the peer-reviewed literature exploring and analyzing social impacts of UOG development for members of the West's sovereign Indian nations has been very slow to emerge, possibly due to both the sea change in acceptable practices for non-native scholars to collect and share the experiences of Native Americans as well as hesitance on the part of tribal members to engage in surveys and interviews. An important set of studies consists of the careful work of Native American graduate scholars studying their own peoples (cf. Tice 2016; Zoanni 2017). Both studies provide thoughtful discussions of the complex history of research and the challenges of decolonizing scholarship on the experiences of Native Americans. When one of Tice's informants on the Forth Berthold Reservation said, "'I wish all the researchers would just leave us alone,'" she articulated a sentiment that our experience suggests is both poignant and not unique to the people of Fort Berthold (Tice 2016: 78).

5. Social Impacts and Perceptions Thereof: Key Questions and Themes

In this section, we identify broad patterns the social impacts and perceptions literature focused on the West's diverse UOG impact geographies. Starting from a national-scale view, national opinion polls suggest that, at broad scales, Westerners' attitudes toward UOG and hydraulic fracturing do not differ significantly from those of Americans living in other U.S. regions in that they are relatively evenly split in terms of support or opposition, with many undecided (Boudet et al., 2014; Pew, 2012). No obvious patterns exist at the state level either – however, across the U.S., urban residents appear to be slightly more likely to oppose hydraulic fracturing than rural residents (Davis and Fisk, 2014).

These national studies of public attitudes toward UOG, necessarily painted with a broad brush, all caveat their results with calls for more nuanced research, citing scholars who highlight the importance of understanding personal experiences with energy development that cannot be captured in national datasets or via simple support-opposition scales (Jacquet, 2012). It is this growing literature that we turn next, using three questions derived from Section 2 as our guides. We address each question by first engaging with the emerging (sub)urban and periphery literatures, and then turning to the more traditional impact geographies in remote and rural regions.

5.2 Which, if any, people and places have experienced predicted psycho-social disruptions, such as changes to quality of life, sense of place, or place attachment? Studies of oil and gas host communities have found that significant psycho-social disruption often accompanies rapid energy development, prompted by worries about impacts and/or actual impacts to personal health or property and by change to local environmental quality, community character, or individual place attachment (Jacquet, 2014a). Assessing psycho-social disruption across the West's differing UOG impact geographies is a challenge because the dynamics of psycho-social disruption are nuanced and difficult to measure, but we make an effort here to highlight relevant findings on quality of life and place attachment from the recent UOG literature.

Quality of life assessments have thus far not been a central feature of the region's (sub)urban literature, but studies are underway. In more closely studied rural boomtowns, anecdotal and some case study reports show severe quality of life effects, but the distribution, magnitude and duration of these effects have proven difficult to quantify. Indeed, several Western boomtowns (especially those in the Bakken, but also Pinedale, Wyoming) have generated an uptick in popular media and trade publications focused on the boom's extreme dimensions—an issue that is noted by some scholars as an effect in and of itself.

Several studies show that the intensity of reported quality of life impacts vary with exposure to the economic benefits and rising costs of living associated with UOG development (Fernando and Cooley, 2015; Rundquist et al., 2012). Those who report improvement to quality of life tend to be the stakeholders who experience the most direct economic benefits, such as entrepreneurs, mineral rights owners, oil industry workers, and some homeowners, in contrast to non-oil industry workers, renters, and senior citizens (Fernando and Cooley, 2016a). Residents of some Bakken periphery communities describe that the modest benefits of boom-related economic and population growth outweigh also modest quality of life costs, such as increased traffic and heightened sense of vigilance (mostly for children's safety) (Junod et al., 2017). However, this "Goldilocks" experience does not appear to extend to the periphery communities within the Fort Peck Indian Reservation. At a 2014 listening session with U.S. Senator Jon Tester on the subject of human trafficking, the Chairman of the Fort Peck Assiniboine and Sioux Tribal Executive Board stated: "We are already seeing negative impacts of oil and gas development with no benefits to us" (Plestina 2014).

Place attachment indicators have been difficult to isolate in petro-suburban areas. In Colorado, political identity and risk perceptions have outweighed place attachment in studies of UOG support and opposition (Mayer, 2017a). That said, Front Range residents do describe a sense of invasion by UOG activities and consternation about the logic behind well pad siting choices (Kroepsch, 2016; Kroepsch, 2018a,b). Moreover, unwanted proximity to UOG development has a strong negative influence on perceptions of risks and benefits (Mayer, 2016), and some of the community members most active in local UOG debates have been moving away (Zilliox & Smith 2018). In boomtowns, place attachment has been a critical element in perception and response to social impacts of rapid population growth. An in-depth exploration of the elements of place-attachment in rural North Dakota, Fernando and Cooley (2016a) document the following values as fundamental to local perceptions (and by implication, most at risk for disruption): perceived unity, attachment to social supports, and safety and security. In some periphery communities, the risks of UOG to place meanings and identities—such as those around safety and crime—may be lower than initial concerns (Junod et al., 2017).

A nascent but important literature led by emerging Native American scholars helps to provide the necessary rich detail that explains the cultural dimensions of resistance to, and accommodation of, UOG development within sovereign nations. Zoanni (2017) points to the sacred role of water in Sioux and Assiniboine traditions that influence concerns about UOG development on the Fort Peck reservation. Tice (2016) offers a nuanced exploration of tensions between the emerging extraction ethic with cultural traditions of a spiritual land ethic. Her discussion about the experiences and outcomes of deploying a custom set of survey instrument variables should be consulted by researchers considering similar methods in Indian Country (see pp. 68-91).

5.1. When, where, and how has UOG development produced corrosive versus consensus community dynamics?

The term "corrosive communities" describes circumstances where the pernicious effects of community conflict over energy development become more harmful than the development activities themselves (Freudenburg and Jones, 1991). Factors likely to contribute to corrosive dynamics include a lack of trust in governing bodies and officials, a lack of local leadership, uneven distribution of costs and benefits, uncertainties over environmental or health impacts, heterogeneity of community population and attitudes, and low stocks of social capital and limited bridging capital (Besser, 2013; Jacquet, 2014a). Consensus responses to disruptive shocks have been predicted to occur when social and bridging capital are adequate to encourage a robust response (Erickson, 1994 quoted in Besser, 2013). Examples of consensus responses in the West are the few empowered suburban and exurban communities that rallied to resist UOG development, such as exurban residents on the outskirts of Bozeman, Montana, who successfully rallied local elected officials to enact an emergency zoning ordinance that effectively quashed plans for coalbed methane development in the early 2000s (Williams, 2006).

In Colorado's petro-suburbs, policy actors are polarized on the question of whether energy development should continue at its current rate (Heikkila and Weible, 2015; Weible and Heikkila, 2016). More to the point, two-thirds of policy actors surveyed believe there are organizations and individuals with the authority and trust to help negotiate policy solutions around UOG development, while one-third do not (Heikkila and Weible, 2015). Transparency and a commitment to public engagement by local governments appears to be especially important for combatting corrosive community dynamics, even more so than the negotiated terms of industry-community agreements (Shaffer et al., 2016; Zilliox and Smith, 2017a, 2017b). Both proponents and opponents of UOG have been engaging extensively with local governments in an effort to win policy debates (Weible et al., 2016), with the politics of knowledge production on environmental and public health questions being especially contentious (Jacquet, 2014b; Witter et al., 2013; Zilliox and Smith, 2018). The importance of local government engagement is further supported by studies that find a lack of public trust in state-level government. Some residents report feeling misunderstood by state inspectors and regulators (Opsal and Shelley, 2014), citizen participants in rulemaking processes do not always feel adequately represented in rulemaking-related negotiations (Cook, 2014, 2015a, b; Rinfret et al., 2014), and a range of policy actors reported low levels of satisfaction with the stakeholder panel convened in 2014 by Colorado's Governor Hickenlooper to address UOG policy issues (Heikkila and Weible, 2015).

Boomtowns and rural UOG landscapes provide interesting counterpoints to the policy dynamics of petro-suburbs. With some important exceptions, these geographies have produced less clear social division about whether or not to pursue oil and gas development than the petro-suburban communities of the West. For example, Smith and Haggerty (2018) document rural landowner organizing in the Bakken as an impact mitigation effort rather than a resistance effort. But rural development is not free of social divisiveness. In boomtowns, the challenges in accommodating, interacting with, and integrating newcomers—who often outnumber long-time residents—are numerous and multi-faceted. Institutional practices—school policies, the establishment of man camps—as well as social behaviors have been shown to reinforce divisions between pre-boom residents and boomtime arrivals. For example, Genareo and Filteau, 2016 observed behaviors in school systems that stigmatized Bakken newcomers, reinforcing or maintaining social stratifications. The irony of these divisive strategies is that some research suggests that the greater the opportunity for interaction among pre-boom social groups and newcomers, the greater the reported sense of well-being on the part of both parties (Archbold et al., 2014). In the UOG-agriculture overlay, corrosion of the social fabric may also play out in very localized ways, but it has not yet emerged as a documented phenomenon in the published literature on the American West.

Community dynamics within the West's sovereign nations that host UOG development have received limited attention in the peer-reviewed literature. Media reports have tended to focus on the corrosive dimensions of hosting UOG development, especially in the case of the Mandan, Arikara, and Hidatsa peoples of the Fort Berthold region in the heart of the Bakken (Crane-Murdoch, 2012). On the other hand, media reports (Thompson 2018) and some published accounts draw attention for UOG impacts to act as galvanizing events for coalition-building within and among indigenous nations (Zoanni, 2017) and between indigenous nations and their rural neighbors (cf. Grossman, 2017). These experiences may merit further consideration, but ethical researchers will carefully consider questions of positionality and the impacts of their research for tribal members.

5.2. Lastly, what patterns can we discern in how and why some groups resist or accommodate UOG development in the local context?

Regional economic studies have found that large increases in natural gas production generate modest positive impacts for local labor markets in terms of increases to job opportunities and wages (Brown, 2014; Weber, 2014). Employment in the energy industry is also an important factor in local resistance to, or accommodation of, UOG development in most cases (Boudet et al., 2016), but not all. Perhaps unsurprisingly, suburban UOG areas tend to be the exception. Unemployment has not been a strong predictor of local attitudes toward the industry and its regulation in studies of Colorado, Texas, and Ohio communities (Fisk, 2016). Rather, higher home values and socio-economic status, Democratic partisanship, and larger populations appear to be much stronger indicators of local opposition to the UOG industry and state-level regulatory preemption (Fisk, 2016; Fisk et al., 2017).

On the other hand, in rural areas and many remote boomtowns, studies suggest that opposition to UOG development has been effectively countered by a shared hope among many residents and local leaders that UOG jobs will counter rural decline. Moreover, studies have documented an accommodating attitude toward impacts of UOG manifested through just working harder (Weber, 2014), working differently (Dahle and Archbold, 2015), risk acceptance (McEvoy et al., 2017; Haggerty et al., in press), and taking pride in the work of impact mitigation (Guldborg 2016; Haggerty et al., 2018). Acceptance of industry within rural communities, however, is nuanced, can vary substantially amongst stakeholder groups and may reflect social norms that favor unity over conflict (Fernando and Cooley, 2016a). A recent survey showed that local businesses and landowners in Wyoming, Montana and North Dakota tended to expect the boom to last longer than it did—another data point about the tendency for rural places to demonstrate optimism toward UOG development (Haggerty et al. 2018).

Public trust in the oil and gas industry also plays an important role in local perceptions of UOG, though it is not clear exactly what generates or erases it. Concern about public distrust in the oil and gas industry is one of the few things that Colorado's UOG policy actors agree upon (Weible and Heikkila, 2016). In Colorado, survey respondents who trust the industry also perceive less of every type of UOG risk measured, including impacts on quality of life, health, real estate, land, air, and water (Mayer, 2016). Political ideology appears to play an important, and complex, role in some suburban Coloradoans' sense that the industry can be trusted to manage its own impacts. In surveys of petro-suburban communities, those who embrace free market principles express higher support for federal regulatory exemptions even while reporting negative perceived impacts from UOG development, suggesting that free market ideology might be normalizing UOG impacts for some (Malin et al., 2017). Conservative respondents to a statewide survey demonstrated the contradictory beliefs that the UOG industry is over-regulated while also supporting several regulations that are stricter than those in place, suggesting that conservatives may exaggerate the current degree of UOG regulation (Mayer, 2017b). Relatedly, studies of local newspaper coverage of UOG find that Colorado residents get very different pictures of industry actors, risks, benefits, and uncertainties based on their media diet and whether local media lean liberal or conservative (Blair and McCormack, 2016; Blair et al., 2015).

5.3. Missing Voices, Viewpoints, and Timeframes

This review suggests major gaps in the published literature both in terms of key social groups and angles on the UOG development cycle. The people whose experiences have received inadequate attention proportionate to the importance of their role in the UOG development in the West include the tribal governments, spiritual leadership and individual members of Native American nations; employees of the many components of the oil and gas industry at all levels of the corporate hierarchy; temporary residents and renters; non-English speakers living and working in impact geographies; and children and senior citizens. In many cases, research challenges get in the way of knowing and accessing these groups. Still, the research agenda of the future will do well to take stock of the missing stories that will help flesh out our understanding of the impacts of UOG development in the West.

Similarly, we observe in this survey an understandable, but still problematic, preoccupation with the boom phase of energy development, to the neglect of the 'bust.' This is despite the fact that several notable busts have been underway for a decade in the West—including the decline of coalbed methane and dry gas development, neither of which recovered after the 2007-2008 global financial crisis. As several scholars have said before us, it is impossible to assess the impacts of industrial development without attending to how they evolve over time (Brown et al. 2005; Krannich 2017). As the geologic overview in Section 3 above makes clear, UOG's geologic and technologic constraints leave UOG development particularly sensitive to commodity price cycles, making it extra important that research captures the full social accounting of booms, busts, *and* recoveries as they recur. Another rationale for addressing the ways that social groups experience the post-boom phases of UOG development is that these phases are increasingly the site of active policy development and concern, as attention naturally shifts from one type of urgent issues to another.

6. Summary and Future Directions

The American West (including the Northern Great Plains) is a vast and diverse region—as its emerging UOG development landscapes make abundantly clear. This paper introduces impact geographies as an organizing concept for reflecting on local and social impacts of UOG development. We use the widely varying spatial contexts of recent UOG activities in the American West to demonstrate how geography, geology, and market conditions align to create distinct impact geographies and development cycles in UOG plays that differ in terms of timing, the nature of infrastructure and industrial organization, and social impacts. We suggest that the impact geographies framework offers an easily portable construct for approaching the analysis of the impacts of UOG and other forms of industrial development.

As developed in this paper, a proper description of an impact geography integrates UOG's subsurface variables (geologic and technologic) with surface variables of economic, cultural, and land use conditions. By using the categories of "subsurface" and "surface" as organizing devices, we do not intend to imply that subsurface and surface variables are entirely distinct from each other. In fact, we aim to more clearly acknowledge that what happens in the subsurface influences surface systems and environments, and vice versa. We leverage these two categories in an effort to (1) bring subsurface dynamics, such as geology and changing extractive technologies, more directly into the social impacts conversation and (2) argue that the interactions among subsurface and surface dynamics be more thoughtfully integrated in UOG scholarship going forward (alongside careful scrutiny of these often taken-for-granted categories). In our application of impact geographies, we focus on the interaction of subsurface material characteristics with technological innovations and market cycles and how these relationships coalesce in development cycles that in turn shape and are shaped by surficial material, political and social conditions.

We argue that, with this description of development-location dynamics in hand, researchers may begin to make more articulate comparisons of social (or other) impacts of development than those organized around political or other distinctions – such as rural/urban – which can be vague and less meaningful. We expect that improved comparisons will, in turn, generate sharper findings about common patterns among impacts and impact geographies as well as more careful acknowledgement of diversity, distinguishing characteristics, and data gaps. One of the greatest potentials for the impacts geography approach is its attention to energy development as a diverse and complex group of actors, institutions and processes that assemble, are maintained, and disassemble in response to the particularities of local circumstances. Attention to these organizations and assemblages is critical to understanding social impacts and their sources. In addition, the impact geography framework has the potential to inform geographic concepts such as the region, as well as conversations organized around them (e.g., such as this article, which is focused on the American West as a region, and this special issue, which adopts a regional approach). As impact geographies assist scholars in highlighting commonalities and departures within a given region, and also among regions, they also encourage us to ask to what extent the region is useful as a geographic frame of reference – in other words, what what work regions or regional approaches do for us academically, culturally, and politically in the context of energy impacts.

We hope that this framework marks the beginning of – or at least serves as a punctuation point within – a larger academic conversation about the geographies of impact and the impact of geography in energy development and other contexts. Surely our list has not captured *all* of shale development's important impact geographies. As such, we look forward to the targeted expansion of an inventory of shale impact geographies worldwide. This approach also merits broadening by the addition of a variety of industrial impacts, since energy development is but one of many forms of large-scale industrial development processes. Finally, we can also imagine the concept of impact geography transcending the "impacts" approach to energy social science altogether and serving as an organizing framework within research structured around energy transitions and other approaches.

As for the 150,000 wells developed in the West since 2000 and the region's critical national role as a producer of shale oil and gas, this paper speaks to the intensity of the development in all of the geographies in which it has occurred at the same time that it demonstrates the unique experiences of different places. Indeed, across UOG impact geographies in the West, the stakeholders in and the nature of social impacts varies, often so widely that it hardly makes sense to search for common patterns in the social impacts of UOG development across its vast geographic footprint. We note the substantial differences in the human UOG experience in the diverse impact geographies we document: from the boomtowns, industrialized countrysides, and peripheries in rural UOG landscapes to the petro-suburbs of urban UOG development to the sacred and sovereign lands in which UOG development intersects the political and cultural territories of the West's Native American nations.

Across these impact geographies, however, some patterns do emerge. UOG development hardly goes "unnoticed"—its impacts are intense for those living in and near well sites and the infrastructure needed to build and operate them. Tolerance of those impacts appears to vary with access to the economic benefits associated with UOG development. That said, this review does show a more dynamic and actively contested and negotiated local response in urban areas, somewhat in contrast to trends in rural places of being more accommodating and less 'organized' about UOG impacts.

This review suggests several important future directions for scholars of UOG activity in the American West. There is a clear gap in the literature concerning the experiences and perspectives of Native Americans with and about UOG development. Few studies take a longitudinal or post-boom perspective. In addition to outtakes of social perspectives on development after the fact, research should focus on the dynamics of adaptation and co-evolution that emerge in the complex systems of local UOG developments (see Fernando and Cooley 2016b; Jacquet et al., 2018). A key feature of adaptation and evolution is the governance response to UOG impacts. The depth of the literature and scholarship on UOG in the West suggests that it should be possible for scholars to collaborate on a conceptual framework of the impact-adaptation-response-recovery cycle—perhaps testing and expanding Brown et al.'s boom-bust-recovery model that is so widely cited but rarely revisited in the literature.

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