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Spatial Dimensions of Drilling Technologies: Controversies Over Unconventional Oil and Gas Development in Northern Colorado

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SPATIAL DIMENSIONS OF DRILLING TECHNOLOGIES: CONTROVERSIES OVER UNCONVENTIONAL OIL AND GAS DEVELOPMENT IN NORTHERN COLORADO

by

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This dissertation investigates three controversies surrounding oil and gas development in populated areas of the Front Range region of northern Colorado that have emerged as a result of renewed interest in developing unconventional hydrocarbon resources using horizontal drilling and hydraulic fracturing techniques. These controversies surround disputes between competing capital interests over rights of access to subsurface hydrocarbon resources, municipal challenges in accommodating oil and gas development in residential areas, and perceptions among more 'moderate' residents regarding activism resisting oil and gas development in Colorado and alternative strategies adopted by these residents to oppose hydrocarbon extractive activities in their neighborhoods. Through extensive ethnographic and archival research, I demonstrate that horizontal drilling plays a significant role in shaping these controversies, largely due to the different spatial dimensions of horizontal drilling technology compared to that of vertical drilling. First, I argue that this advancement in drilling technology has increased the ability to access hydrocarbon resources—including those owned by others—which has prompted a reconsideration of processes and regulations granting rights of access to these resources. Secondly, through a comparative study of vertical drilling in the City of Greeley during the 1980s and a contemporary horizontal development project in the Town of Windsor, I

demonstrate that the use of these different drilling technologies in residential areas present distinct sets of concerns and responses for these municipalities regarding planning and growth. Finally, I illustrate that suburban and rural perspectives regarding hydrocarbon development in the Front Range are influenced by differences in the spatial aspects of vertical and horizontal development, as well as matters of place and place identity—specifically the area's location in the region of the American West. Furthermore, matters of social identity and rejection of 'activist' characterizations shape resident efforts to resist hydrocarbon development in their neighborhoods. This dissertation connects resource geography with urban geography to illustrate ways in which controversies surrounding resource extraction in surface and subsurface urban spaces are fundamentally shaped by the materiality of resources and the spatial dimensions of extractive technologies.

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LIST OF ABBREVIATIONS

COGCC	Colorado Oil and Gas Conservation Commission
CUG	Conditional Use Grant
DJ	Denver-Julesburg
FLIR	Forward-looking infrared
GMO	Genetically modified organism
GWA	Greater Wattenberg Area
MAUP	Modifiable areal unit problem
MOU	Memorandum of Understanding
NATC	Neighbors Affected by Triple Creek
PLSS	Public Land Survey System
UOGD	Unconventional oil and gas development
VOC	Volatile organic compound
WNRD	Windsor Neighbors for Responsible Drilling
WOGLA	Weld Oil and Gas Location Assessment

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- Chapter 1 -
Introduction

This dissertation investigates controversies over oil and gas development in northern Colorado. These controversies are largely the product of two concurrent and spatially overlapping phenomena this area is experiencing—a surge in hydrocarbon extraction activities and a population and housing boom.

The use of advanced techniques of hydrocarbon extraction—namely the combined application of horizontal drilling and hydraulic fracturing technologies—has sparked renewed interest in developing unconventional oil and gas resources in Colorado's Greater Wattenberg Area (GWA), located in the north-central portion of the state. Crude oil production in Colorado has quadrupled since 2010 due, in large part, to the use of horizontal drilling and hydraulic fracturing technologies (US Energy Information Administration [US EIA], 2019). Colorado has experienced a dramatic shift in recent years from vertical to horizontal development, with horizontal wells comprising 72% of all wells drilled in Colorado in 2017 compared to 5% in 2010 (COGCC, 2017). Colorado is ranked fifth and sixth among all US states for crude oil and natural gas production, respectively (US EIA, 2019). The boom in hydrocarbon production in Colorado is part of a broader trend occurring across the United States, and indeed globally, of utilizing companion techniques of horizontal drilling and hydraulic fracturing to extract unconventional oil and gas resources contained within geologic formations such as shale and tight-sandstone that have previously been inaccessible or uneconomical to recover. Although hydraulic fracturing ("fracking") has received much of the attention in both scholarly literature and the popular media, this technology is not altogether new—the technique has been used in

hydrocarbon production for several decades (Montgomery & Smith, 2010). The major change in how oil and gas resources are developed is technological advancements in drilling technologies—from vertical to horizontal development.

Vertical development involves drilling a single well straight down into the target oil and gas-bearing geologic layer. Horizontal development allows a wellbore to deviate from a vertical position and be drilled laterally through a geologic layer. Horizontal drilling has significantly changed the spatial aspects of hydrocarbon extraction in several ways. Horizontal drilling condenses wells and production equipment onto a single surface location, it permits hydrocarbon producers to reach minerals previously inaccessible due to existing surface development, as well as allows the same oil and gas resources to be accessed from a number of surface locations (Kroepsch, 2018). Consideration of these changed spatial dimensions of oil and gas development provides the foundation for this dissertation, particularly as they relate to oil and gas development in urban, suburban, and rural settings.

In recent years, Colorado has undergone a considerable population boom. The population of Colorado increased 13.2% between 2010 and 2018 (United States [US] Census Bureau, 2019b), making it the fourth fastest growing state in the US during that time period (US Census Bureau, 2019a). In-migrants tend to be younger and well-educated individuals originating primarily from California, Arizona, Texas, Florida, and Illinois, and who relocate to the Denver Metropolitan Area (Colorado Department of Local Affairs, 2018). Although the population of Colorado is predominantly white, the state has experienced a large increase in its Hispanic population, which grew approximately 55% between 2000 and 2017 (Colorado Department of Local Affairs, 2019b). Colorado has also experienced an influx of immigrants

from Central America, Southeast Asia, and East Africa in recent years (Healy, 2014). In addition to these demographic changes, Colorado has also undergone significant political changes in recent years.

Many political changes in Colorado have been attributed to the influx of younger, urban-minded individuals moving to Colorado and shifting the state's politics increasingly toward the Democratic Party—a trend which began to take hold within the last fifteen years (Aguilar & Garcia, 2018). The demographic changes, including an increase in young and Latino voters, have fueled a political trend in Colorado toward a more progressive stance. However, although increasingly left-leaning, Colorado still maintains a large number of independent and unaffiliated voters (Aguilar & Garcia, 2018).

Unconventional oil and gas development in Colorado, as in many other states in the US, has stirred up quite a bit of political controversy in recent years, which led to several pro- and anti-oil and gas development initiatives appearing on the state's November 2014 ballot. In an effort to have these measures removed from the ballot, the governor created the Colorado Oil and Gas Task Force to develop recommendations for new state rules regulating unconventional oil and gas development. The new rules were met with significant criticism across the board, which renewed efforts to place several measures on the November 2016 ballot to ban oil and gas development through an amendment to the state constitution and enact more stringent regulations on hydrocarbon extraction. These initiatives failed to garner enough support to appear on the ballot, but another initiative to amend the state constitution—one supported by the oil and gas industry—did make the ballot and was adopted by Colorado citizens.

The passage of Colorado Amendment 71—commonly referred to as "Raise the Bar"—made it more difficult to amend the state constitution. Specifically, it requires that signatures from two percent of registered voters in each of Colorado's thirty-five Senate districts be obtained to appear on the ballot, and measures must receive a fifty-five percent vote rather than a simple majority in order to pass (Hutchins, 2018). This ballot initiative was launched by Building a Better Colorado, "a diverse, nonpartisan coalition of Coloradans that have come together with the shared belief that Colorado can do better than the divisive arguments that have come to dominate our political discourse" (Building a Better Colorado, 2019). The impetus behind this initiative was to give more Coloradans a voice in matters of state governance, particularly those regarding issues affecting rural Colorado, and wrest control away from the urban and suburban population centers of the Front Range (Hutchins, 2016). The initiative was supported by the petroleum industry as a response to efforts in 2016 and prior years attempting to amend the state constitution to implement more stringent regulations on oil and gas development, as well as outright bans on the activity (Hutchins, 2016).

Other political controversies surrounding oil and gas development include the May 2016 Colorado Supreme Court decision that struck down local government bans on oil and gas development as unconstitutional (Finley, 2016). Furthermore, the death of two individuals in a home explosion linked to a nearby vertical gas well heightened already existing concerns among residents living near oil and gas development (Finley, 2017), and resulted in substantial changes to state regulations governing flowlines from hydrocarbon wells (The Associated Press, 2018). At the time of this writing, Colorado recently passed state legislation both redefining the role of the state oil and gas regulatory agency—the Colorado Oil and Gas Conservation

Commission (COGCC)—to prioritize protecting of public health, safety, welfare, and the environment, as well as empowering local governments with greater control over oil and gas operations within their jurisdiction.

Although the statewide political changes discussed above have important ramifications for the politics of hydrocarbon development in Colorado, this dissertation focuses on the Front Range area of Colorado to investigate controversies surrounding UOGD, with particular attention given to Weld County and its municipalities of Greeley and Windsor.

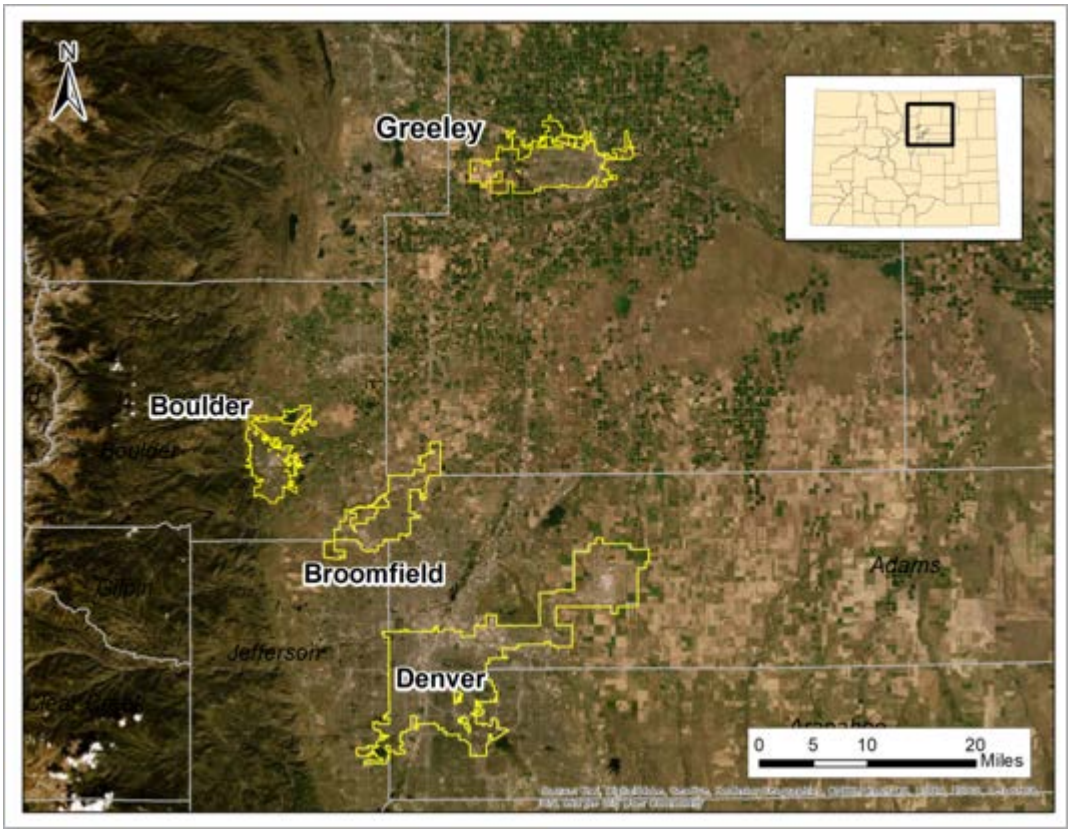

Figure 1. Colorado's Front Range corridor (Map by the author)

Study area

The Front Range area includes the communities situated along the Interstate 25 corridor, east of the Rocky Mountains, and between Denver and Fort Collins. The Front Range is

a semi-arid region comprised primarily of grasslands and shrubs, as well as agricultural fields, in the undeveloped areas of the Front Range. The area is characterized by low humidity, sporadic rain and snow, and substantial seasonal and daily ranges in temperature spanning from maximum highs of 95°F in the summer months to low temperatures below 0°F in the winter (Doesken et al., 2003). Elevations of the Front Range area where the plains meet the Rocky Mountains vary gradually between 5,000 and 6,500 feet (Doesken et al., 2003). The relative flatness of the area and its location just east of the Rocky Mountains provides unobscured views of mountain peaks exceeding 14,000 feet. Two major rivers flow through the Front Range area: the South Platte River meanders northward from Denver and the Cache la Poudre River descends from the Rocky Mountains, flowing eastward from Fort Collins. Greeley is situated just west of the confluence of these two rivers.

Weld County, the southern and western portion of which comprises a substantial part of the Front Range area, contains just under two million acres of agricultural land, is the top agricultural-producing county in Colorado, and consistently ranks in the top ten agricultural-producing counties in the US (Weld County Department of Planning and Zoning, 2019). Weld County leads the state in dairy production, beef cattle, sugar beets, and grain (Weld County Department of Planning and Zoning, 2019). In 2017, Weld County was the second fastest growing county in Colorado (Dunn, 2018). The Weld County population grew 66% between 2000 and 2017, with an increase of almost 20% between 2010 and 2017 and a 15% increase in housing units during the same time period (Colorado Department of Local Affairs, 2019a). Many of the fastest growing towns in Colorado are located in southwestern Weld County, which is part of the sprawling suburbs surrounding Denver (Silvy, 2018).

Greeley's population has grown approximately 13% since 2010 to reach approximately 105,000 residents (Silvy, 2018; Upstate Colorado Economic Development, 2019). In 2017, the Greeley Metropolitan Statistical Area ranked third in the nation in terms of growth at 3.5% (Dunn, 2018). The number of permits for new homes in the Greeley metropolitan area increased approximately 220% from 2010 to 2015 (US Census Bureau, 2016). The Town of Windsor straddles the border between Weld and Larimer Counties. Windsor's population nearly quadrupled between 1995 and 2015, totaling approximately 32,000 residents (Economic & Planning Systems, 2015; Town of Windsor, 2019).

The most active area of hydrocarbon drilling activity in the Front Range occurs in the Greater Wattenberg Area (GWA), which encompasses the Wattenberg field—the fourth-largest oil field in the US (US EIA, 2015). The GWA is located primarily in Weld County, and stretches from the City and County of Broomfield in the southwest to the northeast past Greeley—the county seat of Weld County. In 2017, 62% of the drilling permits in Colorado were issued in Weld County, of which 98% were for horizontal wells (COGCC, 2017). At the end of 2017, Colorado had approximately 55,000 active oil and gas wells, 43% of which were located in Weld County (COGCC, 2017). Weld County accounts for approximately 90% of the total crude oil and 43% of the coalbed methane and natural gas produced in Colorado (Colorado Oil and Gas Conservation Commission [COGCC], 2019).

Political controversies over UOGD in Weld County

Weld County and its communities provide some of the most salient examples of the contentious politics surrounding UOGD in Colorado. The Weld County Board of County

Commissioners were displeased with the Colorado Oil and Gas Conservation Commission (COGCC)—the state oil and gas regulatory commission—and new state regulations adopted in 2015 governing hydrocarbon development, claiming that the new state rules limit the board's control over land use in the county. The commissioners established a new county oil and gas permitting process in December 2016—the Weld Oil and Gas Location Assessment (WOGLA)—aimed at protecting local government land-use authority from usurpation by a state agency, providing greater assurances for oil and gas producers regarding surface regulation, and protecting the property rights of surface landowners (Freeman, 2016). However, this new process stirred political controversy by removing the public hearing process on proposed oil and gas development (Marmaduke, 2016).

In 1985, the City of Greeley—the county seat of Weld County—was one of the first municipalities in Colorado to ban oil and gas development within city limits. Thirty years later, Greeley is now an epicenter of oil and gas development in the American West. Furthermore, the 1992 Colorado Supreme Court decision that overturned the city's ban set the legal precedent upon which recent bans on hydrocarbon extraction by Colorado municipal governments have been overturned.

Other examples of the contentious politics surrounding oil and gas development in Weld County communities include the Greeley City Council's March 2016 reversal of the city planning commission's denial of a permit for the twenty-two well Triple Creek project located near residential neighborhoods on the city's west side. In November 2014, The Town of Windsor force-annexed an enclave of unincorporated Larimer County at the behest of residents in order

to contest the location of a large multi-well UOGD facility proposed within residential neighborhoods—a facility that was ultimately relocated away from the neighborhoods.

Figure 2. Oil and gas production facility in an agricultural field in Weld County, Colorado (Photo by the author)

Figure 3. Large multi-well oil and gas production facility near residential subdivisions in the Town of Mead in Weld County, Colorado (Photo by the author)

Fieldwork and methodology

My research methods for this project consisted of extensive archival and ethnographic work conducted primarily in the Greeley and Windsor areas, but, at times, this research also

extended into other communities of the Front Range region. To conduct this research, I lived in Greeley for ten months between September 2016 and June 2017, which provided me with day-to-day experiences of living in an urban environment located in the heart of oil and gas development in northern Colorado. Several informal conversations during daily activities and at community events—including outdoor concerts, a rodeo, restaurants and bars, dog parks, laundromats, and recreation trails—informed my research by providing insight into the perspectives and experiences of Greeley and other Front Range residents regarding UOGD in and around their communities, as well as Colorado more generally.

My fieldwork included twenty-two semi-structured personal interviews conducted with a variety of individuals, including two Greeley city officials, three Windsor town officials, four Weld County farmers, and thirteen residents of the Front Range area—many of the latter which resided in Greeley and Windsor. Interviews with municipal officials were aimed at understanding processes, opportunities, and challenges associated with UOGD within their municipal boundaries. Interviews with farmers and residents provided various insights into their perceptions and experiences of UOGD on or near their property, in their community, as well as Colorado more broadly. Attempts were made to interview many other individuals in a variety of roles, including COGCC staff, Weld County commissioners, and a number of additional farmers and suburban residents, but were unsuccessful.

My research methods also included conducting observation at several meetings, including those of the Weld Board of County Commissioners, COGCC hearings, Windsor town board meetings, and meetings of two different environmental groups. Attendance at an oil and gas industry-sponsored symposium, as well as three community outreach meetings hosted by

an oil and gas company in Windsor and Brighton, Colorado, provided an opportunity to observe informational presentations and interact with oil and gas industry employees and representatives. My field research was further informed by tours of both an active drilling rig and hydraulic fracturing site, as well as a demonstration of a "thumper" (seismic vibrator) truck at a community outreach meeting.

Archival research was mainly conducted at the Hazel E. Johnson Research Center at the Greeley History Museum in Greeley, Colorado to investigate historical issues surrounding oil and gas development in the Greeley area. A thorough review of an extensive collection of newspaper articles taken from *The Greeley Tribune* related to oil and gas development in Greeley and surrounding communities was conducted. Other archival research included reviewing meeting minutes of both the Greeley City Council and Planning Commission, as well as examining La Salle town board meeting minutes.

Each chapter in this dissertation draws on specific research methods and data sources, and a more detailed discussion of these is provided within each individual chapter.

Overview and findings

This dissertation is structured around three different controversies that have emerged from oil and gas development in Colorado's Front Range area. The following three chapters of this dissertation are written as stand-alone papers, with each devoted to examining one of these three controversies. In the final chapter of this dissertation, I summarize my major findings and conclusions and provide suggestions of directions for future research.

Chapter 2 examines disputes between operators[1] over rights of access to hydrocarbon resources in the GWA that have emerged from horizontal drilling technology. I discuss the institution of laws and regulations governing vertical development of oil and gas resources in the United States, which were aimed at establishing efficiencies and equity in extraction. In the GWA, such regulations have been modified to accommodate changes in drilling technologies from vertical to horizontal development; however, horizontal drilling has presented new challenges for state regulators in conferring rights of access to subsurface hydrocarbon resources. Using Ribot and Peluso's (2003) access analysis framework, I illustrate how factors beyond that of mineral property ownership and laws and regulations influence access to oil and gas—namely those of drilling technology and the materiality of hydrocarbon resources. In doing so, I address the following research questions:

1. How has horizontal drilling changed spatial dimensions of the *ability* to access oil and gas resources?
2. How have these changes complicated rights-based access to these resources?

I argue that the shift from vertical to horizontal drilling technologies has changed the spatial dimensions of hydrocarbon development by allowing for a greater ability to access minerals, including those owned by others. Additionally, horizontal drilling has introduced spatial

[1] In the oil and gas industry, an operator is a company that designs, manages, and oversees an oil and gas development project, including exploration and production activities, as well as securing a drilling contractor and service companies.

complexities requiring a reconsideration of rights-based mechanisms of access to oil and gas resources in choosing between competing claims to these minerals.

In Chapter 3, I examine the role that drilling technologies play in municipal challenges to accommodating oil and gas development in residential areas of Colorado. I provide a comparative study of vertical development in Greeley during the 1980s and a recent horizontal oil and gas project proposed in the Town of Windsor to address the following question: what effects and implications for municipal governments emerge from proposed oil and gas development in residential areas of municipalities, and how has horizontal drilling affected these dynamics?

I demonstrate that the two distinct drilling technologies create different sets of concerns and impacts regarding matters of urban growth. More specifically, vertical wells dispersed across Greeley precluded development in the space surrounding those wells and impacts growth patterns of housing and other types of development. The proposed horizontal oil and gas project in Windsor created concerns regarding the intensity of the condensed site located amongst residential neighborhoods. Additionally, horizontal drilling facilitates the ability of operators to engage in *strategic siting* of oil and gas production facilities for more favorable conditions of development. Furthermore, I find that the subterranean space of cities and the extractive activities occurring therein play a significant role in shaping resident and municipal responses to urban oil and gas development.

Chapter 4 of this dissertation examines perceptions of both unconventional oil and gas development, as well as activism surrounding such extractive activities ("fracktivism") in Colorado among suburban residents and rural farmers in the Front Range area. I attend to the

ways in which the Front Range as a place in the American West region play a role in the perspectives of these residents and farmers, as well as examine how differences between vertical and horizontal drilling enter into these perspectives. I examine the role that place identity and social identity play in perceptions of fracktivists, in addition to alternative resistance strategies adopted by suburban residents to contest extractive activities in their communities. This chapter addresses the following two research questions:

1. How do rural and suburban residents of Colorado's Front Range area perceive unconventional oil and gas development in their communities?
2. How do these two categories of residents view resistance efforts by activists to oppose extractive activities, and what alternative strategies do these residents adopt?

Through my analysis, I find that Front Range farmers possess a strong connection to their land, and past experiences with vertical development made them more accommodating to horizontal UOGD. Suburban residents generally viewed UOGD in their communities as intrusive. Both farmers and suburban residents hold relatively negative views of fracktivist efforts to resist oil and gas development; however, several suburban residents indicated a desire for a collaborative relationship with fracktivists. Additionally, I show that the resistance strategies undertaken by suburban residents were largely aimed at avoiding characterization as a fracktivist, appealing to the broader public, presenting objective knowledge, and establishing legitimacy and credibility of their claims.

Significance

This dissertation contributes to several bodies of literature and areas of geographic inquiry. My research puts concerns of resource geography into conversation with urban geography as part of a broader shift in geography of energy resource production from traditionally rural settings of extraction to more highly populated urban and suburban areas that heretofore have largely escaped such development (Lave & Lutz, 2014). Importantly, I demonstrate the significance of accounting for the spatial dimensions of technologies of resource extraction—namely vertical and horizontal drilling—in understanding controversies surrounding hydrocarbon development. This research also contributes to geographic literature on vertical and volumetric spaces by moving beyond larger-scale geopolitical concerns regarding subsurface spaces. Rather, this study provides a more 'micro-level' analysis of the physical and theoretical relationships and connections between subsurface resource extraction activities and the 'lived' surface spaces of urban environments in specific places.

First, this study contributes to understandings of how the materiality of resources and advancements in extractive technologies influence access to these resources, and potentially results in competing claims to resources. Additionally, this study contributes to understandings of the complexities of establishing laws and regulations governing access to resources that emerged from changes in the spatial dimensions of resource extraction.

Secondly, this study contributes to the limited, yet growing, literature on resource extraction in urban environments. This research demonstrates that the spatial aspects of different extractive technologies have create unique sets of challenges for municipal governments, particularly with respect to matters of urban planning and the politics of urban

growth. Furthermore, this research demonstrates the significance of considering the role that subsurface extractive activities play in constructing a volumetric territory of the city.

Finally, this research contributes to the literature on perspectives of resource extraction occurring in different settings—namely urban, suburban, and rural areas. This study provides key insights into the complexities of 'middle-ground' perspectives on resource extraction beyond the polarized viewpoints common in the existing literature. Furthermore, this dissertation contributes to understandings of how the geography of place and social identity, as well as extractive technologies, influence perceptions of and responses to issues surrounding resource extraction.

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- Chapter 2 -
Horizontal drilling and spatial dimensions of access: Competing claims to oil and gas resources in Colorado

In December 2017, Crestone Peak Resources filed suit against Extraction Oil & Gas, the City and County of Broomfield, and the Colorado Oil and Gas Conservation Commission (COGCC)—the state's oil and gas regulatory agency. The lawsuit was prompted in large by COGCC's denial of Crestone's application to establish a *spacing unit*, which would designate a space within which the company would use horizontal drilling techniques to exclusively develop its own minerals. Concurrently, COGCC approved Extraction's application to establish an alternative configuration of spacing units to drill horizontal wells, in which the second company would develop minerals owned in part by Crestone. Laws and regulations permit such an action through *pooling*, in which adjoining tracts of land under different ownership are combined to meet spacing unit requirements to drill a well, with production proceeds from that well distributed on a *pro rata* basis. Furthermore, Crestone claimed that the presence of Extraction's wells would prevent the former from drilling from the overlying surface area. The company argued that the presence of existing homes and other surface development overlying the remainder of its minerals would preclude it from accessing those resources from an alternate surface location, thereby 'stranding' those minerals and preventing their recovery. As horizontal drilling and hydraulic fracturing technologies have led to a boom in the development of oil and gas resources in Colorado's Greater Wattenberg Area (GWA), north of Denver, this

type of dispute between operators[2] has become an increasingly common source of contention between competing capital interests.

These advancements in extractive technologies—horizontal drilling and hydraulic fracturing—have sparked renewed interest in developing unconventional oil and gas reservoirs, such as shale and tight-gas sandstone, around the United States. Conventional extraction of oil and gas resources involved drilling a vertical well to extract hydrocarbon minerals. Unconventional oil and gas development utilizes horizontal drilling which allows the drill bit to deviate from a vertical position and enter a target geologic formation laterally (Figure 4). This drilling technique is combined with hydraulic fracturing, in which a mixture of typically water, sand, and chemicals is pumped into the well under high pressure to fracture the source rock and release the hydrocarbon resources. Horizontal drilling and hydraulic fracturing technologies have further complicated estimates and claims of "peak oil" (Bridge, 2010) by opening up numerous oil- and gas-bearing formations as new "resource frontiers" (Bridge, 2014).

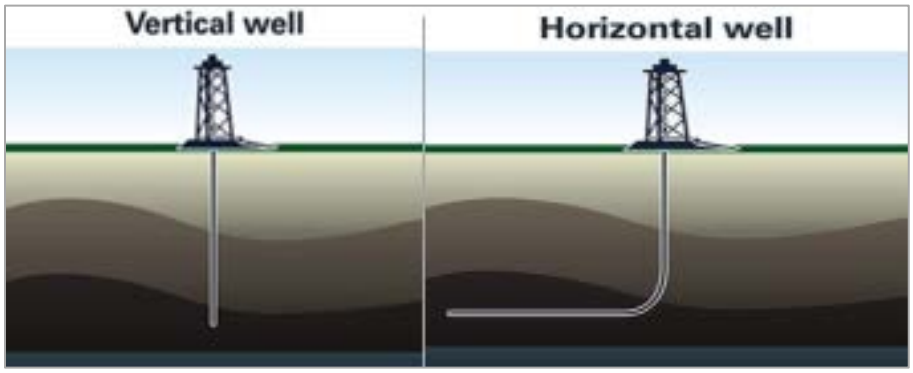

Figure 4. Vertical and horizontal drilling technologies (Image credit: Tortoise Advisors, image downloaded from https://www.uncoverenergy.com/ideas/the-will-to-drill)

[2] In the oil and gas industry, an operator is a company that designs, manages, and oversees an oil and gas development project, including exploration and production activities, as well as securing a drilling contractor and service companies.

Hydraulic fracturing has received disproportionate attention in both the popular media and scholarly literature in the social sciences, while the implications of horizontal drilling have remained relatively unexplored (for an exception see Kroepsch, 2018). One key implication is that horizontal drilling has changed the way producers gain *access* to oil and gas resources. In this chapter, I use Ribot and Peluso's (2003) theory of access to illustrate how factors beyond simply that of property ownership influence access to these resources. Spacing and pooling are prime examples of what Ribot and Peluso (2003) refer to as *rights*-based mechanisms of access, which confer the *right* to benefit from the extraction of oil and gas resources. However, Ribot and Peluso (2003) argue that attention to rights-based access through laws, customs, and conventions are insufficient to account for the myriad of ways in which actors are able to benefit from resources. Rather, Ribot and Peluso (2003) argue for a second category of access—*structural and relational*—through which various processes and mechanisms, such as technology, capital, knowledge, and labor, confer the *ability* to benefit from resources. In addition to several access mechanisms outlined in Ribot and Peluso's (2003) theory of access, Ginger et al. (2012) identify the importance of biophysical factors—namely environmental conditions and spatial proximity—in influencing access to natural resources. I expand on this point by attending to the distinctive material characteristics of oil and gas resources and spatial dimensions of horizontal drilling, and I also contribute to understandings of how changes in technologies of extraction create new abilities to access these resources. Additionally, horizontal drilling technology has forced a reconsideration of rights-based access to hydrocarbon resources, specifically through the reevaluation of spacing and pooling regulations.

By establishing exclusive spaces for extraction and ensuring equitable distribution of production from a well, spacing regulations and pooling laws, respectively, fundamentally influence where and how hydrocarbon resources are developed. In turn, the shift from vertical drilling to horizontal drilling has radically altered the application of spacing and pooling regulations. Although numerous legal scholars have examined the emerging challenges of applying spacing and pooling rules to horizontal development (e.g., Holliday, 2013; Kramer, 2010; Kramer, 2014; Pierce, 2011; Whitworth & McGinnis, 2011), geographers and other social scientists have not substantively engaged with either type of regulation (for exceptions see Hanschel & Centner, 2016; Holahan & Arnold, 2013). The increased propensity of operators intersecting one another's mineral leaseholds becomes more prevalent with horizontal drilling, which in many cases has encouraged greater cooperation and planning among operators in designing their extractive projects (Kroepsch, 2018). Yet, as discussed above, this cooperation is not always the case, and this chapter examines situations in which competing capital interests seeking access to subterranean space for oil and gas extraction using horizontal drilling come into conflict with one another.

This chapter addresses the above gaps in the existing geographic and social sciences literature by addressing the following questions:

1. How has horizontal drilling changed spatial dimensions of the *ability* to access oil and gas resources?
2. How have these changes complicated rights-based access to these resources?

To answer these questions, I extend the access analysis framework developed by Ribot and Peluso (2003) and further built upon by Ginger et al. (2012) in examining access to the subsurface for purposes of extracting hydrocarbon resources. This is the first application of this theoretical framework to oil and gas development. In this chapter, I investigate disputes between operators in Colorado's Greater Wattenberg Area (GWA) over access to oil and gas minerals, as well as the Colorado Oil and Gas Conservation Commission's (COGCC) discussion and evaluation of alternative rights-based mechanisms of granting access to these hydrocarbon resources. Through this analysis, I demonstrate that advancements in drilling technology—from vertical to horizontal development—have changed the spatial dimensions of oil and gas extraction by allowing for a greater ability to access minerals, including those owned by others. Furthermore, horizontal drilling has introduced spatial complexities requiring a reconsideration of rights-based mechanisms of access to oil and gas resources in choosing between competing claims to these minerals.

In what follows, I provide an overview of the development of access rights to oil and gas resources in the United States, including spacing regulations and pooling laws. I then discuss the access analysis framework developed by Ribot and Peluso (2003) and review relevant literature demonstrating the complexity of factors driving the analysis. Next, I provide an overview of the study area and research methods before turning to an analysis of the complexities that horizontal drilling presents in establishing rights-based access to oil and gas resources.

Rights of access in vertical oil and gas development

Disputes between oil producers regarding access to hydrocarbon resources emerged in the early days of oil and gas development during the late nineteenth and early twentieth centuries, when courts in the US applied the rule of capture to the extraction of these minerals. Under English common law, the rule of capture allowed a landowner to hunt any wildlife that migrated onto their property. Applied to oil and gas, it entitled a property owner to the rights to any oil and gas resources produced from a well located on their property, regardless of whether those minerals originated from underneath their property (Kramer & Anderson, 2005). A common solution for a landowner wishing to protect their minerals from being produced from a well on adjacent land was to drill offset wells on their own land to ensure capture of the minerals underlying their land (Hardwicke, 1935). This "finder's keepers" logic encouraged a race to produce as much oil as possible, as quickly as possible (Daintith, 2010). This resulted in overdrilling, which damages the natural reservoir pressure, thereby preventing maximum recovery of oil and gas resources—resulting in 'waste.' In addition to this physical waste, overdrilling also created economic waste of oil and gas resources by producing too much of the resource too quickly. This led to significant storage and transport issues for oil producers which, in turn, resulted in a glut that severely diminished hydrocarbon prices (Daintith, 2010; Huber, 2011).

Courts applied the rule of capture to oil and gas development due in large part to incomplete knowledge at that time regarding the materiality of oil and gas resources, including petroleum geology and reservoir mechanics (Daintith, 2010; Mommer, 2002). During the initial decades of oil and gas development in the US, it was commonly thought among oil producers

that oil and gas flowed through underground fissures or veins and pooled in subsurface cavities. Court rulings in legal battles over rights of ownership and access to oil and gas resources contained judicial analogies likening oil and gas to water—whether percolating through the subsurface or flowing like an underground river (Daintith, 2010; Mommer, 2002). By the turn of the twentieth century, geologic knowledge had improved—oil producers came to understand that oil and gas were contained within the pore space of source rock and forced to wells through reservoir pressure. This created areas of drainage surrounding a wellbore—production from existing wells was diminished when new wells were drilled nearby. Even though this geologic 'fact' was known by the 1880s and 1890s, in practice, the industry knowingly developed oil and gas from neighboring properties (Daintith, 2010). This knowledge raised issues of equity in that the production from a well was less attributable to pure serendipity than it was to appropriation from neighboring landowners. With this geologic knowledge, courts began to limit the rule of capture in adopting the view that all landowners overlying a reservoir collectively held rights to the hydrocarbon resources contained within the reservoir (Daintith, 2010), which soon led to a significant shift in oil and gas development.

Conservation legislation adopted by many oil- and gas-producing states in the US during the early- to mid-twentieth century aimed to counteract the inequities associated with waste through overdrilling and overproduction, as well as property disputes associated with the rule of capture (Mommer, 2002). A key component to this conservation legislation was the protection of correlative rights in oil and gas: collectively-held rights that allow each mineral owner equal opportunity to develop the minerals they own, provided it be done in such a way so as not to interfere with the rights of others to develop their own minerals (Daintith, 2010).

Two crucial legal and regulatory mechanisms established as part of this conservation effort were well spacing rules and pooling statutes (Daintith, 2010). Spacing regulations established minimum distances both between wells and between wells and property or lease lines. The resulting drilling or spacing units territorialized extraction by designating exclusive spaces to individual wells in order to account for areas of drainage. However, in doing so, spacing rules could result in spatial issues of inequity through a 'takings' of property rights by precluding drilling and development on small or irregularly-shaped tracts of land. To avoid such issues, conservation legislation typically included pooling statutes which allowed for the aggregation of tracts of mineral ownership for sufficient acreage to meet spacing requirements (Figure 5). In doing so, pooling allowed for two or more mineral interests contained within a spacing unit to be combined for purposes of cooperative development. Pooling ensured that mineral owners received their equitable share in the production from a given well, typically determined by the pro rata percentage of land ownership within the spacing unit. Anticipating potential conflicts that might arise from mineral owners who would not consent to having their minerals developed, many states in the US also enacted compulsory pooling (also referred to as statutory pooling or forced pooling) statutes, which allow for non-consenting mineral owners to be forcibly entered into pooling arrangements (Daintith, 2010).

All of these rights-based access mechanisms—conservation legislation, spacing, pooling, and protection of correlative rights—serve to overcome problems of access in the race to drill under the 'finder's keepers' logic of the rule of capture. These regulatory controls changed rights-based access to oil and gas resources from a focus on ownership of mineral property under the rule of capture to that of cooperation and equity in the extraction of oil and gas

resources with conservation legislation. This shift was largely due to advancements in geologic knowledge and attention to the particular materiality of oil and gas reservoirs, including areas of drainage. The subsurface location of hydrocarbon resources makes it difficult to control access to these minerals and thus, spacing and pooling addressed these complexities. Spacing regulations attended to the materiality of oil and gas reservoirs by establishing minimum distances between wells for optimization of mineral recovery; pooling legislation served to resolve issues related to mineral property ownership created by spacing regulations.

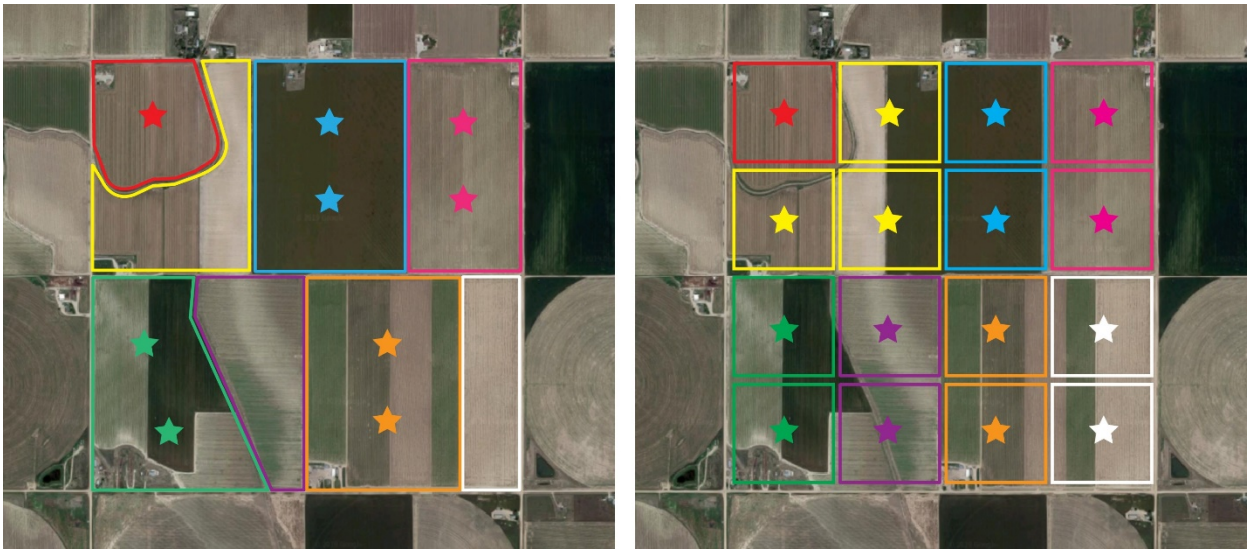

Figure 5. Spacing and pooling. Surface location of wells (stars) restricted by property boundaries on a 1 square mile (640-acre) tract of land, precluding drilling in small or irregularly-shaped tracts of ownership (left). This issue is resolved through spacing and pooling, which allows for the maximum number of wells to be drilled in this space by disregarding property boundaries (right). (Image source: Google Maps) (Figure credit: Julia Ciha)

However, new issues surrounding access to oil and gas resources have emerged from the application of these laws and regulations designed for vertical development to horizontal development of unconventional oil and gas reservoirs (Holliday, 2013; Kramer, 2010; Kramer, 2014; Pierce, 2011; Whitworth & McGinnis, 2011). The following section introduces Ribot and Peluso's (2003) theory of access as a starting point to construct an analytical framework

through which to understand the complexities of access to oil and gas resources that emerge from horizontal drilling.

Horizontal drilling and the complexity of access

Ribot and Peluso (2003) contend that attending to issues of property ownership alone is insufficient to understand the ways in which actors are able to access natural resources. In defining access as "the ability to benefit from things," Ribot and Peluso (2003, p. 153) consider various other mechanisms besides property ("the right to benefit") that combine to create "bundles and webs of powers that enable actors to gain, control, and maintain access" to derive benefits from resources (p. 154-5). The mechanisms through which actors are able to benefit include both *rights-based* means of access—whether through legal or illegal[3] means—and *structural and relational* means of access, including "technology, capital, markets, labor, knowledge, authority, identities, and social relations" (ibid., p. 162). Both rights-based and structural and relational mechanisms of access play important roles in fostering the ability to benefit from oil and gas resources. Ownership of mineral property and spacing and pooling regulations confer rights-based access, as discussed in the previous section. Structural and relational access mechanisms allowing the ability to benefit from oil and gas resources include access to capital, geologic and petroleum engineering knowledge, as well as access to hydrocarbon markets and skilled labor.

Although Ribot and Peluso (2003, p. 153) focus on "the ability to benefit from things" and note the importance of considering the characteristics of "things" in their analytical

[3] Ribot and Peluso (2003, p. 161) include access through illegal actions within rights-based mechanisms since "rights define the bounds of illegal activities."

framework, the authors neglect to elaborate on the ways in which "things" themselves may affect access (Myers & Hansen, 2019). Ginger et al. (2012) address this shortcoming in their identification of biophysical factors—specifically environmental conditions and spatial proximity—that influence actors' ability to benefit from natural resources. Along the same vein, the materiality of oil and gas reservoirs matters in shaping social relations of extraction (Bakker & Bridge, 2006), particularly with consideration of both the biophysical and geographic characteristics in which both humans and these resources are situated (Myers & Hansen, 2019). For example, pooling in oil and gas development attends to the fugacious properties of hydrocarbon resources, which readily migrate across subsurface boundaries of property ownership.

The materiality of oil and gas reservoirs—in particular, their specific geology and the fugacious nature of fluid hydrocarbons—is an important consideration in access to these resources. Due to their physical characteristics, oil and gas reservoirs function as common pool resources. That is, because oil and gas resources readily flow toward low-pressure subsurface areas created by wells, it is difficult to exclude others from accessing those same resources by drilling their own well (McCarthy, 2009). This is further complicated in the US by the widespread private ownership of mineral tracts within these reservoirs (Mommer, 2002; Pierce, 2011). Problems related to access of common pool resources emerge from situations in which two or more rights-based domains intersect with the domain of a resource (Giordano, 2003). This is precisely the type of scenario discussed above, and in which rights-based access mechanisms, including spacing and pooling regulations, were created to overcome the challenges of access presented by both the materiality of oil and gas and rights-based access

through property ownership. However, missing from these types of scenarios is consideration of the technology necessary to access, or benefit from, resources.

Technology plays an important role in mediating access to resources—in both controlling access, as well as enabling or expanding physical access of resources (Ribot & Peluso, 2003). Access to hydrocarbons through vertical drilling technology requires that a well be drilled from a surface location directly above the minerals targeted for extraction. Furthermore, spacing regulations largely dictated the surface location of the entry point to the subsurface. Thus, technology and regulations presented spatial limitations to accessing hydrocarbon resources through proximity and location, respectively. Spatial proximity is an important factor that influences physical access to resources; more specifically, distances between resources and resource users can render access difficult (Ginger et al., 2012). Horizontal drilling technology has changed the spatial aspects of physical access to resources.

Compared to vertical development, horizontal drilling has allowed for significantly greater recovery of oil and gas resources at a distance through the extension of horizontal wellbores ("laterals") for distances up to a few miles (Holliday, 2013). Horizontal drilling also allows for the recovery of hydrocarbon resources previously inaccessible due to issues such as existing surface development. Furthermore, the lateral reach of horizontal wells through geologic formations allows operators to condense their extractive activities by drilling multiple wells from a single well pad, in contrast to conventional vertical development in which numerous individual wells are drilled from dispersed locations (Kroepsch, 2018). Horizontal drilling, particularly when combined with hydraulic fracturing, has upended conceptions of oil wells as a "discrete, molecular point of access rather than a contiguous territorial claim"; as "a

vertiginous point in space, rather than a laminar, extensive presence" (Bridge, 2009, p. 46). That is, vertical wells provide a conduit to access hydrocarbon resources directly below the surface point of entry. In contrast, the drilling of multiple horizontal wells from a single surface location, and the subsurface space allocated to these wells for extraction, creates an expansive space of production. Thus, horizontal drilling technology warrants greater exploration of the relations among those accessing subsurface spaces.

A focus on the materiality of the subsurface and its resources, as well as the technology required to access these spaces, merits an examination of the politics or power relations through which access to and control of subsurface resources are 'secured' (Bridge, 2013). Conflicts over access to subsurface resources have taken varied forms and are part of the history of mineral extraction in the US (Huber & Emel, 2009). For example, the "law of the apex" allowed owners of lode claims to 'follow' veins of hard rock minerals from outcroppings at the surface to wherever they may branch, irrespective of vertical boundaries of those claims (Bridge, 2013). Three-dimensional seismography has transformed the way in which extractive industries envision the dimensionality and space of the underground (Bridge, 2013). But it is also worthwhile to consider the links between the surface and subsurface. Just as Adey (2010) describes links between the air and the terrestrial surface of the earth through the concept of "vertical reciprocity," oil and gas wells create links between the surface and subsurface (Bridge, 2009; Bridge, 2013). These connections between the surface and subsurface are not only theoretical; in the case of hydrocarbon extraction, these connections may be physical in nature and take the form of casing and tubing within the well or wellheads and other production equipment at the surface.

Rights-based access mechanisms of spacing and pooling were created to address the spatial peculiarities of accessing oil and gas resources through vertical drilling technology. What has yet to be explored is how an advancement in drilling technology—from vertical to horizontal development—and its spatial aspects has complicated rights-based mechanisms of access to oil and gas resources. Existing literature in the social sciences has attended to rights-based access to oil and gas resources through horizontal development in the context of property (e.g., Hesse et al., 2016; Hudgins, & Poole, 2014), including split estate arrangements (Ryder & Hall, 2017). However, few scholars in the social sciences have engaged with the rights-based access mechanisms of spacing or pooling, with the exceptions of Hanschel and Centner (2016) and Holahan and Arnold (2013). These studies provide a comparison of legal and regulatory institutions encouraging and constraining unconventional oil and gas development in the US and Germany, respectively (Hanschel & Centner, 2016), and examine the shortcomings of policies developed for conventional vertical development to address negative externalities associated with horizontal development (Holahan & Arnold, 2013).

Case study and research methods

In what follows, I present my empirical case of Colorado's Greater Wattenberg Area (GWA) to illustrate how horizontal drilling has changed the spatial dimensions of accessing subsurface hydrocarbon resources through variability and flexibility in wellbore design, as well as how these changes have invited a rethinking of existing procedures of conferring rights-based access to these resources.

The GWA is located primarily in Weld County in the Front Range region north of Denver; it stretches from the City and County of Broomfield in the southwest to the northeast past Greeley—the county seat of Weld County (Figure 6). The GWA falls within the semi-arid High Plains region of the American West located just east of the Rocky Mountains. The GWA encompasses the Wattenberg Field and is part of the larger Denver-Julesburg (DJ) Basin.

The Wattenberg Field, part of the Denver-Julesburg (DJ) Basin, underlies much of the Front Range region of Colorado and contains several oil- and gas-bearing formations, including the Greenhorn, J Sandstone, D Sandstone, Codell, and Niobrara (Sonnenberg, 2015). Oil and gas exploration in what became known as the Wattenberg Field occurred during the 1950s, but it was not until 1970 that the first successfully-producing (vertical) well was drilled and the field was "discovered." Development of the oil and gas resources in this region continued into subsequent decades (Ladd, 2001), with much of the drilling activity during the 1980s occurring in the Codell Sandstone and, to a lesser degree, the Niobrara formation (Sonnenberg, 2015). Operators experimented with horizontal drilling in northeastern Weld County as early as 1990 (Algeo, 1990), but it was not until late 2009 when the horizontal "Jake" well in northern Weld County sparked renewed interest in the Niobrara formation in the DJ Basin (Anderson et al., 2015). Noble Energy's successful "Gemini" horizontal well kicked off the horizontal drilling boom in the GWA in 2010 (Sterling et al., 2016). Recent horizontal development in the Wattenberg Field has focused primarily on the Niobrara, but also the Codell, formation (Sonnenberg, 2015).

Colorado adopted oil and gas conservation legislation through the Colorado Oil and Gas Conservation Act of 1951 ("the Act"). The Act established the state oil and gas regulatory

agency—the Colorado Oil and Gas Conservation Commission (COGCC)—and charged the agency with fostering the responsible development of oil and gas resources consistent with the

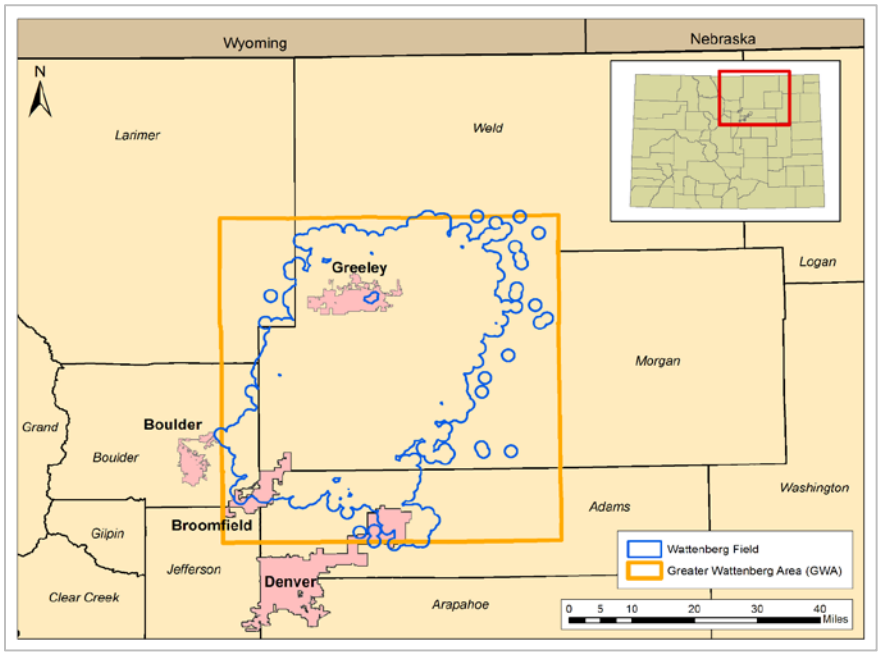

Figure 6. Wattenberg Field and GWA of northern Colorado (Map created by the author)

protection of public health, safety, welfare, protecting against waste of these resources. The Act also charged COGCC with protecting correlative rights and mitigating adverse environmental impacts. Colorado statutes grant COGCC "the power to establish drilling units of specified and approximately uniform size and shape covering any pool," as well as the authority to force-pool nonconsenting mineral owners (CRS § 34-60-116). The Act established the COGCC as the agency controlling access to oil and gas resources in the State of Colorado.

As in most states in the US, drilling and spacing units in Colorado are based on the Public Land Survey System (PLSS)[4] (Figure 7) (Sylvester & Malmsheimer, 2015). The PLSS is used to

[4] The Public Land Survey System (PLSS) is a land tenure system established through the Land Ordinance of 1785 passed by the US Congress to survey public lands of the US. The system established "townships" of 36 square miles that are divided into 1 square mile (640-acre) "sections," which are further divided into "quarter sections" of 160 acres and still further divided into "quarter-quarter sections" of 40 acres (US Department of the Interior, 2009).

define the boundaries of the GWA, in which specific well location and spacing unit regulations are established under COGCC Rule 318A. These well location and spacing rules established distinct spatial dimensions and arrangements of extraction and attend to the specific geology of the area—materiality matters for rights-based access mechanisms of spacing. Traditional drilling and spacing units in the GWA for vertical development of the Niobrara formation allowed for one well per 40-acre quarter-quarter section. Further regulatory changes allowed for 160-acre spacing units for vertical infill wells ("5-spot" wells) and directional wells (Figure 8). Wells may be drilled within designated drilling "windows" centered on the center of each quarter or quarter-quarter section.

As horizontal drilling appeared in the GWA, COGCC once again modified spacing regulations to accommodate this drilling technology. COGCC permitted "horizontal wellbore spacing units" to be established for individual horizontal wells, and these spacing units 'follow' the path of the wellbore (Figure 9). Multiple horizontal wells are commonly drilled from a single surface location (well pad) and, thus, horizontal wellbore spacing units may overlay one another, and typically do. Because of this practice, operators commonly seek to establish all wellbore spacing units for a multi-well pad simultaneously[5]. Under COGCC regulations, operators have the choice to establish horizontal wellbore spacing units for each well to be drilled from a multi-well pad or establish a traditional drilling and spacing unit in which they can

[5] Wellbore spacing units—whether for directional or horizontal wells—do not require formal applications, per se. Rather, regulations require operators to provide at least thirty-day notification to all mineral owners within the proposed unit of their intent to establish a spacing unit. In the absence of any objections from the notified mineral owners within that thirty-day period, COGCC administratively approves the wellbore spacing unit and confers required drilling permits concurrently.

drill several horizontal wells. The regulatory changes in spacing units to accommodate horizontal drillings marks an important shift in both the spatial dimensions and arrangements of extraction, as well as rights-based mechanisms of access to oil and gas resources.

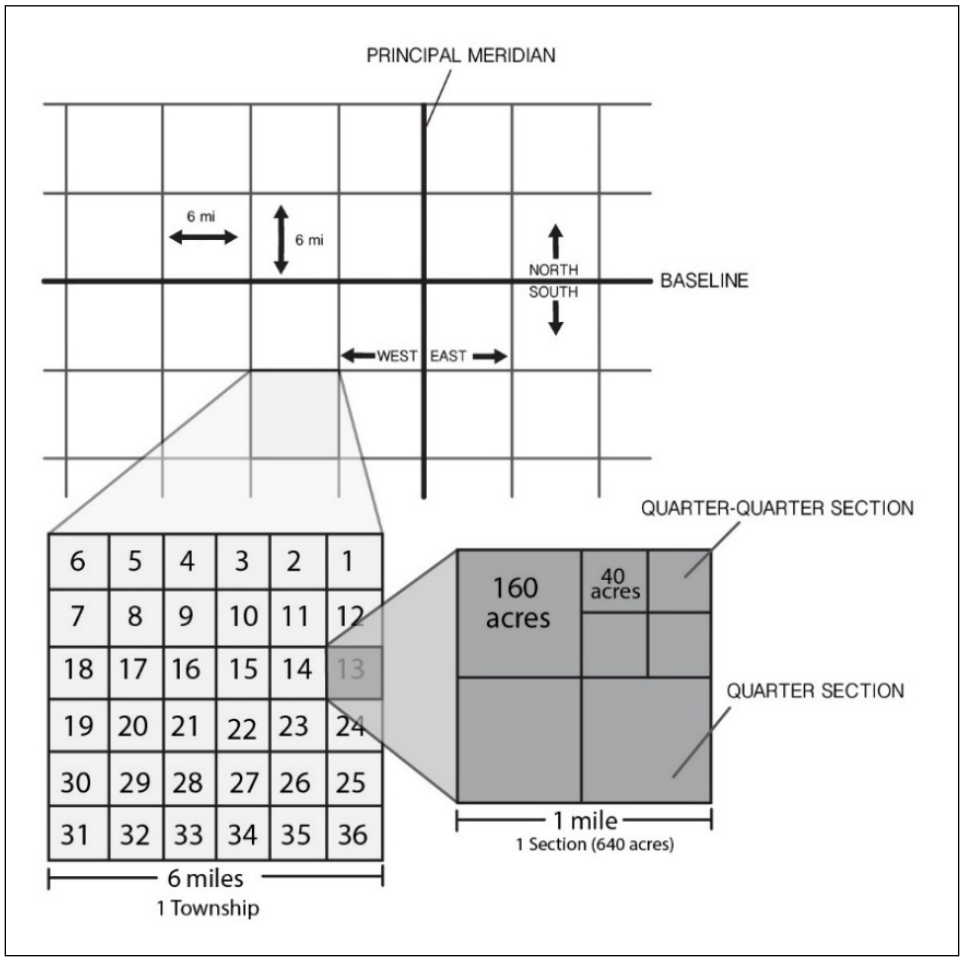

Figure 7. Public Land Survey System (PLSS) (Adapted from Reisterer, 2019)
(Image credit: Julia Ciha)

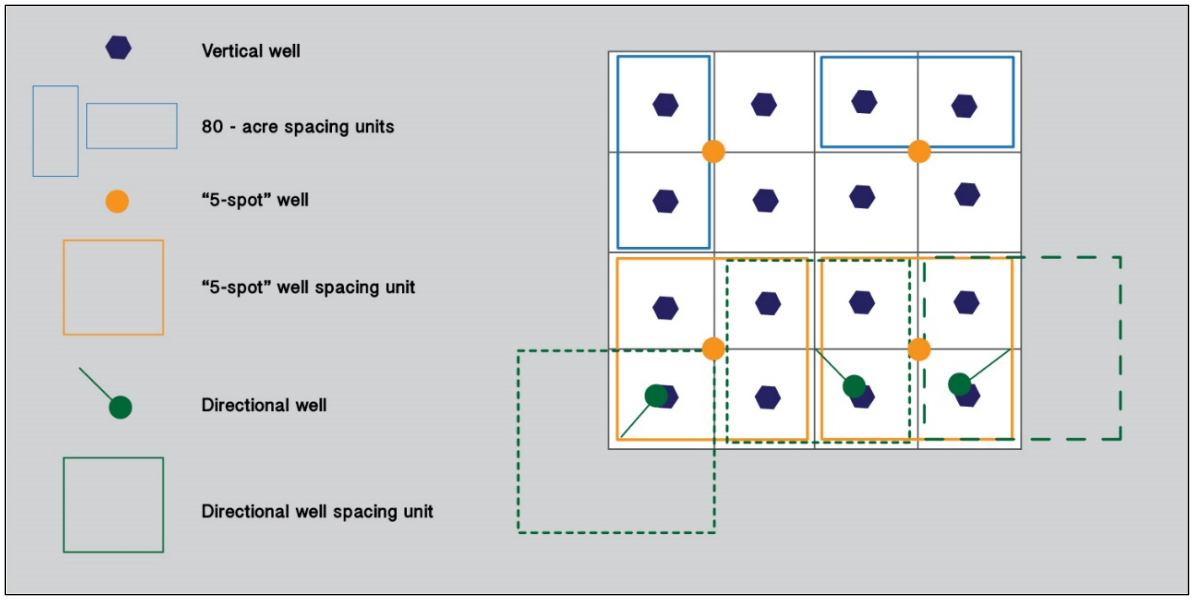

Figure 8. Traditional drilling and spacing units for vertical wells and wellbore spacing units for directional wells in one PLSS section (640 acres) of the Niobrara formation (Adapted from Lepore, 2017) (Figure credit: Julia Ciha)

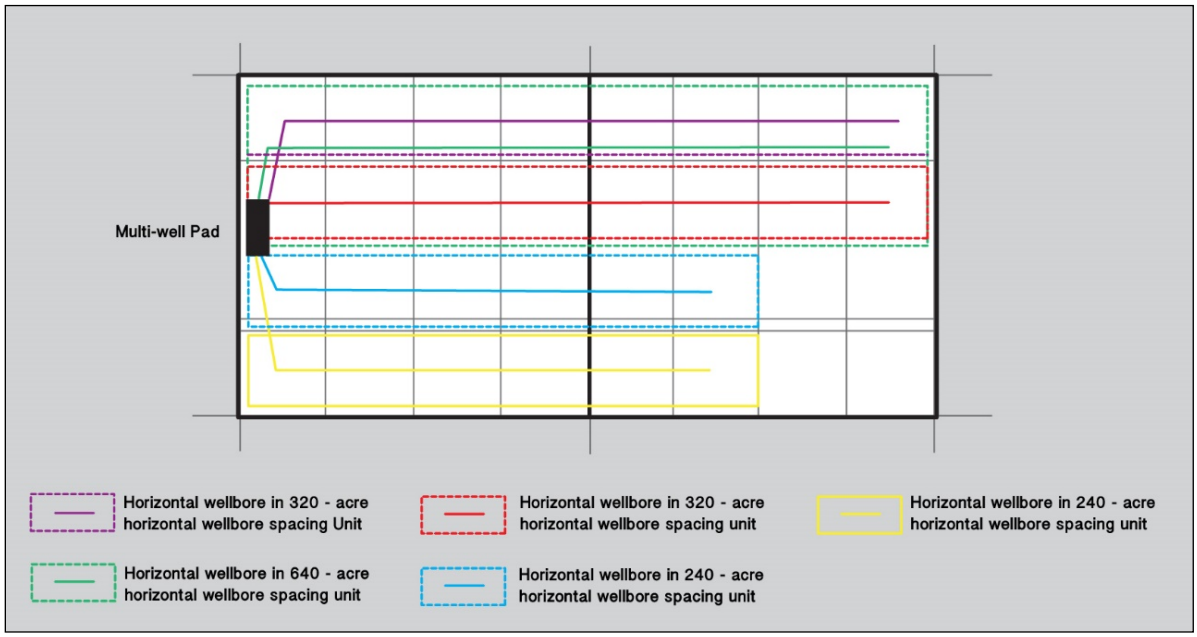

Figure 9. Horizontal wellbore spacing units in two PLSS sections of the Niobrara formation (Adapted from Lepore, 2017) (Image credit: Julia Ciha)

This analysis will discuss the establishment of spacing units—whether a traditional drilling and spacing unit or the aggregate of several horizontal wellbore spacing units for a multi-well pad—as a "spacing application." An operator can apply for COGCC approval to pool

mineral interests either concurrently with a spacing application or after the spacing application has been granted. Although some states require a minimum percentage of mineral ownership to pool, laws and regulations in Colorado, as well as several other states, do not require a minimum amount or percentage of mineral ownership to either establish a spacing unit or pool mineral interests within a spacing unit (IOGCC, 2015). Thus, a single mineral owner—typically an operator—can pool all other mineral owners within a spacing unit, which has contributed to controversies among operators seeking to develop minerals in the GWA.

The data for this analysis is primarily based on presentations by COGCC staff members (Lepore, 2017; Lepore et al., 2016) and ensuing discussions with agency Commissioners at COGCC hearings in Sterling, Colorado and Denver during October 2016 and January 2017, respectively. I conducted participant observation at the January 2017 hearing through attendance as a member of the audience. Presentation slides were obtained from the COGCC website following both hearings, and audio recordings of the hearings were available through COGCC's channel on YouTube for review and analysis. The staff presentations introduced the Commissioners to the disputes between operators over efforts to develop at least partially the same minerals. The subsequent discussions among COGCC staff and Commissioners centered around various proposed criteria to resolve these disputes. A review of applicable State of Colorado laws and regulations pertaining to oil and gas development provided background and context to the issues discussed at these COGCC hearings. An extensive semi-structured personal interview with an oil and gas company employee provided additional background information regarding matters of land acquisition. This analysis was further informed by tours of both an active drilling site and hydraulic fracturing site provided by an operator in the GWA.

Several limitations exist regarding the research methods used for this analysis. Specific information regarding mineral ownership and details of proposed projects among competing operators was limited in the presentations by COGCC staff. Rather, in their presentations, COGCC staff provided abstractions of the real-world examples they encountered. The inability to secure an interview with COGCC staff, particularly the Director, to provide further detail beyond that included in the presentations and discussions with COGCC Commissioners presented another limitation to the research methods for this chapter.

Problems with "first in time" as a rights-based mechanism of gaining access

COGCC has increasingly encountered situations in which operators compete for access to at least partially the same oil and gas resources through the rights-based mechanism of spacing applications (Lepore, 2017). In these situations, agency staff receive an application from an operator (Operator A) to establish spacing for a given number of horizontal wells. Following receipt of this first application, COGCC might receive a second application from a different operator (Operator B) requesting to establish spacing for at least some of the same land included in Operator A's application. Another possibility is that Operator B formally protests Operator A's application and submits a competing application. Protests can only be considered on very limited grounds: either that Operator A's application does not conform to rights-based access requirements stipulated in the Act and will result in waste or harm correlative rights, or that rights-based access through mineral ownership is violated by Operator A proposing to develop minerals it does not own. Typically, the protestant objects based on the grounds that it owns some of the minerals within the proposed unit and wishes to develop its minerals how it

sees fit. When both proposed spacing unit applications received meet statutory and regulatory requirements, COGCC has historically approved the first spacing application received. However, "first in time" approval is an informal rights-based policy; no statutory or regulatory requirement supports this criterion (Lepore, 2017).

Objections among operators regarding competing spacing applications may be based on several different spatial relationships, which are illustrated in the below schematics that are adapted from those presented by COGCC staff at the January 2017 COGCC hearing and based on actual situations of competing spacing applications received by the agency (Lepore, 2017). Objections may be based on a simple spatial relationship, such as overlapping spacing applications (Figure 10). Competing spacing applications may intersect, vary in areal extent, as well as have different wellbore orientations (Figure 11).

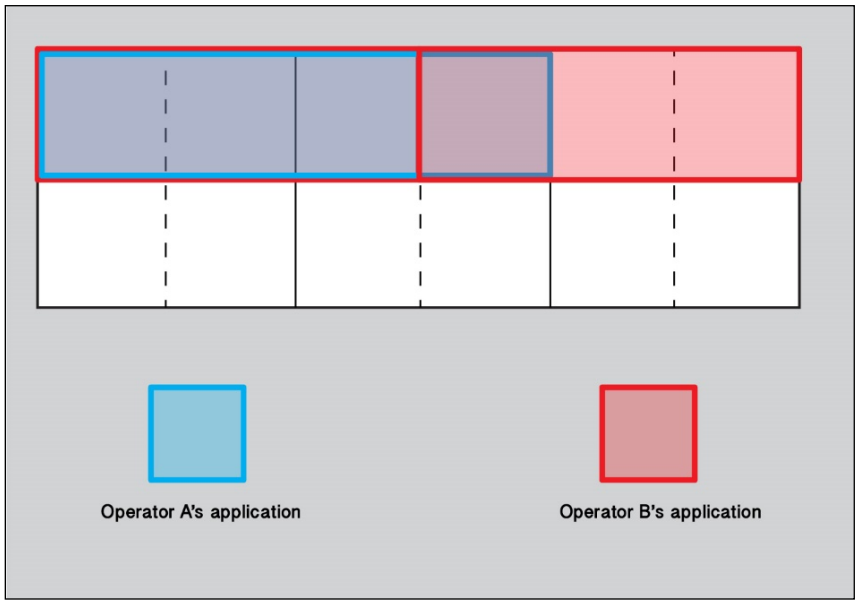

Figure 10. Intersecting spacing units occurring within three PLSS sections (Adapted from Lepore, 2017) (Image credit: Julia Ciha)

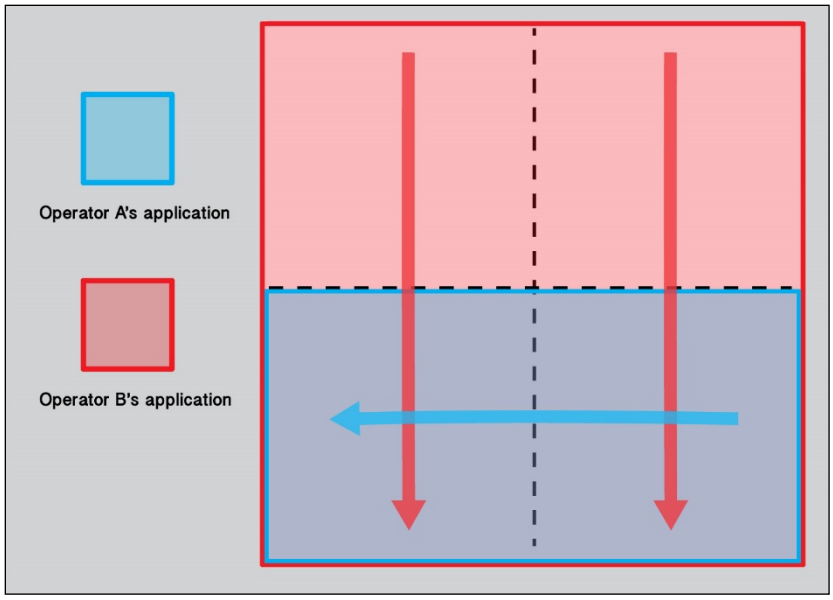

Figure 11. Disputes over wellbore orientation within one PLSS section (Adapted from Lepore, 2017) (Image credit: Julia Ciha)

However, there is often greater spatial complexity underlying competing spacing units. Operators may also invoke amount or percentage of mineral ownership as rationale for supporting their spacing application (Figure 12). Finally, operators may object on the grounds that the competing operator's spacing application will interfere with their plans to integrate surrounding tracts of mineral ownership into larger projects (Figure 13) (Lepore, 2017).

Operators vying to develop the same minerals may invoke various rationales both to object to the competing application and to assert that their proposed spacing application is superior (Lepore, 2017). These claims illustrate the spatial dimensions of horizontal development, as well as appeal to both rights-based access mechanisms—including property and legal requirements of the Act—and environmental conditions. One claim is that a particular orientation (north-south or east-west) of wellbores will better adhere to the requirements of

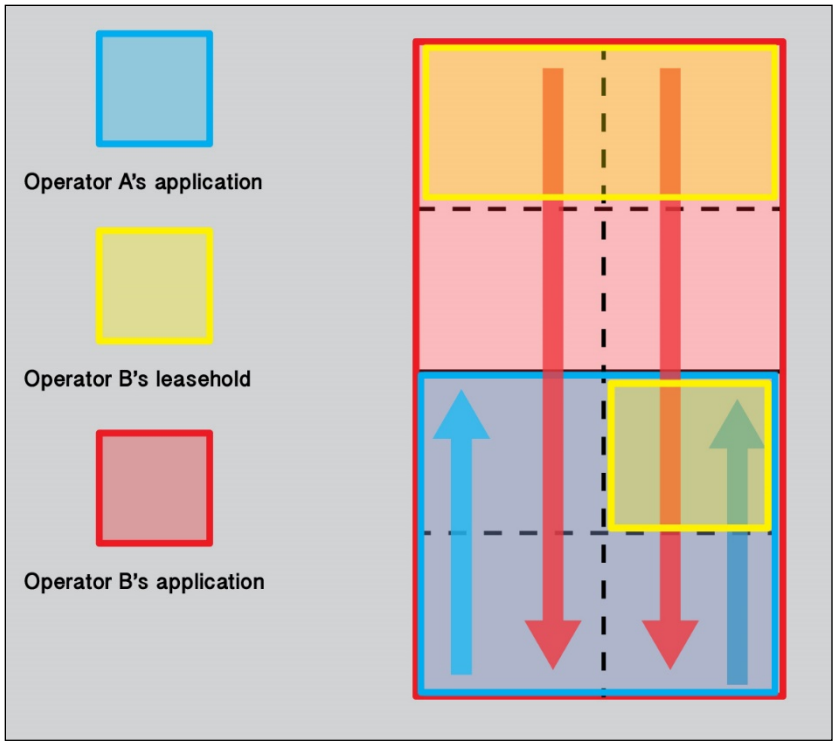

Figure 12. Percentage of mineral ownership.7 Operator A applied to develop one PLSS section (blue) in which it owned 75% of the minerals. Operator B applied to develop both PLSS sections (red) while only owning 37.5% of the minerals contained therein (yellow) (Adapted from Lepore, 2017) (Figure credit: Julia Ciha)

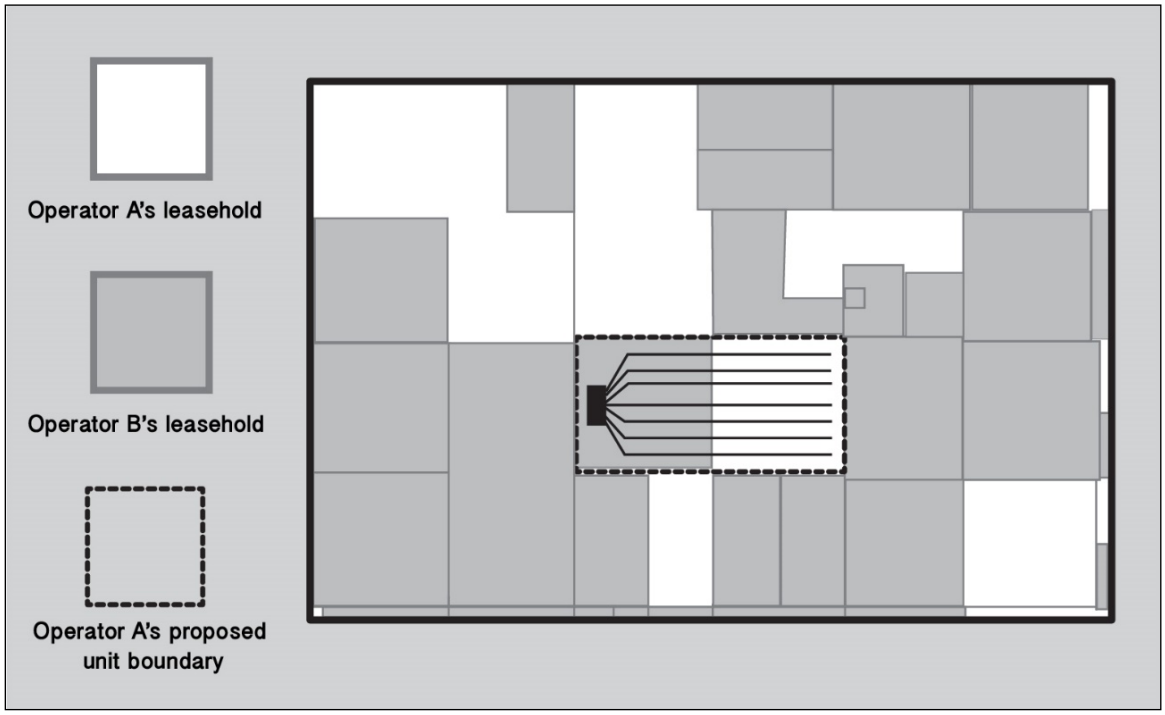

Figure 13. Leaseholds surrounding proposed spacing unit boundary for multi-well horizontal development of two PLSS sections (Adapted from Lepore, 2017) (Figure credit: Julia Ciha)

the Act by either allowing for greater recovery of hydrocarbons (and, thus, less waste), or will protest based on claims of negative impacts to the rights-based access mechanism of property ownership through dilution of mineral interests, in which the operator holding the lesser amount of mineral ownership "absconds" with the majority owner's minerals (Lepore, 2017). Protests may also be based on claims regarding wellbore length: for example, that longer laterals not only increase profitability, but also reduce the number of wells needed to develop a given tract of minerals, which in turn minimizes surface disturbance. However, the reduction in surface disturbance is not a statutory or regulatory requirement and, thus, does not have a rights-based foundation upon which to support approval of a spacing application. Yet, reduction in surface disturbance highlights spatial links between surface and subsurface activities through the concentration of oil and gas production equipment onto a single well pad (Kroepsch, 2018). Operators also base their claims on other factors related to the environmental conditions of development—particularly surface impacts—including plans to install pipelines to transport oil rather than trucking oil from above-ground storage tanks and "master development" plans with "integrated infrastructure network to reduce various impacts" (Lepore, 2017). Finally, operators invoke a temporal dimension of extraction in supporting their application: that it is ready to commence development immediately rather than a later point in time. Often, operators invoke more than one factor in supporting their proposed spacing units (Lepore, 2017; Lepore et al., 2016).

In light of the various objections and supporting rationale received from operators, COGCC staff increasingly view the "first in time" criterion as "not very satisfying" and feel that there are greater "nuances and complexities" regarding the proposed oil and gas development

projects that ought to be considered in choosing between competing spacing applications (Lepore, 2017). The COGCC Director characterized the "first in time" policy in Colorado as a "race to the permit" state regarding oil and gas development, which results in land grabs (Lepore, 2017). This is not to imply that conflicts among operators regarding rights of access in the GWA are necessarily rampant; operators do engage in collaborative planning with one another (Kroepsch, 2018), including the practice of "blocking up," or voluntarily swapping mineral acreage to increase contiguous leaseholds (industry representative). The COGCC Director felt that operators ought to spend "more time planning and less time just trying to grab up and develop what they can or what they maybe already have" (Lepore, 2017). Operators frequently discuss the value of "secure operatorship," meaning the ability to develop their own leaseholds as they see fit, rather than having their leaseholds pooled into another operator's project (Lepore, 2017). To address the disputes over access presented by competing spacing applications under the rights-based mechanism of "first in time," COGCC staff sought direction from the Commissioners regarding potential solutions or alternative criteria, or a combination thereof, that might be used in lieu of "first in time" to evaluate and choose between competing spacing applications.

Horizontal drilling technology has reconfigured the spatial aspects of rights-based access to hydrocarbon resources. Although spacing rules as rights-based access mechanisms were adapted to accommodate the subsurface spatial dimensions of horizontal development, they have led to increasing competition among capital interests in accessing oil and gas resources in the GWA. "First in time" approval of spacing applications—an informal rights-based mechanism of access—has deepened these controversies. Claims made by operators in their protests of

competing spacing applications evidence other spatial dimensions of horizontal development besides the flexibility and variability in wellbore design. These include vertical dimensions of extraction—namely, impacts at the surface that result from subsurface extractive activities—in addition to horizontal dimensions related to mineral ownership within proposed units. Since the use of "first in time" is problematic, the question arises of what other criteria might be appropriate for choosing between competing spacing applications.

Consideration of alternative factors to "first-in-time" in granting access

To address the increase in disputes between operators that have emerged through the spatial complexities of horizontal development using the "first-in-time" protocol, agency staff sought guidance from the Commissioners at the January 2017 COGCC hearing regarding additional or alternative factors that might be considered in preventing such disputes or choosing between competing spacing applications. The factors considered included regulatory modifications, surface impacts, mineral ownership, availability of capital, and temporality of extraction. The efforts at the hearing to adopt alternative decision-making criteria aimed to establish a fairer and more equitable rights-based process of granting or enabling access to oil and gas resources. Of the several alternative factors considered, many impacted one another—primarily generating potential constraints or restrictions to access—and the complexities of these interrelationships are noted as they arise (Table 1).

Regulatory modifications

One proposal to alleviate disputes between operators consisted of changes to rights-based access through modification of spacing regulations themselves. The COGCC Director wondered if wellbore spacing units, as well as their expedited approval process, have "outlived their utility" and suggested one solution was to perhaps eliminate this spacing unit type (Lepore, 2017). Instead, COGCC could consider requiring traditional drilling and spacing units in which operators could drill as many horizontal wells as they deem necessary to develop the mineral resources. The Director noted, however, that operators have expressed the value they place on the expediency and efficiency of creating wellbore spacing units for horizontal wells (Lepore, 2017). Furthermore, a COGCC staff member noted that reverting to traditional drilling and spacing units for horizontal wells would not necessarily resolve the spatial complexities of competing spacing applications (as illustrated in Figures 9 – 12) (Colorado Oil and Gas Conservation Commission [COGCC], 2017).

Another proposed regulatory change was to approve both competing spacing applications. However, concerns emerged that doing so would violate requirements of rights-based access stipulated in the Act through the drilling of unnecessary wells and harm to correlative rights—as well as further promote land grabs while increasing surface impacts by discouraging comprehensive planning (COGCC, 2017). Thus, a commissioner suggested that imposing an expiration date on spacing units would be appropriate to avoid situations where an operator 'holds' the land, thereby delaying development of the minerals.

A further regulatory modification suggested was to establish a default or minimum spacing unit size. Colorado statutes grant COGCC "the power to establish drilling units of

specified and approximately uniform size and shape covering any pool" (CRS § 34-60-116); however, the Director stated that there is considerable legal uncertainty as to how to interpret "approximately" (Lepore, 2017). The Director felt that standardizing spacing unit size would introduce predictability into the approval process. This would encourage operators to reduce surface impacts by engaging in more comprehensive planning of projects while, at the same time, discouraging the land grabs associated with "first in time." However, the Director noted that larger spacing units are not inherently 'better' than smaller spacing units. Rather, there are other details of a development plan that might be important considerations in choosing between competing applications, such as reducing surface impacts by using pipelines to transport product rather than above-ground storage tanks and trucking (Lepore, 2017).

Surface impacts

COGCC Commissioners and staff also deliberated whether the surface impacts of subsurface extractive activities ought to be considered in choosing between competing spacing applications (COGCC, 2017). This consideration illustrates the connections between the surface and subsurface. Comprehensive plans serve to build and integrate surface infrastructure necessary for development, such as access roads, production facilities, and pipelines. Such integrated infrastructure would help minimize surface impacts, including protecting public health, safety, and welfare and the environment. However, giving preference to extractive projects that included comprehensive plans could also disadvantage smaller operators who may not have sufficient capital to build integrated infrastructure or own sufficient mineral acreage to make doing so cost-effective. Additionally, COGCC staff proposed that operator

engagement with local government might be a factor to consider as part of a comprehensive planning to ensure adherence to local ordinances and regulations, as well as minimize impacts to the community (COGCC, 2017).

Another factor considered at the hearing to reduce surface impacts, and related to spacing unit size, was the number and length of proposed horizontal wells in competing spacing applications (Lepore, 2017). Longer laterals not only create efficiencies in extraction, but also result in a fewer number of wells required to 'drain' a given area. This, in turn, can reduce surface impacts through a fewer number of production facility locations at the surface. However, although a reduction in surface impacts is desirable, no regulatory foundation exists upon which to require such. However, giving preference to projects that reduce surface impacts through the drilling of longer laterals could, arguably, better adhere to the Act's mandate that COGCC protect public health, safety, welfare and the environment (Lepore, 2017).

Mineral ownership

Another topic of deliberation at the hearing was property as a rights-based access mechanism. Specifically, COGCC staff suggested that percentage of mineral ownership in operators' respective proposed spacing units might be a factor to consider in evaluating their applications—that the operator with a greater percentage of mineral ownership contained within their spacing application ought to receive preference (COGCC, 2017). Commissioners felt that, beyond simply a percentage, having specific information regarding mineral interests, such as the amount and distribution of mineral ownership within a proposed spacing unit, would also be desirable. The Director noted that obtaining such information can present challenges,

since mineral ownership is not readily available to COGCC—operators must provide this information on a voluntary basis, and competing proposed spacing units often are not always seeking to space the same exact land (COGCC, 2017).

Availability of capital

COGCC staff and Commissioners explored a structural and relational access mechanism identified by Ribot and Peluso (2003): access to capital (COGCC, 2017). Access to capital is generally related to the size of an operator, with larger operators tending to have a greater amount of capital available for oil and gas projects. Operator size and availability of capital hold significance in several respects and are related to the factors discussed above. Due to limited available capital, smaller operators in the GWA tend to hold fewer and/or smaller tracts of mineral ownership. Thus, a smaller operator with less mineral ownership could be disadvantaged in relation to larger operators who may have the necessary capital available to develop a larger unit or own a greater amount of mineral acreage in a given area. If surface impacts and comprehensive planning were adopted as a deciding factor between competing spacing applications, smaller operators could be disadvantaged in that they tend to have less capital available to design larger development projects and construct integrated production infrastructure. Thus, the Director argued that percentage of mineral ownership might be a more appropriate factor to consider rather than operator size, so as not to disadvantage smaller operators who wish to develop their leaseholds (COGCC, 2017).

Temporality of extraction

A final alternative factor deliberated at the hearing was the temporality of extraction. Rather than approving the first spacing application received, COGCC could consider the timing of actual drilling and development, giving preference to operators who will commence drilling sooner rather than later (COGCC, 2017). However, this could potentially disadvantage smaller operators who need time to raise the necessary capital to begin development, potentially allowing an operator with the necessary capital available to "abscond" with their minerals. Although COGCC staff maintains a preference for development to commence sooner rather than later, determining precisely when an operator will begin development following approval of drilling permits can be difficult to ascertain since several issues can influence timing, such as market factors (COGCC, 2017).

COGCC staff and Commissioners sought to address disputes that have arisen between operators regarding access to oil and gas resources through competing spacing applications. In doing so, several additional or alternative factors geared toward fairness and equity in access were considered in lieu of the long-standing and informal "first in time" decision-making policy. These factors included regulatory modifications, surface impacts, mineral ownership, availability of capital, and temporality of extraction. Several complexities regarding rights-based access through horizontal development of hydrocarbon resources emerged through the deliberations surrounding these potential alternative factors. The following section provides an analysis of these complexities that have emerged from horizontal drilling as a technological mechanism of access and how the spatial dimensions of horizontal drilling technology have complicated rights-based access to oil and gas resources.

Table 1. Proposed alternative factors for approval of spacing applications

Factor	Advantage(s)	Disadvantage(s)	Factor(s) impacted
Regulatory modifications			
Abolish wellbore spacing units	Eliminates expedited approval process	Does not resolve issue of competing spacing applications	N/A
Approve both units	Expeditiously resolves disputes	Unnecessary wells; violation of correlative rights; discourages planning	Surface impacts
Default/minimum unit size	Introduces predictability; discourages land grabs; encourages planning	Constrains project size	Surface impacts; availability of capital
Number/length of laterals	Longer laterals result in less surface impacts	Increased expense of longer laterals	Availability of capital
Surface impacts			
Comprehensive/master planning	Reduction in surface impacts; encourages engagement with local governments	Time expenditures; constraints for smaller operators	Availability of capital; temporality of extraction; mineral ownership
Number/length of laterals	Longer laterals result in less surface impacts	Increased expense of longer laterals	Availability of capital
Mineral ownership			
Percentage of mineral ownership	Preference for greater mineral ownership within proposed unit	Percentage varies according to acreage owned and proposed unit size	Availability of capital
Availability of capital			
Size of operator	Operator possesses sufficient capital to commence development and implement intended aspects of project	Smaller operators tend to possess less capital and less mineral ownership	Mineral ownership; temporality of extraction
Temporality of extraction			
Timing	Preference given to operators commencing development sooner	Smaller operators may need time to raise necessary capital	Availability of capital

Discussion

Spacing and pooling both served to address the material realities of vertical oil and gas development. The physical characteristics of oil and gas reservoirs render them a common pool resource, which is complicated by spatially delineated private ownership of mineral property within hydrocarbon reservoirs. Spacing regulations attended to the materiality of oil and gas reservoirs by establishing distances between wells to ensure orderly and efficient development of these resources. Pooling legislation attended to issues of private ownership of minerals by ensuring equitable distribution of production from wells.

However, the shift from vertical to horizontal development has complicated rights-based access through spacing and pooling. Advancements in drilling technology—from vertical to horizontal development—have changed the spatial aspects of oil and gas extraction in several ways. Vertical drilling required a well to be located directly above the surface point of entry to an oil and gas reservoir. Horizontal drilling allows for wells and production equipment to be concentrated onto a single surface location and allows for flexibility in surface location of wells to access the same minerals (Kroepsch, 2018). Horizontal drilling has further facilitated greater access to oil and gas resources through the ability to 'reach' minerals previously inaccessible due to existing surface development (Kroepsch, 2018), as well as overcome geologic constraints and allow for increased recovery of hydrocarbons when combined with hydraulic fracturing technology (Holliday, 2013). However, these material characteristics of horizontal development are only one part of the larger picture; the changed dimensions of horizontal development have, in turn, necessitated modifications to regulations as rights-based access mechanisms to accommodate the new spatial dimensions.

In the GWA, traditional drilling and spacing units for vertical development are characterized by uniformity and predictability in their spatial arrangements (Figure 5). Spacing units for vertical wells have consistency and uniformity in the location of wells and the space allocated to them (i.e., one well per 40-acre quarter-quarter section). Wellbore spacing units for directional drilling maintained consistency in the space allocated (i.e., 160 acres), but introduced a degree of flexibility in location due to the fact that these units could be superimposed over existing spacing units. Horizontal wellbore spacing units are characterized by flexibility and variability, in that the spacing unit "follows" the wellbore and well design is largely the product of decision-making processes by operators (Figure 6). The length and direction of horizontal wells determine the size or areal extent, shape, and orientation of horizontal wellbore spacing units. The same characteristics of flexibility and variability hold true for traditional drilling and spacing units in which horizontal wells are drilled. Thus, advancements in extractive technologies—from vertical to horizontal drilling—have not only compelled changes in spacing regulations as rights-based means of access, but also have implications for another type of rights-based access: that of property.

Compared to vertical development, the increased areal extent of spacing units for horizontal wells, along with their variability, leads to an increased propensity that spacing units will contain numerous more tracts of different mineral ownership. COGCC recognized this aspect at the time that horizontal wellbore spacing units were created through rulemaking, and noted that this issue, combined with the expedited administrative approval process for these units, would necessitate a high degree of cooperation among operators (COGCC, 2014). Indeed, operators in the GWA have cooperated and engaged in collaborative planning with one another

(Kroepsch, 2018). However, as discussed in the preceding section, cooperation and collaboration does not always occur, and operators have increasingly come into conflict with one another through competing spacing applications for rights of access to develop at least partially the same minerals.

Issues of property ownership are at the core of the disputes between operators over rights of access to oil and gas resources. These issues include the development of noncontiguous mineral property, percentage of mineral ownership within a proposed spacing unit, dilution of mineral interests, and integration of contiguous mineral leaseholds. The examples of competing spacing applications demonstrate that horizontal drilling—as a technological mechanism of access—have necessitated a rethinking of spacing regulations as rights-based access mechanisms. For COGCC, the challenge became how to determine which competing application is 'better'—both more fair and equitable, as well as most efficient—and should thus be approved. The potential alternative deciding factors deliberated by COGCC regarding rights-based access reveal how horizontal drilling as a technological access mechanism has reconfigured spaces of extraction in terms of both spacing unit/intra-unit and vertical/three-dimensional complexities.

Spacing unit and intra-unit complexities of access

The COGCC considered multiple alternative factors to choose between competing spacing applications. These deliberations highlighted the complex spatial relationships between mineral leaseholds and the spacing units containing them. The relevant factors considered were percentage of ownership, size and distribution of tracts of ownership within the proposed unit,

number and length of laterals, and a default or minimum unit size (COGCC, 2017). The spatial 'problem' being considered is how to most equitably establish rights-based access through spacing units given a mosaic-like arrangement of tracts of mineral property with varying ownership. The flexibility and variability of spacing units for horizontal wells, as discussed above, allows for numerous different spatial configurations of spacing units and are, thus, 'modifiable.' The spatial 'problems' that emerge are akin to those inherent in spatial analysis: namely, the modifiable areal unit problem (MAUP) and the boundary problem.

The MAUP emerges from the fact that the way in which boundaries are drawn to demarcate space directly affects analysis of phenomena occurring within those spatial units (Wong, 2009). Two particular issues comprise the MAUP—the scale effect and the zonation effect. The scale effect in the MAUP arises from variations in the scale used, producing different results based on the number of areal units used in the analysis. The zonation effect in the MAUP pertains to "the manner in which a larger number of smaller areal units are grouped into a smaller number of larger areal units" and produces different results based on "alternative combinations of areal units at similar scales" (Dark & Bram, 2007, p. 472). Because of the modifiability of spacing units to accommodate horizontal wells, consideration of percentage of ownership or size and distribution of tracts of ownership within a proposed spacing unit (e.g., Figure 9) becomes problematic. Different spatial patterns of tracts of mineral ownership, as well as different percentages of ownership, result depending on how the unit boundaries are proposed.

Another challenge in spatial analysis is the boundary problem, in which variations in the placement of boundaries of areal units of analysis can conceal spatial patterns of the

phenomenon being investigated (Burt et al., 2009). Figure 10 illustrates such a boundary problem in that focusing solely on the proposed spacing unit and mineral ownership therein obscures the 'bigger picture'—that the protestant owns the majority of the surrounding mineral property and perhaps ought to receive preference in rights of access.

Vertical and three-dimensional complexities of access

Attending to the spatial dimensions of subsurface resource extraction encourages consideration of the theoretical and material connections between the surface and subsurface, including both the vertical and three-dimensional aspects of development (Bridge, 2009; Bridge, 2013). Thus, an analysis of access to subterranean hydrocarbon resources ought to consider not just the horizontal dimensions within particular geologic strata, but also how the impacts of subsurface resource extraction manifest themselves at the surface.

Besides the spatial arrangements and configurations of spacing units and mineral property in the subsurface space of the GWA, horizontal drilling has created other spatial complexities in rights-based access to oil and gas resources: namely, those with vertical and three-dimensional aspects. These spatial aspects include factors of proximity and environmental conditions identified by Ginger et al. (2012) that influence access, but are not simply limited to issues at the surface. They include connections between the surface and subsurface, and COGCC considered these links in their deliberations regarding alternative factors of rights-based access.

Horizontal drilling has overcome the need for spatially-proximate surface locations of wells to reach target resources. Thus, proximity is no longer a limiting factor to access with

horizontal drilling technology. Moreover, vertical development of hydrocarbon resources requires the surface location of the well to be positioned directly above the target entry point of the reservoir. Horizontal drilling technology has overcome this spatial limitation by allowing for the development of minerals from a surface location several miles away (Kroepsch, 2018). Furthermore, access to hydrocarbon resources is no longer limited by existing surface development that would preclude the location of wells, and wells and production equipment can be condensed onto a single surface location (Kroepsch, 2018). This clustering at the surface can provide a greater benefit for those residing in areas undergoing extraction, but at the expense of the few who live nearest to those production facilities (Kroepsch, 2016). COGCC considered such environmental conditions of oil and gas development in their deliberations regarding alternative factors to "first in time."

Discussions at the COGCC hearing regarding the environmental conditions of horizontal drilling centered on comprehensive planning and the surface impacts of development. Concentrating production equipment and integrating infrastructure necessary for the development and transport of hydrocarbons, including access roads and pipelines, can reduce surface impacts. COGCC Rule 216 allows operators to voluntarily enter into Comprehensive Drilling Plans (CDPs), which are "intended to identify foreseeable oil and gas activities in a defined geographic area, facilitate discussions about potential impacts, and identify measure to minimize adverse impacts to public health, safety, welfare, and the environment, including wildlife resources, from such activities" (COGCC, 2018). Thus, comprehensive or master planning can work to minimize potential impacts on public health, safety, welfare, and the environment. However, minimization of environmental impacts at the surface is complicated by

the financial expense of doing so, which can be a prohibitive factor in establishing this as part of a rights-based access mechanism. This expense, as well as other capital expenditures can limit an operator's ability to benefit from development of their minerals.

Availability of capital

Ribot and Peluso (2003) identify access to capital as a structural and relational mechanism of access to resources, including the availability of finances and equipment necessary to access and derive benefits from resources. In the case of competing spacing applications in the GWA, access to capital played a significant role in the reconsideration of alternative factors in that the availability of capital to operators would present a significant enabling or constraining influence on their ability to fulfill certain proposed mechanisms of rights-based access.

Smaller operators tend to have both less capital and less mineral acreage than larger operators, which can potentially disadvantage them in several respects. Longer laterals are costlier to drill, so giving preference to spacing applications with longer proposed laterals may disadvantage smaller operators that may not possess the necessary capital to drill longer laterals. In a similar vein, establishing a default or minimum unit size that is too large may preclude smaller operators from meeting those minimums. Yet, at the same time, it could constrain operators who wish to drill laterals to lengths exceeding a default unit size. Considering percentage of mineral ownership could benefit smaller operators who have smaller tracts of mineral ownership and seek to establish spacing to develop primarily (or exclusively) their leaseholds. However, having a small leasehold, such as the applicant in Figure 9 (160-acre

quarter section), creates a situation where it may not be economical to develop a small leasehold without spacing and pooling adjacent leaseholds, potentially leading to disputes with another operator over competing spacing applications. Additionally, smaller operators may not have either the necessary capital to engage in comprehensive planning and building pipelines, or sufficient mineral acreage in a given to area to warrant such an investment.

Conclusion

The combined use of horizontal drilling and hydraulic fracturing technologies has had several distinct impacts on the extraction of energy resources, not least the opening of unconventional oil and gas reservoirs as new "resources frontiers" (Bridge, 2014). Hydraulic fracturing has received a disproportionate amount of attention in scholarly literature on unconventional oil and gas development. This study responds to calls by other scholars (Kroepsch, 2018) to attend to the ways in which horizontal drilling has changed the geographies of hydrocarbon development. To do so, I examined a key implication of horizontal drilling technology—that of changes in the ways in which producers gain access to oil and gas resources.

This study is the first to apply Ribot and Peluso's (2003) theory of access to oil and gas development. In doing so, I have extended their access analysis framework to examining not just how horizontal drilling as a technological mechanism of access increases the physical ability to access hydrocarbon resources, but also how advancements in technology—from vertical to horizontal drilling—and the changed spatial dimensions of extraction resulting from this transition have complicated rights-based access through spacing and pooling to oil and gas

resources among competing capital interests. However, technology as an access mechanism is only one part of the equation—the materiality of resources also matters (Bakker & Bridge, 2006).

I build on Ginger et al. (2012) in attending to biophysical factors of oil and gas resources—particularly their fugacious nature—and how this characteristic influences rights-based access. Rights-based mechanisms of spacing and pooling attend to both the physical characteristics of oil and gas resources, as well as ownership of these resources as property. However, spacing and pooling were established for a specific technological mechanism of access—vertical drilling. Horizontal drilling has complicated these mechanisms through the flexibility and variability of wellbore design, and changes to spacing regulations to accommodate it. Horizontal drilling has affected the ability to benefit from hydrocarbon resources by enabling or constraining access, and this technological advancement has influenced and impacted rights-based access to resources.

At the time of this writing, Colorado recently passed legislation amending the Act, redefining COGCC's charge from 'fostering' the development of oil and gas resources "in a manner consistent with protection of public health, safety, and welfare" to 'regulating' oil and gas development in a manner to 'protect' those values (SB19-181, 2019). This prioritization of protecting public health, safety, welfare, and the environment may have significant bearing on how COGCC chooses between competing spacing applications; for example, greater consideration may given to surface impacts of proposed projects.

The complexities of rights-based mechanisms of access to hydrocarbon resources—property and regulations—as well as the influence of these mechanisms on surface impacts of

oil and gas development ought to be given more attention in scholarly literature. Future research might investigate operator perspectives and attitudes toward the disputes over access, as well as potential regulatory changes. Although this study considers only one limited case, it nonetheless reveals ways in which horizontal drilling may affect competing claims to hydrocarbon resources in a variety of contexts.

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- Chapter 3 –

Hydrocarbon extraction in residential neighborhoods: Drilling technologies and municipal challenges in accommodating hydrocarbon development in Colorado

In 1985, the City of Greeley, Colorado adopted one of the state's first municipal bans on oil and gas development. This ban was enacted in response to increased concerns about *vertical* drilling for hydrocarbon resources in and around the city's residential neighborhoods. These issues included not only the impacts of extractive activities on residents, but also planning challenges as the city's growth increasingly intersected with hydrocarbon development. The Colorado Supreme Court struck down the city's ban in the landmark 1992 *Voss v. Lundvall* case, ruling that, although local governments could regulate certain local impacts of oil and gas development, outright bans were unconstitutional. Aware of this legal precedent, officials in the neighboring town of Windsor pursued an alternative strategy to control the impacts of oil and gas development—that of forced annexation—when residents mobilized to resist a 28-well *horizontal* development project proposed by Great Western Oil & Gas Company on a tract of land nestled amongst their neighborhoods. Although surrounded entirely by the Town of Windsor, the tract was an enclave of unincorporated Larimer County, and thus not subject to the town's local oil and gas permitting process. Annexation of the property began a process through which the surface location of the project was ultimately relocated away from the neighborhoods while still accessing the targeted minerals—an outcome achievable with horizontal drilling technology.

As indicated by the case of Greeley in the 1980s, oil and gas development in residential neighborhoods of Colorado is not altogether new. What has changed since that time, however, are the spatial implications of utilizing different drilling techniques for oil and gas development

in residential neighborhoods. Vertical development involves drilling a *single* well straight down from a well pad at the surface to access subsurface hydrocarbon resources. Horizontal drilling allows the wellbore to deviate from the vertical position and enter the target geologic formation laterally for distances up to a few miles, commonly with *multiple* wells drilled from a single well pad. The concentration of several wells onto a single site with horizontal drilling, in contrast to individual vertical wells spread over an area to develop the same minerals, benefits the many residents who live in that area at the expense of the few that live near such intense sites (Kroepsch, 2016). Compared to vertical wells, horizontal drilling provides operators[6] with a greater ability to access a given area of minerals from different surface locations (Kroepsch, 2018). Furthermore, horizontal drilling has allowed for the extraction of hydrocarbon resources previously inaccessible due to existing surface development—a significant limitation of vertical technology. These changes in the spatial aspects of oil and gas development brought about through horizontal drilling technology have played a significant role in bolstering drilling in residential neighborhoods (Kroepsch, 2018). The former Director of the Colorado Oil and Gas Conservation Commission (COGCC)—the state's oil and gas regulatory agency—attributed recent controversies over oil and gas activity in residential areas of Colorado to the changed dimensions of horizontal development compared to traditional vertical development—a matter of "scale, proximity, intensity" (Jaffe, 2015).

Oil and gas development in residential neighborhoods presents challenges not only for residents of these communities, but also for municipal officials. Numerous controversies have

[6] In the oil and gas industry, an operator is a company that designs, manages, and oversees an oil and gas development project, including exploration and production activities, as well as securing a drilling contractor and service companies.

emerged from the unexpected appearance of unwanted extractive activities in (sub)urban Colorado neighborhoods—an industrial activity that many residents anticipated local regulations would prohibit (Haggerty et al., 2018). Two intersecting booms largely fuel these tensions: an oil and gas boom driven by horizontal drilling technology and a population and housing boom. As such, hydrocarbon extraction and residential development increasingly encroach on one another, with new homes constructed near existing wells, as well as the siting of new horizontal development facilities in existing residential areas (Haggerty et al., 2018; Paterson, 2017). Furthermore, the death of two individuals in a home explosion linked to a nearby vertical gas well heightened already existing concerns among residents living near oil and gas development (Finley, 2017a).

Scholarship on oil and gas development has increasingly examined concerns associated with hydrocarbon extraction in residential neighborhoods; however, these investigations have largely been confined to issues of state preemption of local authority (e.g., Davis, 2014; Goho, 2012), the development of municipal drilling ordinances and policies (e.g., Fry, 2013; Fry & Brannstrom, 2017; Ryder, 2017), and municipal agreements with oil and gas companies (e.g., Zilliox & Smith, 2017). Less is known about the political and spatial issues that hydrocarbon extractive activities present for municipal governments, including matters of city planning and urban growth (Fry et al., 2017). Setback distances between hydrocarbon wells and buildings, arguably, are among the most crucial policies to consider when examining the impacts of drilling in residential areas. Although scholars have examined issues surrounding the development of municipal setback policies (e.g., Fry, 2013), research on the implications of setbacks on surrounding land uses is scant (for an exception, see Fry et al., 2017).

Scholars and practitioners of urban planning recognized that *vertical* oil and gas development in urban areas presented challenges for municipalities, including impacts on growth patterns (e.g., Branch, 1972; Smutz, 1965), but existing research has largely neglected to investigate such challenges presented by contemporary techniques of *horizontal* drilling (for an exception, see Fry et al., 2017). Fry et al. (2017) provide the first investigation of the impacts of horizontal unconventional oil and gas development (UOGD) on surrounding land uses, finding several different types of impediments to residential development surrounding existing UOGD production sites. Furthermore, we know that horizontal drilling has changed the spatial dimensions of oil and gas extraction, including the ability to drill laterally for up to a few miles through a target hydrocarbon-bearing formation (Kroepsch, 2018). Yet, to date, the geographic and social sciences literature has neglected to consider the implications when these horizontal wellbores extend beyond or across municipal political boundaries.

This chapter builds on Fry et al.'s (2017) research on the impacts of horizontal UOGD on surrounding land uses by examining how changes in extractive technologies—namely technological advancements from vertical to horizontal drilling—affect political and spatial issues for urban hydrocarbon development. To do so, it provides a comparative analysis of the challenges faced by two different municipalities with oil and gas development in residential areas—one experiencing vertical development, and the other, horizontal development. Through a comparison of two neighboring towns in Colorado at different points in time, this chapter investigates the implications of advancements in drilling technologies—from vertical to horizontal development—for municipal governments. The first case examined is the City of Greeley, which experienced significant political controversies and transformations of urban and

residential spaces during the 1980s as vertical oil and gas development entered the city, culminating in one of the first municipal bans on oil and gas development in Colorado. The second is the Town of Windsor, where controversy erupted around a 28-well horizontal development project proposed to be located amongst residential neighborhoods. Through this comparative study, this chapter addresses the following question: what effects and implications for municipal governments emerge from proposed oil and gas development in residential areas of municipalities, and how has horizontal drilling affected these dynamics? I demonstrate that vertical drilling for oil and gas resources in residential areas presents significant urban growth challenges for municipalities, largely due to the dispersed nature of vertical well siting. Although horizontal drilling technology has alleviated many of the spatial concerns associated with vertical development, at the same time it has introduced a new set of spatial concerns. Among these concerns is the significance of municipal political boundaries in oil and gas development, including facilitating the ability of operators to engage in *strategic siting* of oil and gas production facilities for more favorable conditions of development. Furthermore, I find that the subterranean space of cities and the extractive activities occurring therein play a significant role in shaping resident and municipal responses to urban oil and gas development.

In what follows, I first review relevant literature to provide context regarding the impacts of oil and gas development in residential areas and how municipal governments have responded to these challenges. I then provide background on the study areas of Greeley and Windsor and discuss my research methods before developing my analysis of the similarities and differences of implications, effects, and actions of residents and local officials as a result of oil and gas development in residential neighborhoods.

Impacts of urban drilling and municipal responses

Oil and gas development in residential areas has received limited, albeit increasing, attention in scholarly literature. This could certainly be attributed to the fact that only a few select (sub)urban areas of the United States are experiencing oil and gas development, rather than lack of scholarly interest. However, geographers and other social scientists are increasingly examining the unique challenges faced by local governments as unconventional oil and gas development (UOGD) and residential development increasingly intersect (e.g., Czolowski et al., 2017; Fry & Brannstrom, 2017; Fry et al., 2017; Kroepsch, 2018; Ryder, 2017). Such issues include the development of urban drilling policies and setback distances by municipalities (Fry & Brannstrom, 2017) and a politics of scale between local and state governments regarding state preemption of local authority regarding oil and gas-related matters (e.g., Davis, 2014).

UOGD impacts on communities and challenges for local governments

There are numerous potential impacts that unconventional oil and gas development (UOGD) can have on neighborhoods or entire communities. Impacts to the urban landscape include the rapid industrialization of communities, which may strain existing infrastructure as well as create an inability to keep pace with building new infrastructure to accommodate industry and community needs (Jacquet, 2014). The increased amount of heavy truck traffic associated with UOGD can not only lead to traffic congestion, but also deteriorate roads leading to increased costs of maintaining transportation infrastructure (Rahm et al., 2015).

Residents of communities hosting UOGD can also be affected by the arrival of extractive industries. Hydrocarbon development in urban areas poses several potential health risks to

surrounding residents (Adgate et al., 2014), as well as safety risks from accidents such as fires and explosions (Blair et al., 2017). UOGD can produce social-psychological stress and result in community stigma (Jacquet, 2014). Residents near UOGD operations, particularly during drilling and hydraulic fracturing processes to prepare wells for production, may be impacted by noise, vibration, lights, and dust, which can impact their quality of life (Davis & Fisk, 2014; Shaffer et al., 2017). A depreciation of property values is also of concern for many individuals residing near UOGD facilities (Davis & Fisk, 2014); however, studies have found mixed results as to whether such activity depreciates property values (Bennett & Loomis, 2015; Balthrop & Hawley, 2017).

Not all impacts of UOGD to communities are necessarily negative—many communities hosting UOGD benefit economically from job creation and a booming local economy (Devlin, 2015; Engelder, 2011), although these booms may also be followed by 'busts' (Jacquet, 2014). Benefits also accrue to both local governments through tax revenues, as well as mineral owners through leases, signing bonuses, and royalty payments (Brown et al., 2016; Bugden et al., 2016).

Local authority to regulate UOGD

UOGD in the United States is characterized by a "decentralized regulatory approach," which, unlike in other nations where UOGD governance is vested at the national level, confers much of the regulatory authority on state and local governments (Small et al., 2014). However, powers granted to local governments to regulate oil and gas development vary by state (Loh & Osland, 2016). Many states in the US have allowed for local governments to expand municipal

autonomy by adopting home rule charters. Under home rule, municipalities are permitted to exercise greater local control over municipal functions provided such controls do not conflict with the state's laws, constitutions, court decisions, or are otherwise prohibited by the state legislature (Platt, 2014). Several states that are part of the UOGD boom, such as Pennsylvania, Colorado, and Texas, allow for home rule local governments; however, variations exist among these states with regard to the level of state-level intervention into municipal oil and gas-related ordinances and policies (Davis, 2014). In Colorado, restrictions to municipal authority over oil and gas-related activity was largely established through the *Voss* ruling (Toan, 2015), and details regarding these limitations are discussed in the following section of this chapter.

Methods of local control

Local governments often develop ordinances and other controls, as allowed by state authority, in order to reduce, avoid, or mitigate the various potential impacts that UOGD poses for communities (Goho, 2012; Mayer, 2017). Several 'tools' exist for municipalities in the US to control UOGD as a land use within their jurisdiction. Some states allow zoning regulations as an option available to local governments to mitigate impacts of UOGD on the local landscape, as well as protect public health, safety, and welfare (Loh & Osland, 2016). Municipalities have also established locational restrictions on UOGD through setback ordinances establishing minimum distances between wells and buildings (Fry, 2013; Goho, 2012), and adopted regulations addressing particular impacts of UOGD—such as noise, odors, truck traffic, water use, and aesthetics (Goho, 2012). Memorandums of understanding (MOUs) with operators provide another 'tool' in which municipalities are able to both provide more local control by

incorporating the interests of local residents and officials into mutually agreed upon conditions of development, as well as expedite municipal approval of necessary local permits (Zilliox & Smith, 2017). In certain circumstances, local governments have imposed moratoria or outright bans on oil and gas development (Goho, 2012), such as Greeley adopted in 1985.

Vertical drilling in urban areas

Oil and gas development in residential areas is not strictly a recent phenomenon brought about by horizontal drilling, and neither are the municipal concerns surrounding urban extractive activities. Historically, residents and municipal officials have viewed oil and gas development as incompatible with urban or other residential areas (Laurie, 1965). During the early 20th century, Los Angeles was among the first cities in the US in which vertical drilling for oil and gas resources occurred (Smutz, 1965). Thus, the city can serve as an important example of how municipal governments navigated accommodating vertical development of hydrocarbons in populated areas, while still being attentive to its municipal obligations (Branch, 1972; Smutz, 1965).

Land use regulations governing vertical oil and gas extraction in urban Los Angeles during the early- to mid-20th century were largely developed through a process of trial and error (Branch, 1972). These regulations included various zoning restrictions, the establishment of "urbanized oil-drilling districts" instituting well spacing constraints, and routine inspections of production facilities (Branch, 1972). Other controls implemented by Los Angeles to mitigate undesirable impacts of urban oil drilling, included fencing to conceal the drill site, transport of hydrocarbons by pipeline, and use of electricity rather than diesel or other combustion engines

to power drilling and production equipment (Smutz, 1965). Other hazards associated with vertical oil and gas development in urban areas that raised concern among planners in Los Angeles during the mid-20th century included surface subsidence and potential of explosions from migration of natural gas to the surface (Endres et al., 1991).

UOGD and urban land use challenges

Drilling for hydrocarbon resources—whether vertical or horizontal development—in urban environments can present significant land use challenges. Urban planners in Los Angeles recognized that the presence of vertical oil wells would potentially impact future uses of residentially zoned but undeveloped areas of the city and, thus, the city established zoning laws prohibiting drilling in such areas (Smutz, 1965). This type of impact is of relevance, particularly to planners, however, such impacts on future land uses remain underexplored in existing literature (Fry et al., 2017).

Some of the same planning challenges regarding vertical oil and gas development in urban environments pertain to horizontal development as well. Fry et al. (2017) provide the first in-depth study examining the impacts of horizontal UOGD on surrounding land uses. The authors identify several challenges that emerge from the increasing growth and intersection of residential development and UOGD sites (Fry et al., 2017). The presence of well pad sites precludes other development of the surface in the space that these sites occupy, in addition to precluding surface development in the area surrounding well pad sites due to setback requirements. Furthermore, implementation of reverse setback policies, which allow for new surface development to occur within the buffer zone created by setback distances from new

wells to existing structures, has been debated among developers and municipal officials. Developers prefer establishing a memorandum of understanding (MOU) or other private agreements with operators since it avoids municipal interference into matters of private contractual agreements (Fry et al., 2017).

UOGD and the politics of urban growth

Oil and gas development in growing cities, such as those along Colorado's Front Range, creates a politics of urban growth as local governments must increasingly grapple with the challenges of two competing land uses commonly viewed as incompatible with one another: residential development and hydrocarbon extraction. Municipalities have attended to such challenges of accommodating urban extraction through the adoption of regulatory 'tools' (as discussed above) to avoid or mitigate the impacts of extractive activities in residential neighborhoods. These 'tools' may include a spatial aspect, such as setback ordinances, zoning restrictions, or outright bans. A politics of urban growth also includes other spatial aspects related to territorial jurisdiction, which, to date, has not been addressed in the geographic or social sciences literature on UOGD.

Municipal political reorganization—incorporation, secession, and annexation—is a fundamental component of a politics of urban growth (Purcell, 2001). These actions serve as spatial strategies of restructuring urban space to pursue local growth agendas (Purcell, 2001), and are thus political exercises of 'territoriality': the strategic use of territory (Agnew 2010). Cities have utilized annexation as a mechanism through which to restructure urban space since there is a territorial imperative to protect the political and economic well-being of cities. For

example, property provides a tax base, and land-use policies structure location of different types of surface activities (Thomas, 1984). Thus, such spatial strategies are important means through which municipalities can assert land use control over or derive tax benefits from extractive activities.

Annexation, in particular, can serve as an important local government response to oil and gas development for both economic and growth concerns. Municipalities frequently employ annexation as a strategy to capture tax revenues (Heim, 2012), as well as a strategy for growth management, economic development, or land-use coordination functions (Edwards, 2008). Annexation can be a controversial process, particularly when resistance stems from economic concerns over taxes, imposition of building and zoning regulations, impinge on desires for self-determination, or perceived changes to sense of community, identity, and place (Edwards, 2008). Involuntary (forced) annexation—such as the Town of Windsor pursued—is a highly controversial method of annexation, and scholars have debated its merits on the grounds of increasing benefits and efficiencies in the provision of municipal services versus its undemocratic basis. For example, those residents subject to annexation efforts have not voted for those municipal officials pursuing such efforts, and involuntary annexation may infringe on private property rights (Smith, 2012).

Drilling technology and vertical/volumetric territory

The discussion thus far has focused on the impacts and controls on oil and gas development in the "lived" surface space of cities. However, hydrocarbon extraction is very much a subsurface activity and warrants attention to the depths and volumes of subterranean

space (Elden, 2013). An examination of the surface impacts of oil and gas development ought to examine the "vertical reciprocity" (Adey, 2010) of links between the terrestrial surface and subsurface, including both the physical and theoretical connections, as well as the resources contained therein (Bridge, 2009; Bridge, 2013).

Drilling technologies—whether vertical or horizontal—provide such physical connections between the surface and subsurface and, importantly, the spatial dimensions of these technologies ought to receive consideration. Vertical wells are drilled from a surface location directly above the target entry point to a hydrocarbon reservoir. With the advent of horizontal drilling technology, the spatial dimensions of oil and gas extraction have changed significantly by allowing for flexibility in the surface location of wells to access the minerals, the ability to access minerals previously inaccessible, and condensing wells and production equipment onto a single site (Kroepsch, 2018). These changed spatial dimensions have considerable implications for all stakeholders involved in oil and gas development—whether residents, operators, regulatory agencies, and, importantly, local governments.

Much of the geographic and social sciences literature on unconventional oil and gas development in residential areas has focused on the plethora of effects on communities, whether to the physical space of cities (e.g., Jacquet, 2014; Rahm et al., 2015) or impacts on residents (e.g., Jacquet, 2014; Shaffer et al., 2017). Other literature has examined the complexities of a politics of scale in governing and controlling UOGD, including municipal efforts (e.g., Fry, 2013; Goho, 2012). What is less known, however, is how extractive activities in residential areas affect land use and municipal growth, an issue identified and addressed by Fry et al. (2017). In what follows, I examine such issues through the cases of Greeley in the 1980s

and contemporary Windsor, providing the first comparative analysis that attends to the challenges presented by different extractive technologies—vertical and horizontal drilling—to municipalities pursuing urban growth. Furthermore, this study contributes to existing literature by examining the role of municipal political reorganization—namely annexation—as well as the role of the subsurface in shaping municipal responses to hydrocarbon development.

Research area and methods

Greeley and Windsor are neighboring towns located in the Front Range region of northern Colorado, east of the Rocky Mountains and north of Denver. The Front Range region has been undergoing a rapid population and housing boom over the past decades, even more so in recent years. Of the total population growth in Colorado during 2010 to 2015, 96% of this growth occurred in the Front Range area (Colorado Department of Local Affairs, 2017). Greeley is a home-rule city of approximately 105,000 residents (Upstate Colorado Economic Development, 2019) and is the county seat of Weld County. Windsor is a home-rule municipality of approximately 32,000 residents (Town of Windsor, 2019) and straddles the border between Weld and Larimer Counties. The population of Weld County grew almost 20% between 2010 and 2017 (Colorado Department of Local Affairs, 2017). The population of Windsor nearly quadrupled between 1995 and 2015 (Economic & Planning Systems, 2015).

The Wattenberg Field, part of the Denver-Julesburg (DJ) Basin, underlies much of the Front Range region and contains several oil- and gas-bearing formations, including the Greenhorn, J Sandstone, D Sandstone, Codell, and Niobrara (Sonnenberg, 2015). The Codell and Niobrara formations were the primary targets of development in the early 1980s (Ladd, 2001)

with much of the vertical drilling activity occurring in the Codell Sandstone, such as was the case in Greeley during this time period (Seelmeyer, 1983). Horizontal drilling in the Wattenberg Field, including that occurring in and around Windsor, began in 2010 and has focused primarily on the Niobrara and, to a lesser degree, the Codell (Sonnenberg, 2015).

Colorado citizens established municipal home rule by constitutional amendment in 1902, with amendments in subsequent decades further strengthening municipal powers. These powers grant home rule municipalities in Colorado exclusive control over local affairs, except in matters deemed to be of "state interest," in which the state may preempt home rule regulations or allow regulations to the extent that they do not "operationally conflict" with state interests (Toan, 2015). The Local Government Land Use Control Enabling Act of 1974 grants local governments in Colorado limited land-use authority to regulate certain oil and gas-related activities within their jurisdiction (Toan, 2015). Current COGCC regulations stipulate that new oil and gas wells must be drilled a minimum of 500 feet from existing building units, and 1,000 feet from high occupancy buildings. These regulations also establish additional local government consultation requirements for "large urban mitigation areas" which have defined thresholds regarding the scale of oil and gas activity occurring within 1,000 feet of a high-occupancy building unit or 22 building units (Colorado Oil and Gas Conservation Commission, 2019a). As discussed earlier, these state-level regulations preempt local authority on oil and gas-related matters.

The *Voss* case is an important precedent that helped establish a legal framework for balancing local and state powers with respect to oil and gas development activities (Toan, 2015). This Colorado Supreme Court ruling was the culmination of a contentious regulatory

battle in Greeley during the 1980s over local government restrictions on oil and gas development as such activities increasingly encroached on populated areas. Local governments—both at the city and county level—have held little to no standing with the Colorado Oil and Gas Conservation Commission (COGCC)—the state oil and gas regulatory agency (Toan, 2015). The preceding legal and regulatory background sets the stage for my research.

Research methods

The data collected for this analysis consists largely of archival and personal interview sources. To examine issues surrounding oil and gas development in Greeley during the 1980s, I conducted archival research primarily at the Hazel E. Johnson Research Center at the Greeley History Museum in Greeley, Colorado. This archival work consisted of a thorough review of an extensive collection of newspaper articles taken from *The Greeley Tribune* related to oil and gas development in Greeley and surrounding communities. This archival research also included a review of a report prepared by two petroleum consulting firms regarding hazards of drilling in the Greeley area. My investigation of the controversy surrounding the proposed Pace project in Windsor is largely based on eleven semi-structured interviews I conducted and transcribed as part of my fieldwork. The analysis is based on interviews with six residents of the neighborhoods surrounding the Pace property, three former and current town officials (at the time of fieldwork), a representative from Great Western, and an individual involved in the controversy in a professional capacity. Further data to provide context for the Windsor portion

of this analysis was collected from Windsor Town Board meeting minutes and newspaper sources, including *The Coloradoan* and *The Greeley Tribune*.

Limitations to this research include the reliance on newspaper articles for archival data. Greeley City Council and Planning Commission meeting minutes between 1980 and 1987 were available; however, in many cases, the newspaper articles provided greater detail than official city records. Research costs were a barrier in obtaining supplemental materials ("agenda packets") for city council and planning commission meetings. Attempts to contact key individuals listed in these newspaper articles for interviews were unsuccessful. Residents of Greeley during the 1980s that I interviewed as part of this study either had very limited memory of details of oil and gas-related issues at that time or were less than forthcoming. Additionally, attempts to interview the developer in Windsor were unsuccessful.

The following two sections present analyses of the cases of 1980s Greeley and contemporary Windsor. The section on Greeley is structured as a chronological narrative to trace the challenges that vertical oil and gas development presented for the city as they unfolded over the course of several years. The section on Windsor examines the controversy that emerged around the location of a single multi-well project proposed near homes—what Haggerty et al. (2018, p. 627) refer to as a "focusing site."

Vertical drilling and municipal challenges in Greeley

On February 18, 1984, the showroom of Wickes Lumber Company in La Salle, Colorado exploded, destroying the building. Officials quickly determined that the blast was attributable to a pocket of natural gas of unknown size that had mysteriously accumulated underneath part

of the town. What was not initially clear was whether the subsurface gas pocket was attributable to the recent oil and gas boom in the area. As would be expected, both the explosion and the discovery of the subsurface gas pocket were cause for alarm among both residents and local officials in not only La Salle, but also other surrounding communities that had also experienced a recent surge in oil and gas development. In fact, this incident was a key factor underlying one of the first municipal bans on oil and gas development in Colorado: the ban adopted by the neighboring City of Greeley in 1985. Perhaps surprisingly, it was only a few years prior that vertical hydrocarbon development first arrived in Greeley, and the city initially sought to accommodate urban drilling.

Early concerns over urban drilling

In the early 1980s, Greeley officials established the first local controls for vertical oil and gas development within city limits to address potential impacts to the community. City officials recognized the need to balance the interests of drillers and mineral owners with those of citizens. Due to public safety concerns, they adopted municipal ordinances that, among other issues, addressed two activities typical of oil and gas development: open burning of natural gas (flaring) and above-ground storage of oil in tanks (Bangert, 1982a). These ordinances established 300-foot setback distances between wells and property lines and buildings, in addition to placing zoning restrictions on the location of wells to maintain the residential character of neighborhoods (Bangert, 1982b). Yet, these local regulations failed to alleviate resident concerns.

Residents questioned whether oil and gas development would present health and safety issues for surrounding neighborhoods; however, Greeley's mayor assured them that allowing oil and gas development in the city would not "sacrifice the health and welfare of our citizens" ("Zoning revision…", 1982). Resident concerns also included impacts that oil and gas development might have on their property values, and residents complained that they felt as though they need to continually remind city officials of the fact (Kanigher, 1984a). These concerns increased as the oil and gas industry took foothold in the city and the impacts of urban drilling were realized. Soon after the first well was drilled within Greeley city limits in November 1982 (Seeman, 1984c), residents were upset and irritated by the quality-of-life impacts and changes to the character of the community that problems it was causing (Peters, 1983). Residents chastised the city council for passing ordinances allowing the "tall monsters" (drilling rigs) into the city, which could be seen for miles, and are "dirty, ugly, noisy, and smelly, and there is a constant thumping and noise around the clock" (Peters, 1983). However, concerns about oil and gas development within Greeley were not limited to just residents.

City leaders also had reservations about allowing oil and gas development to occur within city limits. The president of the Greeley Chamber of Commerce felt that allowing oil and gas development in the city would not only change the atmosphere of neighborhoods but could also have a detrimental effect on property owners, both by restricting their ability to develop their surface property and by depreciating the value of their property. Furthermore, oil and gas development could jeopardize community efforts to keep the city environmentally clean (Bangert, 1982b).

Many of these above concerns—including noise, adverse impacts to neighborhood aesthetics and property values, and public safety—are typical of those discussed in existing literature (e.g., Branch, 1972; Davis & Fisk, 2014; Shaffer et al., 2017). However, a different set of concerns emerged among city planning officials as spatial issues emerged from the effects of vertical drilling on urban growth patterns.

Vertical drilling, planning, and urban growth

The spatial dimensions of vertical drilling technology, combined with state and local regulations regarding the location of wells, played a significant role in shaping how the intersection of urban drilling and residential development proceeded in Greeley. This included significant concerns among municipal officials regarding urban growth patterns. Vertical drilling, which was primarily focused on the Codell formation in the Greeley area during the 1980s, was subject to state well spacing rules which allowed one well per forty acres (Seelmeyer, 1983). These spacing rules dispersed individual vertical wells over a greater surface area, so that the subsurface area of hydrocarbon production from one well would not interfere with the area of production from neighboring wells. As discussed above, city ordinances adopted in 1982 established setback distances of 300 feet between wells and property lines and buildings to address matters of public safety (Bangert, 1982b). To put this in perspective, a 300-foot radius setback around a single vertical well removed 6 ½ acres of developable space from the city. The combination of these two regulations—state spacing rules and city setback ordinances—created distinctive challenges for planning and urban growth patterns in Greeley.

Shortly after the first vertical wells were drilled in the city, Greeley planning officials recognized the impacts that oil and gas development could have on urban growth patterns, potentially creating a "monster" (Bangert, 1983). By early 1983, many of the wells that had been drilled in Greeley were in recently annexed land zoned for future single-family residential development. Planning officials cautioned that the city's setback distances may both inhibit residential and commercial development—creating the need for future surface development to "leapfrog" over areas of oil and gas production—and create small tracts of land unfit for development (Bangert, 1983). Developers, too, foresaw that setbacks from new wells could affect planned, yet undeveloped, subdivisions by reducing the number of residential lots slated for development ("More wells proposed…", 1982).

Indeed, by mid-1983, the city's Director of Community Development reported that setbacks from oil and gas development had reduced the amount of residentially-zoned land available for home construction in the city by one-eighth and, at the then-current rate of drilling, that number could exceed one-quarter. Furthermore, oil and gas development was beginning to preclude development on prime land in the city, such as that at the intersection of major roads. Yet, this land would only be temporarily undevelopable, as these wells were expected to have a production life of only six to ten years. Other planning officials expressed concern that, even if that land is temporarily unavailable, the city may need to annex additional land to accommodate urban growth, resulting in increased costs of providing infrastructure and city services to that land (Seelmeyer, 1983).

However, many in Greeley felt that the impacts of vertical development within the city was manageable with the proper controls. City officials and developers recognized solutions to

the emerging issues, and even opportunity, from the influx of oil and gas development in the city. The Director of Community Development was convinced that, although oil and gas development may present the need to implement creative planning solutions to avoid "tricky planning questions in future years," the city's planning controls would prevent significant urban growth issues (Seelmeyer, 1983, p. B5). Furthermore, COGCC spacing regulations limited drilling to one well per forty acres. Rather than leave the buffer zones created by setbacks undeveloped, the Director of Community Development proposed that the city consider what types of development might be suitable for those areas. Complicating matters, at this time in the early 1980s, oil and gas provided more revenue for developers than did surface development. Yet, some developers claimed that the two land uses could be compatible. For example, housing could be developed in the same places in which wells are located by using techniques such as locating storage tanks away from homes or green spaces could be created around storage tanks and wells sites (Seelmeyer, 1983). City officials maintained that land-use controls would be sufficient to manage urban growth despite the presence of oil and gas wells, and creative planning solutions would resolve these land-use challenges. However, favorable hydrocarbon prices and decreased demand for housing encouraged developers to utilize their land for hydrocarbon extraction, rather than residential or other surface development, exacerbating the issue (Seelmeyer, 1983).

As oil and gas development moved into Greeley during the early 1980s, planning challenges were identified early on, and these challenges illustrate a vertical territory of the city through connections between subsurface extractive activities and surface impacts. At the heart of the matter were state- and city-level spatial controls that dictated the location of vertical

wells through spacing rules and established undevelopable buffer zones around individual wells, respectively. These regulations hindered growth of the city by precluding home construction and other surface development in areas surrounding wells. The resulting need to disperse surface development across a larger area of the city created issues of not only 'wasting' the space of land recently annexed to accommodate urban growth, but also increasing city expenditures through the need to extend municipal infrastructure and services beyond the empty space created by setbacks. A politics of urban growth began to emerge from these challenges in that the city found itself in a position of balancing the economic activity of hydrocarbon extraction and the interests of mineral owners and drillers with municipal interests of urban growth through annexation and the spatial constraints presented by oil and gas development. In essence, the challenge was one of "how best to shape urban space" (Purcell, 2001, p. 615). From this politics of urban growth, vertical dimensions of territory emerge from the influence of subsurface extractive activities on the horizontal 'lived' space of the city. The "straight" oil and gas wells in Greeley had created a vertical territory of the city by linking subsurface extractive activities to surface development. It wasn't long, however, until new issues of territory emerged…

Subsurface concerns over hydrocarbon development

The explosion of the lumberyard building and discovery of the gas 'pocket' underlying La Salle played a significant role in shaping the politics of urban growth in nearby Greeley, located a few miles north of La Salle. Through an investigation into the cause of the lumberyard explosion, officials quickly determined that natural gas had migrated to the surface of the town

through abandoned water wells dating back to the days of La Salle's initial settlement (Engelhardt, 1984a). Fearful of another explosion, and faced with many unknowns, La Salle officials tried to determine the location of other abandoned water wells in the town, as well as inspected the basements of homes for natural gas (Seeman, 1984a). Dozens of venting pipes were placed in the ground in the blocks surrounding the lumberyard in an effort to dissipate the gas pocket. However, after several weeks, monitoring of these venting pipes indicated that the pressure of the gas pocket was not decreasing. This led to concerns that it was continuously being fed and potentially getting larger, especially since officials had yet to determine the source of the gas (Seeman, 1984b). Speculating that the source of the pocket was underground horizontal migration of gas from nearby gas wells, officials inspected several wells in the area and found pressure anomalies and faulty protective casing in the borehole of one particular well (International Engineering Company, Inc. & Amuedo and Ivey, Inc., 1984).

No official cause as to the gas pocket that accumulated under La Salle was determined. However, consultants hired by Greeley and other local governments to investigate potential hazards associated with drilling in the area indicated that, based on testing of the composition of gas emitted from the venting wells in La Salle, the likely source was a nearby gas well that had been hydraulically fractured a few days prior to the lumberyard explosion (International Engineering Company, Inc. & Amuedo and Ivey, Inc., 1984). The consultants' theory was that the gas had escaped through faulty casing in the well, migrated through a geologic layer toward the lower-pressure area underneath the town created by abandoned water wells, and through those wells to the surface (International Engineering Company, Inc. & Amuedo and Ivey, Inc.,

1984). Approximately one month after the lumberyard exploded, monitoring of the venting wells in La Salle indicated that the gas pocket had begun to dissipate (Whiskeyman, 1984b).

Shortly following the La Salle incident, Greeley officials instituted a temporary moratorium on drilling within the city that lasted approximately two months. Although the moratorium was lifted in early May 1984, in the meantime Greeley had enacted more stringent oil and gas ordinances, which angered many industry officials due to the increased costs of drilling the new ordinances would pose (Engelhardt, 1984b). However, the Greeley city manager contended that the city's top priority was protecting the safety and well-being of its citizens (Tribune's Opinion, 1984b). The consultant report noted that numerous abandoned water wells exist in Greeley—some in the urban core of the city and several of which could not be located for testing (International Engineering Company, Inc. & Amuedo and Ivey, Inc., 1984). A state senator from Greeley urged city officials to consider not only the surface impacts of oil and gas development, but subsurface activities (Whiskeyman, 1984a). Furthermore, in light of the La Salle incident, he contended that Greeley officials ought to reconsider drilling within the city, particularly since abandoned water wells exist within former agricultural land that was slated for subdivision development or on which homes had already been built (Whiskeyman, 1984a).

Importantly, the La Salle incident brought conceptions of the volumetric territory of Greeley into the consciousness of residents and city officials. Prior to the lumberyard explosion, the vertical territory of the city was evident to residents and city officials through the impacts of drilling on the urban environment—it created nuisances for residents and urban growth and planning challenges for city officials with regard to surface development. The explosion and

ensuing events in La Salle heightened concerns among Greeley residents and officials regarding hazards of urban oil and gas development. This conception shifted, however, with the potential for migration of natural gas through subsurface geologic layers and to the surface through abandoned water wells led residents and officials to conceive of the volumetric, or three-dimensional, space of the city. The underground served as a space of the invisible and the unknown, where a 'pocket' of explosive natural gas of unknown size and origin could mysteriously appear underneath a populated residential area and endanger residents. The realities of the potential hazards posed by urban hydrocarbon extraction would soon intensify the politics of urban growth in Greeley.

Adoption of Greeley's ban

The incident in La Salle set into motion a series of events that would not only shape the future relationship between drilling and residential development in Greeley, but would also have a broader impact on oil and gas development in residential areas for the State of Colorado. Specifically, conceptions of the volumetric territory of Greeley and the hazards that oil and gas development in and around the city posed to residential areas sparked controversies over allowing drilling to continue, which culminated in Greeley banning hydrocarbon development within city limits.

Greeley attempted to exercise municipal control over the surface space of the city in response to the perceived incompatibilities of hydrocarbon extraction and residential areas, particularly the potential impacts that drilling could have on neighborhoods. Legal trouble for the City of Greeley began to brew in November 1984, when the city council denied a permit for

two wells proposed by Lundvall Bros., Inc. Council members cited the risks posed by drilling and hydraulic fracturing techniques, the consultants' determination that the LaSalle explosion was caused by a gas well, as well as overall incompatibility with surface land uses—particularly the proposed project's proximity to homes and a school (Seeman, 1984b). "People is the key, not zoning," remarked the mayor about the council's decision (Seeman, 1984e). Further compounding Lundvall's ire, at the same meeting the city council approved a zoning change to allow a developer to build more than 850 homes and condominiums on the same land that Lundvall proposed to drill from, land under which Lundvall owned the mineral rights (Seeman, 1984b). In doing so, the city exercised municipal control through the denial of necessary local permits to drill. Furthermore, the city no longer attempted to accommodate urban drilling, but rather explicitly chose to give residential development precedence.

The denial of the permit prompted Lundvall to file suit against Greeley, alleging that the city exceeded its jurisdictional authority over a state-regulated activity and, furthermore, the city's denial infringed on Lundvall's constitutional rights by denying property rights without compensation. In response to the Lundvall lawsuit, Greeley's city attorney claimed that the city maintains the right to zone and regulate the surface, and COGCC only has authority to regulate extraction of oil and gas, not the surface (Seeman, 1984d). This lawsuit filed by Lundvall against the city is critical in that it spawned a legal battle that culminated in the 1992 *Voss v. Lundvall* lawsuit heard by the Colorado Supreme Court.

Following the explosion in La Salle, area residents cited the incident in their protests to local officials regarding proposed oil and gas projects in and around Greeley (Tribune's Opinion, 1985). Residents of a subdivision adjacent to Greeley city limits submitted a petition to the

Weld County commissioners stating that the project was not adequately studied. The petition cited concerns not only about health, safety, traffic congestion, fire protection, and impacts on property values, but also expressed concern about leaks, explosions, and that another incident like that which occurred in La Salle could happen in their neighborhood (Kanigher, 1984c). Many oil and gas-related accidents in the months prior to the La Salle incident had already heightened residents anxieties regarding the safety of oil and gas operations—an oil tanker truck explosion, a pipeline explosion requiring amputation of a worker's leg and causing the death of another, a well explosion in the town of Kersey forcing the evacuation of 140 residents, a pit fire in the town of Mead, and gas leaks from wells in Greeley causing headaches, dizziness, and sore throats for residents (Seeman & Whiskeyman, 1984; Tribune's Opinion, 1985).

Following the La Salle incident, Greeley continued to receive applications for permits to drill wells within the city, and residents fiercely contested these drilling projects. Greeley residents were concerned about many of the same issues previously—including fire protection, traffic congestion, decreased property values, noise, and health and safety hazards. But residents expressed outright fears of leaks and explosions such as occurred in La Salle (Kanigher 1984b; Kanigher 1984c; Seeman, 1984b). The frequency and intensity of disputes regarding oil and gas development steadily increased since the first well was drilled in Greeley in November 1982 (Seeman, 1984b).

However, by mid-1985, the still-pending Lundvall lawsuit left some Greeley officials reconsidering a hardline stance on drilling in the city, while other officials maintained that urban drilling poses risks and impacts to residential areas that cannot be controlled, making the

two activities incompatible. In deliberations on permit applications for a new Lundvall project near two residential neighborhoods, several city council members cautioned that, although drillers can implement protectionary measures, the potential still exists for acts of god or human error to result in threats to public safety, such as the incident in La Salle. One council member felt that not only is drilling within city limits inappropriate, but it also keeps "creeping closer and closer to residential neighborhoods" (Seeman, 1985a). The mayor, however, conceded that landowners within the city have certain property rights, and that the city needs to account for their rights to have their minerals developed (Seeman, 1985a). The city council approved permits for the Lundvall 4-well projects in August 1985 (Seeman, 1985b), around which significant controversy erupted and sparked residents of the neighborhoods surrounding the project to mobilize.

At the following city council meeting, approximately seventy residents—primarily those from the Westmoor and Pheasant Run neighborhoods adjacent to the approved well site—spoke against the Lundvall project, as well as drilling in the city more generally (Seeman 1985c). Residents cited concerns over safety, depreciated home values, as well as the LaSalle incident. Additionally, residents were apprehensive about Lundvall's plan to use directional drilling—drilling at a slant—to reach minerals underneath their homes from a surface location outside of their subdivision. Residents were concerned about the impacts of oil and gas on the city's growth, with one resident stating that "we're dying to get some growth in here, yet we're honeycombing the underground" (Seeman, 1985c, p. A10).

Residents were still concerned about many of the same safety and quality of life concerns as with other projects in prior years, and, even a year and a half after the incident, the

events in La Salle and the associated hazards of drilling in populated areas were still at the forefront of residents' minds. The proposed use of a drilling technology unfamiliar to residents—directional drilling—further contributed to conceptions of a volumetric territory of the city. Rather than a vertical well being drilled outside of, but still near, a residential neighborhood, drilling was slated to occur *underneath* their neighborhoods.

The outrage among residents culminated in a historic turning point for hydrocarbon development in residential areas for Greeley. Residents of the Westmoor and Pheasant Run subdivisions mounted a citizen initiative and submitted a petition to the city council to both rescind the Lundvall permits, as well as ban oil and gas development altogether within city limits (Seeman, 1985f). At the city council meeting, one resident spoke against allowing drilling within Greeley, "We're looking for quick-fix bucks for [an economic] recovery, but we don't need to sell out the city and the quality of life" (Seeman 1985g, p. A16). The resident who spearheaded the petition effort stated that "Oil and gas exploration in the city limits is the epitome of anti-growth policy"; "It is unfortunate that, for the special interests of a few, all of Greeley must suffer" (Seeman, 1985h, p. A16).

The city council put the petition initiatives on the November 1985 ballot, and Greeley voters revoked Lundvall's permits and adopted a city-ban on oil and gas development by a 2-1 margin (Crona, 1985). An oil and gas industry official referred to public and local government opposition to oil and gas development as "The Greeley Syndrome": the idea that resident opposition is based on emotion rather than realistic perceptions of oil and gas development (Lock, 1985).

Following the La Salle incident, the politics of urban growth intensified in the volumetric territory of Greeley. At the surface, existing concerns regarding the compatibility of oil and gas development in residential areas of the city, as well as on areas of future growth, persisted. However, the city's denial of permits for the Lundvall project, which resulted in a lawsuit, demonstrated the city's shift from accommodating hydrocarbon development in residential areas to giving precedence to residential development. The concerns over drilling in neighborhoods were exacerbated by the potential hazards of extractive activities illustrated by the subsurface migration of natural gas under La Salle. The proposed use of an unfamiliar drilling technology—directional drilling—sparked significant concerns among residents. Whereas residents already held fears regarding subsurface migration of natural gas through geologic layers and reach buildings at the surface, such as occurred in La Salle, drilling was now being proposed to occur *underneath* residential neighborhoods. The city's ban served as a way through which to control the volumetric territory of Greeley by not only excluding the activity from the "lived" surface space within city limits, but by also preventing access to the subsurface of the city. However, the issue of access to the subsurface presented by the city's ban on drilling would be contested.

Legal challenges to Greeley's ban

Perhaps unsurprisingly, Greeley's exercise of territoriality through its drilling ban was met with substantial resistance from various stakeholders with interests in oil and gas development. The ensuing legal challenges were battles over the politics of urban growth regarding the volumetric space of the city—including issues of the two-dimensional surface of

the city and the underlying mineral property—as well as a politics of scale over state preemption of local authority.

In December 1985, the state oil and gas regulatory agency—Colorado Oil and Gas Conservation Commission (COGCC)—filed suit against the city, challenging whether home-rule cities, such as Greeley, could usurp the agency's regulatory authority by banning oil and gas development (Wade, 1985a). In the months that followed, several operators with mineral interests in the city also filed lawsuits challenging Greeley's ban, claiming that the recently annexed agricultural land in the city was largely undeveloped, had few residents, and was thus suitable for drilling (Lock, 1987a). Furthermore, Lundvall's attorney noted that the city's ban precluded property owners from developing their minerals from land recently annexed by the city and, thus, constituted a regulatory taking of (subsurface mineral) property (Crona, 1985).

However, echoing their ongoing concerns, Greeley officials were concerned that this recently annexed land would be developed as an oilfield rather than for its intended purpose—urban growth. Furthermore, the city insisted that it maintained sole authority in determining matters of local land-use—not the state (Lock, 1987b). In its response to the COGCC lawsuit, Greeley maintained that the city's home-rule status grants it authority to control land use within city limits. Furthermore, the city's legal brief stated that a ruling in favor of COGCC "would render local land-use planning meaningless in that the best laid development plans could be eviscerated by bureaucratic decisions made in Denver" (Lock, 1987b, p. A1), and that "land-use regulations, community development planning and neighborhood continuity in the City of Greeley would by [sic] seriously crippled, if not destroyed" (ibid., p. A14). Furthermore, Greeley's city attorney claimed that the city's ban does not entirely prevent minerals underlying

the city from being developed—operators could use directional drilling to reach their minerals from outside of the city's boundaries (Lock, 1987c).

Weld County District Court struck down Greeley's ban but, through a series of appeals, the legal battle culminated in the 1992 Colorado Supreme Court decision on *Voss v. Lundvall*, ruling against the city's ban. The court held that, while local municipalities are permitted to exercise limited control over the extraction of these resources, they cannot ban it altogether (*Voss v. Lundvall Bros., Inc*.,1992). Rather than risk additional costly and time-consuming legal battles, Greeley settled the oil and gas company lawsuits for $388,000 (Brovsky, 1993b). Almost a decade after, a former city council member praised the city's drilling ban—even though it cost taxpayers hundreds of thousands of dollars—because homes and subdivisions were built where oil and gas wells were planned to be drilled and wells would have inhibited growth. (Brovsky, 1994d).

The legal battles Greeley faced were both a matter of a politics of scale over state preemption of local authority, as well as a regulatory taking of property. Greeley's ban was one way in which to assert local control over oil and gas development within city limits. The ban was also the culmination of a politics of urban growth, in which the city grappled with competing development—residential and oil and gas. Greeley had annexed land to support a growing city, yet increased drilling on that land was precluding it from residential development.

Issues of volumetric territory also emerged through connections between the subsurface and surface. Greeley's extension of its municipal boundaries at the surface through annexation also brought with it the underlying subsurface space. Mineral owners argued that the rationale underlying the city's ban—incompatibility of oil and gas development with

residential neighborhoods— was ill-suited for circumstances of recently annexed and undeveloped land.

Horizontal drilling and municipal challenges in Windsor

Two decades following the *Voss* decision, the Front Range area of Colorado was undergoing a new boom in oil and gas development—this one facilitated by the use of horizontal drilling. In contrast to the individual vertical wells that were dispersed in and around Greeley during the 1980s, the horizontal drilling boom that emerged in Colorado's Front Range communities beginning in 2010 (and continues at present) was marked by the concentration of multiple wells drilled from a single location. These characteristically more intense sites of hydrocarbon development had to compete for space with the increased residential development resulting from a concurrent population boom. Residential neighborhoods were increasingly built around existing oil and gas facilities while, at the same time, new horizontal wells were being drilled within existing neighborhoods. This very phenomenon came to the Town of Windsor, which resulted in a significant controversy over horizontal drilling in residential neighborhoods.

In August 2014, residents of the Bison Ridge subdivision in Windsor received notification of Great Western Oil & Gas Company's intent to drill twenty-eight horizontal wells from a parcel of land located adjacent to the neighborhood (Windsor Town Board, 2014a) (Figure 1). The parcel of land, owned by the Pace Family, was an undeveloped enclave under the jurisdiction of Larimer County, although surrounded entirely by the Town of Windsor. Given the vast amount of vacant land on the Raindance property east of the proposed site location,

residents of the surrounding neighborhoods questioned selection of the Pace property for the project location (Bluemel, 2015).

Great Western had originally planned the project location on the Raindance property owned by a local real estate developer to the east of the Pace property (personal interview). The initial well that was drilled with a south-north orientation had unexpectedly low production. Realizing that the geologic conditions of the area were not conducive to that wellbore orientation, Great Western decided to redesign the project with a west-east orientation and sought a different surface location from the developer (personal interview). However, in the time that had passed since the initial agreement, the developer had planned to build a golf course on that same land as part of a broader master-planned community. Negotiations between Great Western and the developer to reach an agreement for an alternate surface location quickly deteriorated. Great Western looked elsewhere for a different surface location from which to access their minerals, and found the Pace Family to be a willing landowner (personal interviews).

Residents of the neighborhoods surrounding the Pace property mobilized to resist the proposed facility and sought the assistance of town officials in contesting the location of the project. The town force-annexed the Pace enclave to challenge the project location with state regulators. Through a highly contentious process, COGCC and Windsor officials helped facilitate negotiations between Great Western and the developer and, ultimately, the project was relocated back to different location on the Raindance property (personal interviews).

Two unique spatial dimensions of horizontal development identified by Kroepsch (2018)—concentration of wells and production equipment onto a single site, and flexibility in

surface location of wells to reach the same minerals—played a significant role in influencing the politics of urban growth in Windsor surrounding the Pace controversy. As discussed above, the spatial characteristics of vertical development include individual wells dispersed over a greater surface area, primarily due to spacing regulations. In Greeley during the 1980s, these vertical wells were scattered across the surface of city, each having a setback buffer area in which surface development was precluded, created significant planning challenges for the city in accommodating future growth. In contrast, horizontal development, such as the Pace project in Windsor, reduces the total number of wells required to 'drain' the same subsurface space of minerals and, at the same time, concentrates the necessary wells onto a single surface location. This spatial characteristic of horizontal oil and gas development can reduce the planning challenges that Greeley experienced from vertical drilling during the 1980s, but, in the case of the proposed Pace project in Windsor, can result in a different set of spatial and political issues. Among several such issues discussed below, I highlight the implications of one spatial aspect of hydrocarbon extraction that differentiates horizontal drilling from vertical drilling—flexibility in surface location of wells while still 'reaching' the same area of minerals (Kroepsch, 2018). This flexibility in surface location allows operators to engage in what I term *strategic siting* for more favorable conditions of development.

Condensed surface facilities

At the heart of many concerns of both residents and Windsor officials regarding the Pace project was the size and intensity of the project—a result of horizontal development's concentration of wells and equipment onto a single well pad (Kroepsch, 2018).

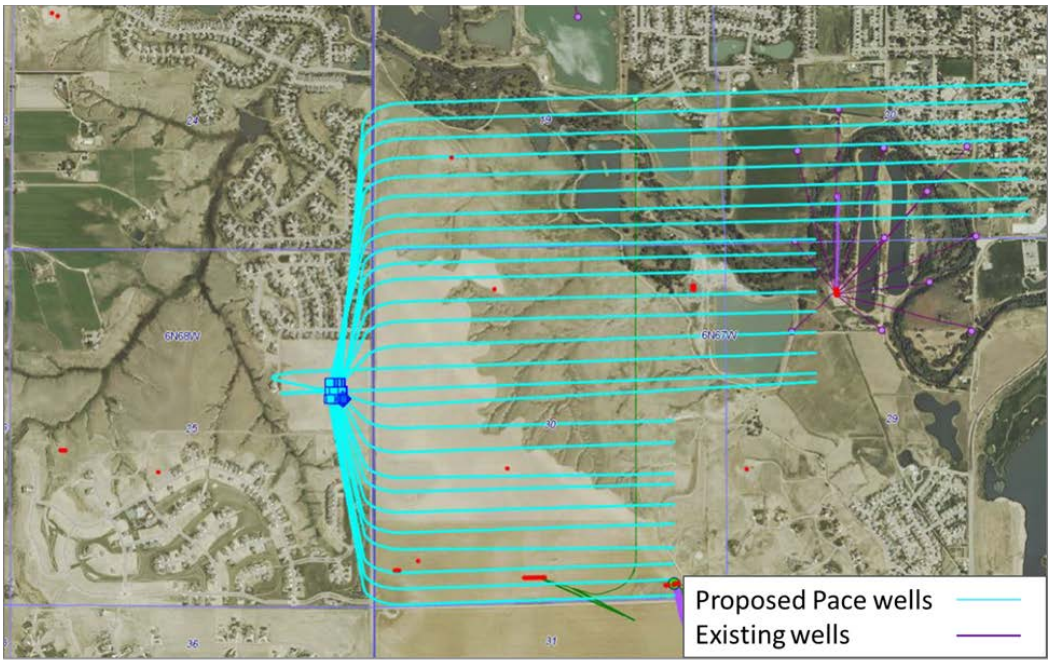

Figure 14. Aerial view of Pace project showing subsurface extent of proposed horizontal wells

A couple of residents made explicit distinctions of differences between vertical and horizontal oil and gas development in residential neighborhoods. Several residents remarked that they were less concerned about living near *any* oil and gas development—a couple wells and pumpjacks, as well as a few storage tanks, which is typical of vertical development, was "reasonable" (personal interviews). However, locating a large, multi-well oil and gas facility in their neighborhood was unacceptable because of the various potential public health and safety concerns posed by the project (personal interviews).

The residents I interviewed discussed a variety of health, safety, and environmental concerns regarding the project's impact on their neighborhood, several of which also directly related to the concentration of wells and associated production equipment onto a single site. Residents held mixed views on potential environmental and public health impacts of the project, varying from skepticism regarding adverse impacts to water and air quality and

exposure to carcinogens to desires to monitor the project for hydrocarbon emissions (e.g., volatile organic compounds [VOCs]) with a FLIR (forward-looking infrared) camera and collect air samples for testing (personal interviews). Residents also had substantial safety concerns, including heavy truck traffic to service the well site, as well as the presence of large quantities of flammable materials in a residential area, the potential for explosions to occur, and the adequacy of emergency response personnel and equipment were a catastrophic event to occur (personal interviews).

Windsor officials were also apprehensive about the visual impacts of a large, multi-well oil and gas facility for horizontal development on both the surrounding neighborhoods, as well as the community at large (personal interviews), which have been previously identified in existing literature (e.g., Loh & Osland, 2016). Concerns included the visual and aesthetic impacts that the location of such a large project—a production facility with twenty-eight wells condensed onto a single site—would have on the town. One official noted that the proposed location of a large project with a sizeable tank battery (group of above-ground oil storage tanks) on open land along a main road for the town would have been a significant eyesore and impacted the character of the surrounding neighborhoods, besides that of the town as a whole (personal interview).

Siting/locational concerns

Horizontal drilling has also introduced a greater amount of flexibility with regard to the surface location of wells, while still accessing the same area of minerals (Kroepsch, 2018). As discussed above, this spatial dimension of horizontal drilling can allow concentrated

hydrocarbon production facilities to be located in residential neighborhoods. All residents interviewed for this research expressed concern about the impacts of a large, multi-well facility on the value of their property, particularly those homes immediately adjacent to the Pace property (personal interviews). One interviewee explained that the proper way to develop oil and gas in residential areas is to establish the multi-well oil and gas facility first before building homes around it—by doing so, potential homebuyers "*know* what they're buying into" and the home values reflect the location near an oil and gas facility (personal interview). Additionally, two residents were concerned about the potential for vibrations from the drilling of multiple horizontal wells from the Pace site over the course of several months to exacerbate existing structural issues with homes in the surrounding neighborhoods (personal interviews). One resident remarked that operators "brag" about the lengthy distances they can drill horizontally, yet insist on drilling in residential areas near homes (personal interview).

Windsor officials also expressed concerns regarding the project's impacts on the values of surrounding properties; however, the property rights of the Pace Family ought to be considered as well. One official remarked that—regardless of their personal feelings on the Pace project—they took a strong constitutional stance on protecting the property rights of the Pace Family to make use of their property as they saw fit—even if that meant oil and gas development near neighborhoods. However, this official found it difficult to reconcile this position with the town's obligation to help protect the value of surrounding residents' homes—likely, the largest investment they will make in their life—from the potential negative impacts of proposed project location (personal interview). The tension between these views regarding property ownership made the town board's decision to pursue forced annexation of the Pace

enclave difficult (personal interviews). This town official reported grappling with personal feelings regarding the importance of property rights and the need to resolve those with his position as a town official and choose what they felt was right for the good of the community (personal interview).

Strategic siting

Of critical importance for town officials were two particular matters of concern specifically related to the proposed location of the project on the Pace property as an enclave of Larimer County, but surrounded by the town. These two issues were municipal permitting and financial benefits (personal interviews). Both of these matters of concern are related to the use of horizontal drilling and issues of municipal political boundaries.

The location of the project on the Pace enclave would not allow the town to enforce its Condition Use Grant (CUG) requirements—municipal permits that would apply to oil and gas development—to mitigate actual and potential adverse impacts of the project, both to the town as well as surrounding residents and their property (personal interviews). Rather, the location of the project on the Pace enclave would subject it to Larimer County development standards. Importantly, town officials were concerned that Great Western intentionally chose the Pace location, rather than seek an alternate surface location for the facility, in order to circumvent Windsor's CUG process and requirements (Garcia, 2014b). Great Western denied that allegation both publicly and during my interview with a representative of the company, and further indicated their intent to adhere to the town's requirements (Garcia, 2014b; personal interview).

The second matter of concern among town officials regarding the proposed project location stemmed from the town's ability to benefit financially from the project (personal interview), which was associated with vertical dimensions of political boundaries. At the time Great Western proposed the Pace project, recently passed state legislation established the point of taxation for oil and gas production according to the location of the wellhead—irrespective of jurisdiction over the land from which the oil and gas were produced. Thus, siting the project on the Pace enclave meant that Larimer County, rather than Windsor, would receive the tax revenue from the twenty-eight wells—even though the vast majority of the oil and gas resources being accessed were under the town proper, and even though the town would be subject to the vast majority of the impacts associated with development (personal interviews). One interviewee remarked that this change in state legislation allows operators to "cherry-pick, or gerrymander, where they have their oil and gas facility to find cheaper taxes" (personal interview).

From these two locational issues illustrated by the Pace project—municipal permitting and point of taxation—horizontal drilling in municipalities can allow operators to engage in *strategic siting* of oil and gas projects. Due to the flexibility available in choosing a surface location while still being able to access the same minerals, operators are able to strategically select a surface location just beyond municipal boundaries in order to avoid local permit requirements, such as Windsor's CUG, as well as locate a project in a jurisdiction that reduces an operator's tax liability. In the case of the Pace project, whether Great Western engaged in strategic siting is purely speculative—Great Western denied allegations that it sought to circumvent Windsor's CUG process (Garcia, 2014b). Furthermore, several interviewees stated

that other factors, including the lack of municipal services connected to the Pace property preventing residential development, influenced the willingness of the Pace family to host the facility (personal interviews).

However, strategic siting was conducted by Great Western for a different project—a representative of Great Western stated that the company chose a drilling location for that project just outside of a particular county's boundaries in order to avoid that county's stringent oil and gas development requirements (personal interview). Furthermore, strategic siting encompasses what two Windsor officials discussed in the town's displeasure that an operator located two large, multi-well projects located just outside of town limits in unincorporated Weld County. These projects are built to Weld County standards—Windsor's CUG process did not apply—and, coupled with the 'tax at the wellhead' legislation, the town receives much of the impacts, but none of the benefits (personal interviews).

Strategic siting is related to the volumetric territory of the municipal hydrocarbon extraction. Horizontal dimensions of territory emerge from the issues at the surface regarding municipal political boundaries and local government permitting processes. State legislation taxing oil and gas production at the location of the wellhead introduces spatial complexities through the importance of considering the vertical extension of municipal political boundaries from the surface to the depths of the subsurface. Furthermore, horizontal wells include both a vertical and horizontal component and these wells may laterally cross the vertical extension of municipal political boundaries from the surface to the subsurface. Multi-well horizontal development projects are designed to 'drain' large volumes of subsurface mineral resources

from a given (more or less) horizontal geologic layer. Thus, these various factors combine to construct the volumetric territory of municipal hydrocarbon extraction.

As mentioned above, whether Great Western's selection of the Pace enclave for their project was a matter of strategic siting is speculative. Whatever Great Western's motive, the consequences for Windsor remained—the town would be subject to the impacts of the development without an opportunity to apply local controls to avoid or mitigate such impacts, and the town would not capture the tax revenue.

Annexation as a territorial strategy for UOGD

The proposed location of the Pace project on the enclave of Larimer County presented several challenges for Windsor officials; the town would be unable to apply local controls to mitigate impacts of the facility and would be unable to capture tax revenue from the production from the wells. Moreover, the enclave was located within the town's growth management area and town officials recognized that future municipal growth issues may arise if the project were to proceed (Garcia, 2014a). Annexation is one strategy municipalities may adopt to address the several challenges that Windsor faced: controlling land uses, managing growth, and capturing tax revenue (Edwards, 2008; Heim, 2012). Indeed, annexation was the strategy the town pursued; however, it was residents, not town officials, that introduced the idea of annexing the Pace property.

Since residents reported that Larimer County officials were not responsive to their concerns regarding the Pace project location, at a town board meeting in September 2014, several residents urged Windsor officials to annex the enclave. Doing so would both subject the

project to Windsor's municipal controls on UOGD through the CUG process and allow the town to formally contest the location of project with the state oil and gas regulatory agency (COGCC) (personal interview; Windsor Town Board, 2014a). Residents did not have formal standing to contest the project location, since COGCC regulations only allow the operator, the surface owner, or the "relevant local government" (COGCC, 2019b) to challenge oil and gas facility siting.

Importantly, horizontal drilling played a key role in the ability to contest the project location, since the technology allows for flexibility in surface location of wells while still being able to develop the same area of minerals (Kroepsch, 2018). Moreover, this same flexibility in surface location of horizontal wells had allowed Great Western to relocate the site of its initial project to the Pace property. This ability stands in stark contrast to spatial dimensions of vertical drilling, such as occurred in Greeley during the 1980s, which requires that a well be drilled directly above the target minerals and, furthermore, state spacing regulations largely dictate the surface location of vertical wells.

The Pace Family opposed annexation, claiming it had been a hastily-pursued process and the family would lose out on financial benefits if Great Western relocated the project (Windsor Town Board, 2014c). Furthermore, the family did not object to neighboring owners' housing development on their own private property—development that changed the character of the Paces' land—and wished residents in the surrounding neighborhoods would respect the family's right to develop their private property (Windsor Town Board, 2014c). A town official noted that relocating the Pace project would respect the Pace Family's property rights in still

allowing for the opportunity to have their minerals developed—horizontal drilling could reach their minerals from an alternative site (personal interview).

Annexation of the Pace property served multiple functions—it allowed Windsor to formally represent resident concerns and contest the project location with COGCC. Furthermore, if the challenge to the location was unsuccessful and the project was to remain on the Pace site, it would be subject to Windsor's CUG process and the town would receive tax revenue. Town officials were receptive to residents' requests to force-annex the enclave despite the Pace Family's objections. Windsor proceeded with the forced-annexation process, which was completed in November 2014 (Windsor Town Board, 2014b; Windsor Town Board, 2014d). Although annexation placed the Pace property within Windsor's jurisdiction, town officials cautioned residents that doing so does not grant the town authority to prevent the project—town officials were aware of limitations on municipal authority established by the *Voss* case as it pertains to oil and gas development (personal interviews). In light of these constraints, a town official stated that it has generally become the town board's position that, if an oil and gas facility is proposed adjacent to Windsor, the town will pursue annexation not only for tax revenue, but also to mitigate impacts of the project by ensuring it is subject to town CUG requirements (personal interview).

The proposed Pace project in Windsor provides only one example of challenges faced by municipal governments when oil and gas development utilizing horizontal drilling occurs in residential neighborhoods.

Two particular spatial characteristics of horizontal drilling identified by Kroepsch (2018)—the concentration of multiple wells onto a single site and flexibility in surface location of wells to develop the same area of minerals—played a significant role in shaping the politics of urban growth surrounding the Pace project. The concentration of numerous wells and associated production equipment onto a well pad located amongst residential neighborhoods along a major thoroughfare raised varying concerns among residents regarding impacts stemming from the intensity of the operations. Town officials also expressed concerns, namely regarding the visual and aesthetic impacts of the large facility. Notably, two residents made a distinction in acceptability of living near hydrocarbon development between vertical and horizontal development, in which a couple of vertical wells would be "reasonable," whereas a large, multi-well facility was considered unacceptable. Flexibility in surface location of wells was also a key factor, raising issues among both residents and officials regarding property rights and property values.

Importantly, flexibility in well location provides a significant challenge for municipal governments regarding UOGD—what I term *strategic siting*, or the ability of operators to intentionally locate oil and gas wells within a particular local jurisdiction that provides more favorable conditions of hydrocarbon development (e.g., lower taxes). Concerns over strategic siting, as well as responsiveness to resident concerns, compelled Windsor officials to force-annex the Pace property in order to contest the location of the proposed extractive facility.

Conclusion

This research is the first study to examine how changes in extractive technologies—namely technological advancements from vertical to horizontal drilling—affect political and spatial issues for urban hydrocarbon development. This chapter provides a comparative analysis of the challenges faced by municipal governments of Greeley during the 1980s, which experienced vertical drilling, and contemporary Windsor, where a horizontal development project was proposed. Through this analysis, I demonstrated that the differences in spatial dimensions of these two drilling technologies served to establish a particular politics of urban growth with regard to drilling in residential neighborhoods.

Vertical drilling disperses individual hydrocarbon wells across the city. In Greeley, this dispersed oil and gas development and the setbacks precluding development around wells created significant challenges for urban growth patterns through competing land uses between hydrocarbon extraction and residential development, particularly as drilling occurred on recently annexed land slated for future urban growth. In contrast, horizontal drilling introduces a significant degree of flexibility in surface location of wells, while still extracting the same hydrocarbon resources. Although this spatial difference alleviates many of the urban growth challenges associated with dispersed vertical wells, it also potentially creates new concerns. In Windsor, the concentration of wells onto a single project site created a more intense site, the location of which created controversy.

The two cases of Greeley and Windsor also point to the significance of municipal political boundaries and (volumetric) territoriality in oil and gas development. Drilling technologies created links between the surface and subsurface, which had different

implications for each of these towns. For Greeley, the potential hazards of subsurface extractive activities expanded how residents and city officials conceived of the space of the city—to include not just the "lived" space at the surface, but also the space underlying the city. The city's ban asserted control over the volumetric space of the city to prevent oil and gas development from impeding residential growth and affecting quality of life for residents. The ruling on the *Voss* case established a precedent upon which state interests in the development of hydrocarbon resources limited municipal control over oil and gas development. In Windsor, municipal political boundaries also played a significant role in the controversy surrounding the horizontal Pace project. The surface location of the project on an enclave within the town prevented the town from exercising local controls over the conditions of development on a parcel of land that was in the town's growth zone. Furthermore, the surface location of the proposed wells combined with "tax at the wellhead" legislation created a situation in which minerals would be extracted from underneath the town, yet the town would not receive financial benefits from those minerals but be subjected to the impacts of such development.

Municipal political boundaries are also important for Windsor in concerns over what I term *strategic siting*. But the intersection of horizontal drilling and municipal boundaries is not just limited to strategic siting, there are also implications for municipal governments. Just as operators can be strategic in benefiting from more favorable conditions of extraction, Windsor was able to manipulate municipal boundaries through annexation to potentially capture tax benefits, as well as enforce local controls on UOGD.

At the time of this writing, Colorado recently passed new oil and gas regulations changing governance of hydrocarbon extraction. The legislation allows local governments to adopt their

own rules regarding oil and gas development within their jurisdiction (Aguilar, 2019). Thus, *strategic siting* could potentially become a more common practice among operators as an effort to circumvent more stringent local government regulations on oil and gas development. In doing so, a local government could potentially adopt more lax local regulations in order to draw in operators to drill from their jurisdiction to capture the tax benefits.

An intermediary drilling technology—directional drilling—received only limited attention in this chapter. Future research might consider the importance of such a drilling technology for municipal planning and growth patterns.

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- Chapter 4 -

Oil and gas development in "the land of the moderate": Perceptions of 'fracktivism' among rural and suburban residents of Colorado's Front Range area

Unconventional oil and gas development (UOGD)—colloquially referred to as "fracking"[7]—has emerged as one of the most contentious, hot-button environmental issues over the past decade. This method of extraction primarily involves two technologies—horizontal drilling and hydraulic fracturing—to extract oil and gas resources from low-permeability, low-porosity unconventional hydrocarbon reservoirs, such as shale and tight-sandstone. Although much of the academic literature, as well as the popular media, have focused almost entirely on hydraulic fracturing, this technique has been used in hydrocarbon extraction for several decades (Montgomery & Smith, 2010). Rather, the shift from vertical to horizontal drilling technology has revolutionized oil and gas extraction, allowing for the development of these unconventional hydrocarbon resources. Vertical development involves drilling a *single* well straight down from a well pad at the surface to access subsurface hydrocarbon resources. Horizontal drilling allows the wellbore to deviate from the vertical position and enter the target geologic formation laterally for distances up to a few miles, commonly with *multiple* wells drilled from a single well pad. Horizontal drilling has introduced a number of significant changes to oil and gas extraction, including the ability to condense wells and production equipment onto a single site, greater flexibility in surface

[7] Use of the term "fracking" (or "fracing") to refer to the entire process of unconventional oil and gas development is a misnomer—hydraulic fracturing is only one process in the larger activity of oil and gas development. Furthermore, the term typically associated with negative connotations (Evensen et al., 2014).

location of wells while still 'reaching' the same minerals, and the capacity to recover hydrocarbon resources underneath existing surface development (Kroepsch, 2018).

UOGD proponents have touted the immense number of economic and environmental benefits provided by this activity (e.g., Devlin, 2015; Sovacool, 2014). On the other hand, a significant number of public health, safety, social, and environmental concerns have been associated with unconventional oil and gas development (e.g., Ladd, 2014; Willow & Wylie, 2014). Controversy surrounding UOGD emerged rapidly in the United States beginning in 2010 with the release of Josh Fox's documentary film, *Gasland* (Mazur, 2016). The public health and environmental consequences of UOGD portrayed in *Gasland* increased conversations regarding 'fracking' on social media, as well as leading to greater coverage in mass media (Vasi et al., 2015). Furthermore, local screenings of the film mobilized many members of the public, especially those in geographic areas hosting such extractive activities, to resist UOGD in their communities (Vasi et al., 2015).

A significant amount of geographic and social sciences literature has examined the various impacts of UOGD on communities, including the risks of rapid industrialization (Jacquet, 2014), environmental hazards and public health risks (e.g., Sangaramoorthy et al., 2016), economic benefits (e.g., Ladd, 2014), and pro-industry discourses normalizing these impacts on communities (e.g., Finewood & Stroup, 2012; Hudgins & Poole, 2014). Other literature has examined the numerous forms that activism and other resistance efforts against UOGD activities have taken (e.g., Simonelli, 2014; Willow, 2014).

Much of the existing scholarship in geography and other social sciences portrays controversies surrounding unconventional oil and gas development as a binary of

stakeholders—anti-fracking activists opposing extractive activities and pro-industry proponents supporting drilling (Evensen et al., 2014). However, I contend that greater complexity exists in perspectives among individuals and groups in areas in which UOGD is taking place. This paper is not the first study to suggest that portrayals of viewpoints on UOGD in much of the existing scholarship are oversimplified as a polarization between those individuals and groups who openly embrace such extractive activities and those actively resisting them (e.g., Luke et al., 2018; Schafft et al., 2013). Attending to the nuances of viewpoints of individuals residing in areas experiencing UOGD provides critical insights into the complexities underlying conflicts and opposition to the activity. Furthermore, forms of resistance to UOGD, as well as motives for such, are commonly lumped together under the generic label of "activism." In fact, such resistance efforts are more heterogeneous than is typically portrayed in academic literature (Luke et al., 2018; Steger & Drehobl, 2018).

I argue that in order to more fully understand opposition to and perspectives on UOGD, scholars cannot merely listen to the most vocal activist responses, nor limit their focus to investigations of efforts undertaken by proponents of UOGD to manufacture support for hydrocarbon extraction in communities, including the activity's social and environmental impacts. Doing so overlooks the many ways in which more "quiet voices" resist or respond to UOGD (Eaton & Kinchy, 2016) and many residents impacted by UOGD adopt nontraditional activist strategies to challenge UOGD in their communities (Luke et al., 2018).

Luke et al. (2018) challenge such oversimplifications in UOGD literature by highlighting the role that place identity and social identity play in influencing rural resident perceptions of and responses to hydrocarbon extraction in their community (Luke et al., 2018). This paper

builds a conceptual framework that draws on Luke et al. (2018), using the Front Range area of Colorado as a study area to examine several factors influencing resident perceptions of and responses to unconventional oil and gas in their community. Through the case of the Front Range, I highlight the importance of 'place' identified by Luke et al. (2018) by examining unique characteristics of the American West as a region in shaping perceptions of and responses to UOGD. This chapter builds on Luke et al.'s (2018) findings by considering two additional factors: variations between residents in suburban and rural settings, as well as differences between vertical and horizontal development.

The shifting geography of energy production from traditional areas of extraction (e.g., coal-mining of Appalachia) to more affluent communities typically unfamiliar with such extractive activities has led to an increase in controversies and debates over UOGD (Kroepsch, 2016; Lave & Lutz, 2014). The Front Range communities of Colorado are one such area of the US where contentious debates over oil and gas development have emerged. Controversies over oil and gas development in Colorado have been attributed an increasing urban-rural divide particularly between the population centers of Denver and Boulder and more rural areas of the state (Handy, 2019; Poulson, 2014; Swanson, 2019). State regulators have characterized these controversies as one of socioeconomic class—that opponents of oil and gas development in Colorado tend to be affluent enough that energy costs are not of concern to them (Cowan, 2013). While these characterizations are undoubtedly debatable, that tensions exist in many Colorado communities where UOGD and residential neighborhoods of the Front Range intersect are indisputable (Paterson, 2017).

This chapter addresses the following two research questions:

1. How do rural and suburban residents of Colorado's Front Range area perceive unconventional oil and gas development in their communities?
2. How do these two categories of residents view resistance efforts by activists to oppose extractive activities, and what alternative strategies do these residents adopt?

My research shows that Front Range farmers possess a strong place identity and connection to their land, and their past experiences with vertical oil and gas development make them more receptive to horizontal UOGD. Suburban residents generally lack a connection to the Front Range as a place and view UOGD in their communities as intrusive and disruptive. I found that both farmers and suburban residents hold relatively negative views of fracktivist efforts to resist oil and gas development; however, several suburban residents indicated a desire for a collaborative relationship with fracktivists. I found that farmers did not report engaging in efforts to oppose oil and gas development, but numerous suburban residents actively resisted UOGD facilities proposed in the neighborhood. My research shows that the resistance strategies undertaken by suburban residents were largely aimed at avoiding characterization as a fracktivist, appealing to the broader public, presenting objective knowledge, and establishing legitimacy and credibility of their claims.

In what follows, I review existing literature on the complexities of perspectives on UOGD before establishing a conceptual framework based on Luke et al. (2018) and highlighting unique characteristics of the American West region as a place. I then use this framework to guide an analysis of farmer and suburban resident perspectives before concluding with final thoughts.

Understanding perspectives on UOGD

Perspectives of proponents and opponents of UOGD

Proponents of unconventional oil and gas development tout its many economic, environmental, and geopolitical benefits. These benefits are particularly salient due to the abundance of unconventional hydrocarbon resources (Sovacool, 2014). The increased production of hydrocarbons through UOGD has led to decreased natural gas prices, which benefits energy consumers, particularly those residing in colder climates who use natural gas for heating (Dews, 2015). For many states in the US, including Colorado, the oil and gas industry injects several billions of dollars into state economies, supports tens of thousands of jobs, and generates billions of dollars in tax revenues—much of which is distributed to local governments and school districts (Xu, 2013). Proponents of UOGD extol its environmental benefits by reducing reliance on 'dirty' coal as an energy source, thereby reducing carbon emissions from combustion, as well as air pollutants such as mercury and sulfur oxides (Sovacool, 2014). UOGD can also reduce reliance on foreign sources of hydrocarbon resources, providing the US with 'energy independence' and 'energy security' (Coloradans for Responsible Energy Development, 2019). Proponents of the oil and gas industry have framed UOGD through ideals of liberty and patriotism, environmental conservation, and scientific expertise (Matz & Renfrew, 2015). Furthermore, proponents view environmental and public health and safety risks commonly associated with UOGD by opponents of the activity as unlikely, potential, or hypothetical. The oil and gas industry often attributes much of this characterization to misinformed, biased, or confused individuals and groups (Devlin, 2015). Moreover, the petroleum industry tends to

view public resistance to UOGD as stemming from misunderstandings of science and failure to recognize that technologies can manage safety and health concerns (Williams et al., 2017).

Concerns among opponents of UOGD regarding its negative economic, environmental, social, and health impacts have generated resistance to the perceived intrusion of industrial extractive activities into communities and associated threats (Simonelli, 2014; Willow, 2014; Wright & Boudet, 2012). In areas facing proposed UOGD projects, residents have mobilized around concerns of groundwater contamination, public health and safety, air quality, quality-of-life impacts, and overall environmental degradation to resist such extractive activities (Ladd, 2014; Staggenborg, 2018; Willow & Wylie, 2014). Opponents of UOGD have employed a variety of strategies to contest the activity, from community organization to outright acts of civil disobedience, such as chaining themselves to bulldozers (Simonelli, 2014). Other strategies have included challenging local government policies on the activity by utilizing ballot initiatives to pass bans or moratoria on drilling at the local level (Simonelli, 2014). Residents in communities facing the prospect of large UOGD facilities sited in their neighborhood may perceive this as a threat to their sense of place. Often, those residents respond in such ways to avoid being labeled an 'activist,' even though they are engaged in activities in opposition to UOGD (Luke et al., 2018).

Complexities of perspectives

Although the literature discussed above provides important insight as to the perspectives of both proponents and opponents of UOGD, it fails to capture the full range of perspectives on UOGD among residents in communities experiencing hydrocarbon extraction

activity. Several studies have demonstrated that a number of factors influence public perceptions of, and thus varying levels of support for, UOGD. These variables include gender, socioeconomic status, political identity, urban versus rural residents, education level, and trust in the oil and gas industry (Boudet et al., 2013; Boudet et al., 2014; Clark et al., 2015; Davis & Fisk, 2014; Mayer, 2016; Mayer, 2017). Other studies have shown that risk perception plays an important role in understanding variations in viewpoints regarding UOGD among the public, including involuntary exposure to potential risks, familiarity with extractive industries, and potential negative impacts on vulnerable populations, among other factors (Graham et al., 2015). Proximity to areas undergoing active development of hydrocarbon resources also serves as a factor determining level of support for UOGD (Clarke et al., 2016; Zanocco et al., 2019). Although a limited amount of social sciences literature has explored the complexities of perceptions on UOGD, this scholarship has largely focused on the tradeoffs individuals report regarding the economic benefits of such activity versus concerns regarding its social and environmental impacts on host communities (e.g., Ladd, 2014; Schafft et al., 2013). What is less known, however, is how these varying perceptions of UOGD motivate responses in communities, as well as different levels of engagement in efforts to resist UOGD.

Research on UOGD has begun to explore such complexities among resident responses to UOGD entering their community. In smaller and more cohesive communities, differences exist among individuals with regard to experiences and perceptions of the impacts of UOGD—whether positive, negative, or neutral (Schafft et al., 2013). Residents of many communities are often conflicted between welcoming the local economic benefits UOGD can offer with the socioenvironmental consequences that may follow (Ladd, 2014). Landowners may be

apprehensive about allowing UOGD on their property, yet feel as though it is their patriotic duty to participate in oil and gas development since it reduces domestic reliance on foreign oil and, thus, contributes to domestic energy independence (Perry, 2012). Other literature has examined the unexpected satisfaction of surface owners in split estate arrangements hosting extractive activities on their property (Bills Walsh & Haggerty, 2019).

How residents respond to the arrival of UOGD in their community can also take many different forms, with some residents avoiding traditional activist actions such as marches, rallies, or demonstrations (e.g., Luke et al., 2018). Lack of vocal opposition or mobilization for collective action among residents in areas experiencing unconventional oil and gas development does not necessarily imply contentment with or indifference to the presence of extractive industries. These residents may engage in individual actions to convey their grievances such as through confrontations with oil and gas workers or filing police reports (Eaton & Kinchy, 2016).

Conceptual framework

This chapter draws on Luke et al. (2018) to build a conceptual framework for analysis, since the themes Luke et al. (2018) identify resonate well with the interview data collected as part of my research. However, what distinguishes my findings from those of Luke et al. (2018) is attention to the implications of different drilling technologies—vertical and horizontal drilling—on resident perceptions, as well as differences between suburban and rural perspectives.

Luke et al. (2018) challenge the oversimplifications in UOGD literature discussed above by examining activism and resistance to unconventional hydrocarbon development through a

comparative study of rural communities experiencing UOGD in four countries. Through an examination of resistance to UOGD in regions of the Netherlands, Canada, Australia, and northeastern United States, Luke et al. (2018) examine how *place identity* and *social identity* influence resident acceptance of or resistance to UOGD.

Luke et al. (2018) draw on environmental psychology in their use of the concept of "place identity" to refer to the ways in which individuals internalize components of the physical environment into their sense of self. Geographers, however, have argued that such internalist notions of places and place identities are problematic, since places are constructed through social relations and interconnections with other places, and place identities are often incorrectly rooted in historical conceptions of the 'true' characteristics of a place (Massey, 1995). Furthermore, multiple and variegated place identities exist among individuals in a given place, and these variations in place identities result, in part, from connections and influences to other places (Castree, 2009).

Place identity and social identity also shape social responses to such extractive activities in different ways. The authors argue that how communities associate with UOGD is largely dependent upon place identity. Furthermore, many communities view activism as incompatible with their social identity; activism being generally regarded as an activity undertaken by 'outsiders.' From this rejection of traditional forms of activism emerge alternative forms of resistance to UOGD, which often draw on 'knowledge' and 'information' to portray resistance efforts as objective and neutral (Luke et al., 2018) (Table 2).

Luke et al. (2018) contend that UOGD can affect place identities through embodiment or disruption of autobiographical factors of past, present, and future connections to places, its

Table 2. Themes identified by Luke et al. (2018)

Themes	Description
How place identity shapes views on unconventional gas development	
Connection to past, present, future	Past history of personal experiences, relations, and memories attach individuals to a place; preserving a place for future generations
Visual amenity	Relationships and identifications with a place; natural beauty; visual amenities; rural idylls
Economic dimensions of place identity	Farming and agriculture connects rural residents to the landscape
(Non) Activist identifications	
How activists are portrayed/perceived	"Professional activists"; "fringe" individuals and groups
Distrusted activism	Past tensions and historical relationships
Activist outsiders	Resistance emerges from outside of UOGD areas; questionable motives and interests; "newcomers"
Accepted activism	Former activists lead new movements
(Non) Activist acts of resistance	
Following the rules, staying within the law	Abiding by legal regulations; finding appropriate legal spaces; avoiding civil disobedience
Distancing from activism	Mobilizing the broader public; involving traditionally conservative people
Production and dissemination of 'objective' knowledge as an act of resistance	Locally trusted knowledge; factual and scientific information and knowledge; avoiding emotion

visual impacts on the physical landscape, and its influences on the economic dimensions of places. Residents of UOGD communities may reject a social identity as an 'activist' due to negative connotations associated with the label (Lloyd et al., 2013; Luke et al., 2018), distrust of activism through perceived dissemination of incorrect or biased information (Koehne & Rasch, 2018; Luke et al., 2018; Steger & Drehobl, 2018), or uncertainties regarding the motives or interests of activists as 'outsiders' (Luke et al., 2018). Rather, residents who reject 'activist' characterizations often employ strategies of resistance that work within existing rules and laws, distance themselves from the activities and viewpoints of more vocal activists, and work to construct and disseminate knowledge regarding UOGD that is considered more 'neutral,' 'objective,' or more locally trusted (Luke et al., 2018).

UOGD and the American West

Although Luke et al. (2018) provide a useful comparative study incorporating regions of four countries across three continents, there are many regions of the US, as well as globally, that are undergoing UOGD and warrant similar consideration as to the role that place identity and social identity play in resident efforts in accepting or resisting UOGD. This paper examines controversies surrounding UOGD in Colorado's Front Range as a part of the broader region of the American West.

The arrival of UOGD to Colorado's Front Range area has reinvigorated debates regarding the relationship between productive economic activities, particularly extractive industries, and the American West as a region (Kroepsch, 2016). Such debates challenge what many scholars have referred to as the 'New West' (e.g., Riebsame et al., 1997), which has been characterized

by a shift from an economy based on traditional, productive activities (e.g., agriculture, resource extraction) to that of natural amenities, recreation, and high-technology and service industries (Albrecht 2004; Beyers & Nelson 2000; Kroepsch, 2016). Explosive population growth has accompanied this economic restructuring, which has led to significant social and demographic changes (Smith & Krannich, 2009). This in-migration to the American West has led to social tensions and conceptions of an urban-rural divide among so-called 'newcomers' and 'old-timers' (e.g., Smith and Krannich 2009). Fulkerson and Thomas (2014) have attributed such social tensions to 'urbanormativity', or the generally unchallenged privileging of urban life, values, and concerns over those of rural people and places. Thus, differences between newcomers and old-timers, as well as urban and rural settings, can create distinctions of place identities and social identities. The intersection of the housing and population boom with hydrocarbon extractive industries in Front Range Communities of Colorado has not only caught many residents—including recent in-migrants—by surprise, but has also resulted in significant controversies over project proposed in residential neighborhoods (Haggerty et al., 2018).

A significant limitation to much of the New West literature is its overreliance on demographic and economic transitions to explain to differences and conflicts between traditional, historically productivity-based communities and amenity-based communities (Beyers and Nelson 2000; Robbins et al. 2009). Robbins et al. (2009) have challenged many of the assumptions and research findings in the literature on the 'New West', particularly with regard to economic transition, social conflict, and environmental change. 'Old West' economies are still important for many communities, and amenity, service, and high-tech economies have arisen alongside existing traditional extractive economies. Although much of the 'New West'

literature has attributed conflict over issues of the environment or natural resource management to cultural and socioeconomic differences between 'newcomer' amenity migrants and old-timers, Robbins et al. (2009, p. 365) contend that "environmental priorities reflect economic interests as much as cultural differences, thereby troubling the distinction."

Just as perceptions of unconventional oil and gas development are replete with complexities, so too are resident responses to UOGD in their communities. Luke et al. (2018) identify such and examine how matters of place identity and social identity influence resistance efforts to UOGD adopted by residents who eschew being labeled an 'activist' or engaging in activities associated with 'activists.' The Front Range of Colorado is one area of the American West region experiencing a boom in unconventional oil and gas development. In what follows, my aim is to build on Luke et al.'s (2018) findings by considering the place-specificity of the Front Range in influencing (non-)activist efforts to contest UOGD.

Study area and research methods

The Front Range area of Colorado is one of several parts of the American West that has experienced a boom in UOGD over the past decade. The Front Range includes the communities situated along the Interstate 25 corridor, east of the Rocky Mountains, and between Denver and Fort Collins. This area of Colorado has also undergone a significant population boom over the past few decades. The Front Range is a semi-arid region comprised of grasslands and shrubs, as well as agricultural fields, in the undeveloped areas of the Front Range. The relative flatness of the Front Range region and its location just east of the Rocky Mountains provides remarkable mountain views.

The study area includes both the 'industrialized countryside'—where agriculture and UOGD overlay one another—and suburban populated areas of 'petro-suburbs' (Haggerty et al., 2018). Weld County, the southern and western portion of which comprises a substantial part of the Front Range area, contains just under two million acres of agricultural land, is the top agricultural-producing county in Colorado, and consistently ranks in the top ten among all counties across the US (Weld County Department of Planning and Zoning, 2019). Weld County leads the state in dairy production, beef cattle, sugar beets, and grain (Weld County Department of Planning and Zoning, 2019).

Although the Front Range of Colorado is an epicenter of unconventional oil and gas development in the American West, and indeed the United States more broadly, it has not received the level of attention among researchers that other states such as Pennsylvania have received (Mayer, 2016). UOGD in Colorado warrants further investigation not simply for the sake of geographic diversity, but particularly because the Front Range area is one of only a few locations in the US where UOGD intersects with suburban landscapes (Haggerty et al., 2018). The Front Range area of Colorado is located at the nexus of urban settings—namely Denver and Boulder—their suburbs, and the agricultural lands of eastern Colorado.

The primary data used for this study are transcripts of semi-structured personal interviews conducted with fourteen residents of Front Range communities in Colorado conducted during ten months of ethnographic fieldwork between September 2016 and June 2017. The interviews ranged between one to three hours in duration. Potential research participants were primarily identified by their names appearing in newspaper and other local media sources, and recruited through mail. Snowballing methods were also used to recruit

additional research participants. Of these research participants, ten were inhabitants of suburban communities and the remaining four were farmers who lived in rural areas of Weld County located a short distance from a nearby suburban center. The suburban residents were a mix of individuals who either lived near UOGD facilities or had one proposed near their home, whereas the farmers all hosted oil and gas facilities on their property—both wells and production equipment, in addition to pipelines. Newspaper articles are also used in this study to provide additional information beyond that obtained during interviews.

To be clear, no claim is being made that the small number of research participants included in this paper are necessarily representative of the full spectrum and complexities of perceptions, experiences, and positions of the broader population of residents in the Front Range area with regard to UOGD. Rather, the depth of the interviews provided rich material from which key themes could be extracted, several of which have been further informed and corroborated through the numerous informal interactions part of the author's larger ethnographic fieldwork, including conversations at community events, dog parks, bars and restaurants, laundromats, and recreation trails.

In what follows, I draw on Luke et al. (2018) to first illustrate how aspects of place and social identity figure into individuals' perceptions of and relationship to UOGD, distinguishing between those of rural farmers and suburban residents. Next, I discuss how interviewees understood and viewed the perceptions and activist efforts among the fervent opponents of UOGD in the Front Range—"fracktivists"—as well as positioned themselves in relation to the fracktivist categorizations. I then highlight specific actions undertaken by residents to resist UOGD in their community and how they situated these efforts relative to those of fracktivists.

UOGD and place identity in Front Range communities

Luke et al. (2018) discuss the significance of place identity in influencing resident experiences of actual or potential UOGD in their community. Resident relationships to the landscape play an important role in shaping place identity and, thus, the impacts of UOGD on landscapes—whether actual or perceived—affect perceptions and degree of acceptance of UOGD in communities (Luke et al., 2018). Autobiographical factors, relationships with the physical landscape, and economic dimensions emerged as the most salient components of place identity in the case studies analyzed by Luke et al. (2018).

This section illustrates similarities and differences among suburban and rural residents. Notably, interviews with farmers illustrated their deep connection to their farms, their familiarity with oil and gas development, and how horizontal drilling has made them more receptive to oil and gas development on their land. Suburban residents in this study were a mix of both longtime residents of several decades, as well as relative 'newcomers' to the Front Range region with less connection to their home or the Front Range as a place.

Personal connections and place identity

Stark differences existed between farmers and suburban residents regarding their identification with the Front Range as a place. The farmers had rich stories to tell about their history and relationship with their land, having spent all or most of their lives living and working on their farm. Suburban residents' responses during interviews provided mixed views regarding personal connections to their land, with longtime residents suggesting greater ties than newer residents did.

Histories of both farming and extractive industries serve to construct a sense of place for the farmers in Weld County. The people I interviewed all have a deep history with the landscape of Weld County, having farmed the land for several decades (personal interviews). For three of the farmers, their farms have been passed down over several generations, two of whose ancestors received title to the land through homesteading (personal interviews). Homesteading was a policy implemented by the US federal government in the mid-19th century to encourage settlement of the American West by granting predominantly white US citizens 160 acres of land in return for settling on and working that land for five years. The third farmer purchased his farm several decades ago on which he raised his family, members of which have continued to work the farm. The fourth farmer inherited the farm, which his father and uncles had purchased during the 1940s. The family histories in working the agricultural land provide deep connections to the landscape of Weld County, which these farmers wish to preserve for future generations (personal interviews).

All of the farmers interviewed had prior experience with vertical oil and gas development on their land. The arrival of vertical oil and gas development on these farmers' lands during the 1980s and the resurgence of extraction from the UOGD boom have provided financial benefits to these farmers, which help them weather downturns in commodity prices (personal interviews). As one farmer noted, often his royalty checks from the oil and gas production on his land are worth more than his crops (personal interview). The income provided by oil and gas development on agricultural land helps these individuals maintain their farms for future generations (personal interview).

While these farmers did not perceive UOGD to be a threat to their livelihood, these farmers felt that urbanization of the Front Range area and conversion of agricultural land to housing and commercial development did pose a threat (personal interviews). These individuals were aware of other farmers who received large sums of money selling their agricultural land to developers looking to build subdivisions. Furthermore, one farmer noted that municipalities in Weld County have purchased farms in order to gain those farmers' water rights and incorporate the irrigation water into the municipal water supply (personal interviews). Water is an already scarce resource in the semi-arid Front Range area of the High Plains, on which a population boom and increasing urbanization contribute additional stress (US EPA, 2019). Another farmer noted that, although hydraulic fracturing requires substantial volumes of water, many irrigation companies in Weld County have benefitted immensely from selling excess water to oil and gas entities during 'wet' times where the needs of all water rights holders are being met (personal interview).

Many of the suburban residents interviewed lacked memories and deep personal experiences with the Front Range as a place, having moved to the area within ten years or less at the time of fieldwork (personal interviews). However, those residents who had lived in the Front Range for several decades or their entire lives discussed changes they have seen occur in Front Range communities, notably the significant growth of the area—what were once small towns are now part of the urban sprawl of Denver (personal interviews). One resident mentioned that many of her friends from high school who had moved away are now returning to Colorado because "it's such a beautiful place to live" (personal interview).

Natural amenities

Physical changes to the landscape as a result of UOGD can have a deleterious effect on individuals' relationships to a place by negatively impacting the visual and environmental character of that place (Luke et al., 2018; Sangaramoorthy et al., 2016). In discussing the visual impacts of UOGD, many residents highlighted distinctions between vertical and horizontal development.

The Weld County environment has been characterized as one in which "the natural landscape and vegetation predominate over the built environment. Agricultural land uses and development provide the visual landscapes traditionally found in rural areas and communities" (Weld County Department of Planning and Zoning, 2019).

For the farmers, oil and gas development, whether vertical development during the 1980s or contemporary horizontal development, did not significantly change their relationship with the environmental amenities of Weld County (personal interviews). One farmer noted the recent increase in oil and gas production facilities appearing on agricultural land in Weld County and "dotting the landscape…changes things a little bit"; however, because of the size of farmers' properties, those facilities are generally located far enough away from their homes so as not to interfere with views of the mountains (personal interview). In addition, several of the farmers remarked that the location of oil and gas facilities in and around agricultural fields did not diminish the visual aesthetics and rural character of their farm or surrounding area (personal interviews).

Longtime suburban residents differentiated between the impacts of vertical and horizontal development on their perceptions of the landscape. Two residents reported seeing a

couple of pumpjacks around their neighborhood during the 1980s, but felt that this production equipment was relatively unintrusive and did not significantly affect the aesthetics of the neighborhood (personal interviews). However, these residents reported that the construction of large, multi-well horizontal development facilities in their neighborhoods significantly affected enjoyment of their home. During the drilling phase, not only did the drilling rig and sound walls surrounding the site serve as an eyesore, but the lights, noise, vibration, and increased traffic impacted home life (personal interviews). Because of these impacts, one resident noted that he was no longer able to enjoy views of open space and pastures behind their house while relaxing on his deck (personal interview). Not only did the sound walls of a drilling site block one resident's view of the mountains, she also explained how the arrival of the UOGD facility near her home ruined the character of her unique property in a residential neighborhood—property with a flowing stream which helped support "the last little bit of sanctuary for what wildlife is left" (personal interview).

All suburban residents of Front Range communities described the appearance of UOGD facilities as changing the character of their neighborhoods, as well as the broader communities themselves (personal interviews). UOGD was unanimously viewed as incompatible with the character of residential neighborhoods. Residents were dismayed by the intrusion of industrial activities of UOGD on residential landscapes, with one resident referring to drilling in suburban locations as "the industrialization of our neighborhoods" (personal interview). Residents discussed how UOGD had or would introduce various risks into their residential landscapes, including safety concerns regarding potential leaks and explosions, as well as health concerns regarding facility emissions (personal interviews). In speaking about the boom in vertical

development in Front Range communities during the 1980s, one resident remarked that "suddenly you're saying that this is more of an oil and gas field than an area that is even *able* to support residential development" (personal interview).

Differences exist among farmers in rural landscapes and those of residents in suburban areas regarding their personal experiences and connections to place, as well as perceived aesthetic impacts of UOGD on landscapes. Farmers found UOGD, as well as vertical development, to be largely compatible with agricultural activities and rural landscapes. Many residents of suburban areas accepted small-scale, vertical oil and gas development, but rejected UOGD as an industrial activity incompatible with the landscape of residential neighborhoods.

Economic aspects and place identity

Farming is associated with how residents in rural UOGD communities construct a place identity, since their livelihood is intimately connected to the landscape (Luke et al., 2018). In their case studies, Luke et al. (2018) discuss mixed perceptions among farmers regarding the compatibility of UOGD with agricultural economic activities. In Weld County, agriculture is not only a defining characteristic of the rural landscape, but also serves as a primary economic activity, in addition to oil and gas development. Conditions of the physical environment—including climate, water quality, and availability of feed for livestock—position the county as an ideal landscape for agricultural production (Weld County Department of Planning and Zoning, 2019). As discussed above, farmers in Weld County have embraced UOGD as compatible with agricultural place identities. Furthermore, many farmers report a close working relationship

between the agricultural and oil and gas industries—a relationship that has changed significantly from the days of vertical development of the 1980s (personal interviews).

When the first oil and gas boom emerged in Weld County during the 1980s, the relationship between the oil and gas industry and agriculture was contentious (personal interviews). One farmer remarked that, at that time, "you had a real bully attitude from the oil companies. They wanted to pay just nominal amounts for surface damages [to agricultural land]. The fact that you could raise $5,000, maybe $10,000 per acre in a given year, and they wanted to give you maybe $500 for crop damage for making a mess of your field" (personal interview). State spacing regulations that dictated location and distances between oil and gas wells typically placed wells in the middle of agricultural fields, which disrupted irrigation practices and made it hard to farm around these facilities (personal interviews). In recent years, many farmers reported a vastly improved relationship with the oil and gas industry, since horizontal drilling technology has allowed oil and gas companies to locate their production facilities at the edges or in the corners of agricultural fields, thereby minimizing intrusions and disruptions to farming practices (Brown, 2015; personal interviews). Thus, horizontal drilling has played a significant role in making farmers more receptive to oil and gas development.

However, although farmers are generally receptive to UOGD, related infrastructure—namely pipelines—has caused a fair amount of tension (personal interviews). Although companies installing oil and gas pipelines pay farmers for easements across their property and must pay for crop damage, the construction of pipelines negatively impacts agricultural activities, including damage to soil quality and irrigation systems, as well as reduces the value of the land (personal interviews). Furthermore, farmers who resist construction of pipelines across

their property have been threatened with eminent domain (personal interviews; Sweeney, 2016).

Economic place identity for suburban residents I interviewed was quite different from that of farmers, largely due to the fact these suburban residents did not rely on their land for their livelihood. However, suburban residents had an investment in their home and their land and, thus, their economic place identity concerns revolved around property values. As one resident noted, the prospect of a UOGD facility sited in his neighborhood threatened his home as an investment—the largest investment he will ever make during his lifetime (personal interview). Similarly, another suburban interviewee remarked of the UOGD boom in the Front Range area, "the biggest risk right now is oil and gas impacts to home values on neighboring properties…homes are people's biggest investment—hundreds of thousands of dollars" (personal interview). Another resident with a real estate background spoke of the significant depreciation in her property value due to the siting of a large UOGD facility adjacent to her property, which she estimated to be in the tens of thousands of dollars. Her property is unusual for a suburban setting, having a stream running through it, and the construction of the UOGD facility next to her home will likely make the property difficult to sell—"it's a lot easier to sell a home next to other homes than next to a 22-well oil and gas facility. People don't want to live with that, especially if they have kids" (personal interview). Another resident stated that it is "not American" when a UOGD facility can be located near residents' homes and negatively impact their property values. In speaking about negative impacts to property values from UOGD facilities, several residents noted the inequity that results from negative impacts on the values

of surrounding properties—impacts that residents are not compensated for (personal interviews).

Characterizations of fracktivists

In communities where UOGD produces perceived threats to place identity, resistance to hydrocarbon extraction among residents may result (Luke et al., 2018). How this resistance unfolds and the specific actions or strategies adopted is often contingent upon social identities. Examples of social identities include 'environmentalist,' 'farmer,' and 'activist.' These social identities may lead to residents rejecting identification with 'activists' or being labelled as such, perceiving of activists as outsiders (Luke et al., 2018). 'Locals' may undertake efforts to delegitimize activism by 'newcomers' to an area, since the actions of these 'outsiders' are frequently viewed as unrepresentative of true 'local' perspectives and attitudes, particularly those of individuals considered "professional activists" (Luke et al., 2018; Steger & Drehobl, 2018). The legitimacy of anti-UOGD activism may be scrutinized along several lines, including credibility of knowledge and expertise, accuracy in representation of local, state, or national concerns, as well as validity of arguments and empirical claims (Steger & Drehobl, 2018).

Indeed, many of these same issues surrounding characterizations of fracktivists were reported by residents of the Front Range that participated in this study. In this section, I use Luke et al. (2018) to guide my analysis; however, I also deviate from their framework in important ways. I begin by discussing how residents explained the complexities of defining and labeling a 'fracktivist' in order to provide context for how the term is used. I then discuss interviewees' perceptions of fracktivists. Here, too, I depart from Luke et al. (2018), who focus

solely on perceptions and portrayals of activists in relation to social identities. Although matters of social identity emerge from resident responses, I add to Luke et al. (2018) in highlighting ways in which the residents positioned their views on UOGD in relation to their understandings of fracktivist views on UOGD. Next, I discuss perceptions of fracktivists as 'outsiders' or 'newcomers' to the Front Range. I then provide a third significant departure from Luke et al. (2018) in highlighting the theme of fracktivist credibility that emerged from interviews with residents. I conclude this section by discussing how interviewees characterized fracktivist strategies to resist UOGD.

Defining and labeling 'fracktivist'

A number of suburban residents explained that the term "fracktivist" is used pejoratively in much of the public discourse in the Front Range area, as well as Colorado, more broadly. Many of these residents mentioned specific high-profile or mediagenic individuals who have opposed UOGD as exemplar of a fracktivist (personal interviews). Several characterizations of fracktivists emerged during interviews with Front Range residents, including fracktivists as un- or misinformed regarding the technical, legal, and regulatory processes and complexities of UOGD, fractktivists' association with and funding from out-of-state environmental groups and wealthy individuals with particular political agendas, exaggerated perceptions of risks associated with UOGD, and participation in traditional activist activities such as demonstrations and protests (personal interviews). The most salient distinctions between fracktivism and other opposition efforts toward UOGD made by interviewees was that fracktivists are against *all* UOGD occurring, rather than give

consideration to locations (e.g., rural or undeveloped areas) where it might be appropriate, and that fracktivist viewpoints are not reflective of broader sentiments among Colorado citizens regarding UOGD (personal interviews). Several of these characterizations are woven into and expanded upon in the remainder of this chapter.

A couple of suburban residents highlighted how public perceptions of opposition to UOGD in Colorado tend to be polarized, troubling their perceptions of the distinctions between fracktivist activities and other efforts to oppose UOGD. One resident who has publicly opposed UOGD in residential neighborhoods stated that "the industry doesn't understand the difference between a 'responsible development' viewpoint and a [name redacted] or fracktivist that wants to see no development. Most people would probably fail to make that distinction either" (personal interview). A different resident who resisted UOGD in her neighborhood stated that, by some people's definitions, she could be considered a fracktivist; however, she claimed that "I'm a citizen, I'm a homeowner, my concerns are based on oil and gas drilling in municipalities, in a zone where no other industry could intrude" (personal interview).

Perceptions of fracktivists

Luke et al. (2018) provide limited information on portrayals and perceptions of activists—"professional activists," activists as 'outsiders.' This latter theme is important in my findings, but is addressed separately in the following section of this chapter.

During interviews, many residents made an explicit distinction between their viewpoints on unconventional oil and gas development and those of fracktivists. In these interviews, as well as during several informal conversations with Front Range residents during my fieldwork,

fracktivists were often referred to as “leave it in the ground” people, meaning they do not wish to see any oil and gas development occur anywhere, at any time (personal interviews).

The Front Range farmers interviewed as part of this study held a variety of views on fracktivists. One farmer I interviewed likened fracktivists to environmentalists who have criticized him and other farmers he knows for “dumping pesticides” on their fields—“[we] don’t, because it’s expensive and it would ruin the soil and water…farmers are very environmentally conscious” (personal interview). Fracktivists were characterized by one farmer as “Luddites that are afraid of technology–the modern Luddites are the people who don’t want to ‘frack’ and are scared to death of our GMO corn” (personal interview). Another farmer questioned the motives of fracktivist groups fighting oil and gas development in Colorado. He viewed these groups as seeking publicity for their own sake, and he doesn’t feel that they can actually prove that ‘fracking’ is harmful (personal interview).

Suburban residents I interviewed also questioned the motivations of fracktivists. One resident reported that some of the fracktivists think of the Front Range as a “sacrifice zone” and wish to see the area ruined environmentally so that it can become the “poster child” for anti-‘fracking’ efforts. Furthermore, this resident viewed some fracktivists as “tied up in not solving the problem, but being part of the drama around the problem,” and “get caught up in those kinds of roles, identities, egos…” (personal interview). Another resident viewed the most extreme fracktivists as “fueled by negative energy and anger” (personal interview).

A significant theme regarding perceptions of fracktivists that was identified through my research was that several of the farmers and suburban residents claimed that fracktivists fail to recognize the importance of oil and gas to society, as both an energy resource as well as for

petrochemicals (personal interviews). Many of these interviewees expressed a desire for a transition away from fossil fuels as an energy source, but recognized the limitations of alternative energy sources (personal interviews).

Two of the farmers interviewed discussed farmers' reliance on oil and gas to run their equipment, such as tractors (personal interviews). One farmer stated that, "folks in agriculture rely on oil and gas because there are no electric tractors yet and, until there is, farmers will rely on fossil fuels to run farm equipment" (personal interview). Another farmer stated that, "agriculture requires oil and gas for running farm equipment and transporting agricultural products, and there just aren't any viable substitutes for oil and gas in this regard" (personal interview). Furthermore, his father and grandfather farmed using horses and mules and he does not want to do that—"that's a lot of work" (personal interview).

Suburban residents also considered alternative energy and modes of transportation. One resident wished that the infrastructure existed for individuals to use electric trains for transportation, but did not see that a ban on oil and gas development would make that a quicker transition (personal interview). Another resident supported automobiles powered by compressed gas, especially as the fuel efficiency of cars is increasing, but noted the limitation is that the infrastructure to fill a compressed gas tank for cars does not exist yet (personal interview). A significant limitation reported by one resident was that electric cars are suitable mainly for in-town trips but not for long distances, and that needs to be taken into consideration (personal interview).

Several suburban residents noted that they either had solar panels on their homes or were considering them (personal interviews). Two of these residents noted a characteristic of

the physical environment of Colorado—abundant sunshine—that made solar energy a viable option for home energy needs in the Front Range area (personal interview).

Fracktivists as outsiders

Skepticism among local residents regarding resistance to UOGD may emerge from what Luke et al. (2018) characterize as 'activist outsiders.' Here, efforts opposing UOGD arise from places other than those in which such extractive activities are proposed or actually occur, leading residents to distrust the interests and motives of these activists. Additionally, residents often perceive UOGD activism by 'newcomers' to an area with suspicion or cynicism, questioning whether their efforts actually represent the concerns of 'real locals' (Luke et al., 2018). Although a few interviewees attributed fracktivism to 'newcomers,' or recent in-migrants to the Front Range area, other themes emerged during interviews, including a perceived urban-rural divide and matters related to environmental imaginaries.

The Front Range suburban residents I interviewed attributed statewide ballot measures to impose highly stringent regulations on UOGD, as well as efforts to ban the activity outright, to urban residents of Denver and Boulder (personal interviews). Regarding initiatives to place anti-oil and gas measures on state ballots, one resident remarked that Denver and Boulder residents "will sign anything" (personal interview). One resident claimed that residents of Denver and Boulder ought not have a say in oil and gas-related matters, since UOGD does not occur in their cities and does not affect them (personal interview). Furthermore, one resident stated that most of the people in Denver and Boulder have never seen an oil or gas well, and never will (personal interview).

The farmers I interviewed viewed fracktivism as an urban phenomenon and attributed it to an urban-rural divide. One farmer attributed recent efforts to enact a statewide ban on oil and gas development to urbanites—"if you take Denver, Boulder, and Fort Collins, you could get any ballot initiative passed because they have the numbers, the population…the demographics of Colorado *is* the Front Range" (personal interview). The urban-rural divide was also related to the agricultural landscape, with one farmer stating that "the closer you get to this [agricultural fields] and the productive people, the less concerned they seem to be about all the worries that people might have. But the closer you get to the producers who are out there producing agriculture products, and the producers who are producing oil and gas…the more real that feels" (personal interview).

Both farmers and suburban residents also attributed fracktivism to the population boom of the region and in-migration of individuals from outside of Colorado, as well as environmental imaginaries of Colorado. Many residents viewed the population boom as primarily due to an influx of people from California and Texas (personal interviews), which was also supported through informal conversations. Although scholars have challenged New West characterizations of social tensions as a matter of 'newcomers' versus 'old-timers' (e.g., Robbins et al., 2009), responses during interviews indicated that this was certainly a sentiment among several residents (personal interviews).

One long-time suburban resident regarded much of the population boom in Front Range communities as stemming from individuals moving to Colorado holding particular environmental imaginaries of Colorado as a picturesque mountain landscape with a favorable climate abounding with outdoor recreation opportunities (personal interview). This resident

understood these individuals as naïve to Colorado's deep past with extractive industries and the history of oil and gas development in the Front Range area, including recent UOGD in residential neighborhoods. Furthermore, she expressed limited sympathy for newcomers to Front Range communities who resist UOGD projects in their neighborhood—these individuals are "heartbroken that fracking's going to take away their dream of Colorado…Colorado's an oil patch" (personal interview).

Credibility and legitimacy

Many Front Range residents that were part of this study viewed numerous fracktivist claims regarding the public health, safety, and environmental risks and impacts of UOGD with skepticism. Several of these residents also viewed fracktivists as having incomplete knowledge regarding the technical, legal, and regulatory aspects of UOGD (personal interviews). These shortcomings illustrate perceived issues of credibility and legitimacy of fracktivist knowledge and claims.

One suburban resident stated of fracktivists, "they don't want to understand [oil and gas development]. It's hard to understand oil and gas development. It's complicated…there aren't any easy answers…technical, legal…understanding legally what's going on" (personal interview). He added that fracktivists often incorrectly cite a particular Colorado researcher's studies on public health and safety risks of UOGD as justification, and that researcher "will tell you that she's been more misinterpreted by the fracktivists than by anybody in the industry" (personal interview). Another suburban resident, who is a health care professional, viewed many fracktivist claims regarding the environmental and public health impacts of UOGD with

skepticism, even when fracktivists cited academic studies. She viewed fracktivists as not fully comprehending studies on the environmental and public health impacts of UOGD, namely the limitations to such studies and the fact that "the conclusion of many of these studies is that more studies need to be done" (personal interview).

This resident also questioned fracktivist claims about the environmental impacts of UOGD on air quality and groundwater contamination in Front Range communities. She stated that it is difficult to pinpoint sources of pollution and questioned whether air quality issues along the Front Range are due to oil and gas development, or whether it is due to the population boom, urban sprawl, and increased automobile traffic along the Interstate 25 corridor (personal interview). Potential groundwater contamination from UOGD was a not a concern for this individual since the municipal water supply comes from snowmelt in the mountains; however, if the municipal water source was groundwater, she noted that that would be cause for concern (personal interview).

Farmers, too, were skeptical of fracktivist claims about the environmental impacts of UOGD. One farmer believed that the air quality in Colorado has gotten better over the past decade, rather than worse from UOGD, as fracktivists claim. He added that many fracktivists do not recognize that things have gotten better, that a lot of the environmental problems of the past—like air pollution—has been cleaned up. He still thought, however, that "there is room for improvement" (personal interview).

Fracktivist strategies

Several Front Range residents discussed their perspectives on fracktivist strategies to contest unconventional oil and gas development in Front Range communities. In a departure from Luke et al. (2018), I examine these perspectives and consider attention to them particularly relevant to highlight before discussing non-fracktivist resistance efforts in the following section.

A number of the suburban residents I interviewed who opposed UOGD in their community had interactions with fracktivists as part of their resistance efforts. They both criticized fracktivist resistance efforts as being unstrategic, as well as desired a closer collaborative relationship with fracktivists, but perceived barriers to the latter. One such suburban resident stated:

> "The fracktivists I know are not thoughtful people. They're not rational, they're not strategic, and that's why they keep blowing holes in their foot, in my foot…in Colorado's feet. It's horrible what they've done. All the [Colorado] Supreme Court decisions…and all their ballot initiatives have been absolutely haphazard. If they could get strategic, we as a community can come together and be strategic, and get something on the ballot and still have it be meaningful" (personal interview).

Furthermore, this resident added that fracktivists are "looking for an easy solution. An easy solution is that we need a half-mile setback; an easy solution is that we need to ban hydraulic fracturing in this state or our municipalities. Those solutions are easy because they're wrong" (personal interview). In a similar vein, another suburban resident perceived an "unnecessary" and "counterproductive" polarization between fracktivists and other individuals resisting UOGD. She remarked regarding fracktivist criticism of her efforts contesting a UOGD facility in her neighborhood, "don't demonize what I'm doing, I won't demonize what you're

doing, maybe sometimes we can help each other in different ways" (personal interview). Another resident questioned fracktivist approaches to contesting UOGD, "do you want to be loud…and self-righteous? Or if you want to have a strategy to make a difference and see a change?" (personal interview).

In sum, suburban residents I interviewed desired to collaborate or work with fracktivists to resist UOGD, but criticized the fracktivist approaches and strategies. In the following section, I discuss approaches and strategies that suburban residents chose to pursue.

Non-fracktivist efforts of UOGD resistance

Rather than engaging in 'traditional' activist efforts—such as protests or acts of civil disobedience—to resist UOGD in their community, many suburban residents mobilized around specific extraction projects proposed in their neighborhoods—what Haggerty et al. (2018) refer to as "focusing sites." The resident resistance efforts identified through this research resonate well with those themes identified by Luke et al. (2018). In what follows, I discuss how residents focused their resistance efforts on existing regulations and operated through formal legal processes to contest UOGD in their neighborhood, avoiding characterization as a fracktivist, and sought to produce 'objective' knowledge. Notably, farmers are largely absent in the following discussion, since none of the farmers interviewed as part of this research reported engaging in efforts to oppose UOGD.

Working within existing rules and laws

For many opponents of UOGD, engaging in traditional activist strategies such as marches, rallies, and demonstrations does not fit with their social identity. Thus, these individuals may employ resistance strategies that utilize formal legal and regulatory processes to contest UOGD (Luke et al., 2018). Several instances of such were illustrated during interviews with suburban Front Range residents, of which I highlight two cases to illustrate these efforts—that of Windsor Neighbors for Responsible Drilling (WNRD) and Neighbors Affected by Triple Creek (NATC). The farmers in this study described satisfaction with UOGD and, perhaps unsurprisingly, did not report engaging in any efforts to oppose UOGD. However, Weld County farmers did contest UOGD-related infrastructure—namely, pipelines—and those efforts are briefly noted below.

Numerous residents of the Front Range community of Windsor mobilized in response to a UOGD facility proposed within their neighborhood. These residents formed a neighborhood group, Windsor Neighbors for Responsible Drilling (WNRD) to challenge the location of the project, which was designed to drill horizontally from a surface location within their neighborhood to vacant land. WNRD argued that it should be the other way around (Bluemel, 2015; personal interviews). Due to state regulations, these residents did not have official standing with the state oil and gas regulatory agency—the Colorado Oil and Gas Conservation Commission (COGCC)—to formally contest the location of the project within their neighborhood. WNRD members approached their municipal government to intervene on their behalf to challenge the project location. WNRD members also spoke at state-level oil and gas rulemaking meetings that, coincidentally, were taking place at the same time in order to raise

attention to the proposed project, as well as UOGD in residential neighborhoods, more generally (personal interviews). Members of WNRD drew attention to one particular regulation, COGCC Rule 604.c.(2)E, which states that "Multi-well production facilities should be located as far as possible from Building Units" (Colorado Oil and Gas Conservation Commission, 2019) as part of their public campaign (personal interviews). One WNRD member described their rationale behind these resistance strategies, "I can't change the laws, but I can work within them" (personal interview).

Similar events occurred in the City of Greeley, where residents mobilized to contest the location of the Triple Creek UOGD facility proposed within their neighborhood and formed the group, Neighbors Affected by Triple Creek (NATC) (personal interviews). NATC members spoke against the project at Greeley planning commission and city council meetings in order to challenge issuance of municipal permits required for the project to proceed. When those efforts failed, NATC filed suit against COGCC claiming the agency did not abide its own regulations in requiring an alternative site analysis and requiring the oil and gas company to use "best available technologies" before approving the project (Glick et al., 2016)

The few farmers that were part of this study did not report engaging in any resistance efforts against UOGD itself. However, farmers in Weld County, more generally, used county-level working group meetings aimed at developing new oil and gas pipeline regulations to bring attention to the negative impacts of pipelines on their farming practices (Knuth, 2018).

Distancing from activism

Besides working within existing laws and regulations, residents also sought to separate themselves from fracktivists in order to appeal to and gain the support of the broader public, in what Luke et al. (2018, p. 531) refer to as "distancing from activism." The strategies Luke et al. (2018) identify include resident participation in policymaking processes to develop alternatives and appearing objective, neutral, and representative of the entire community. These strategies resonate well with the interview data collected as part of my study. However, I identify additional strategies in which research participants sought to establish not only neutrality and objectivity, but also legitimacy and credibility through a demonstrated understanding of UOGD-related regulations and knowledge of the industry, as well as recognizing differences among operators.

Several residents I interviewed noted the importance of avoiding alienating individuals or groups and appealing to the broader public. Part of this strategy included careful consideration of terminology used in resisting UOGD. One resident remarked that, in contesting UOGD, the term 'fracking' should never be used in conversations with state government or oil and gas industry officials because "they'd figure you're either a fracktivist or don't understand that it's only one component of oil and gas development" (personal interview). Rather, using phrases such as "responsible oil and gas development" and "the industrialization of our neighborhoods" appeals to "real concerns that *everybody* shares and *everybody* can understand" (personal interview). This statement implies a perception that the concerns and perspectives of fracktivists are not shared by the broader public. As part of broadening appeal, several residents noted the importance of acknowledging and respecting property rights in

opposition efforts to UOGD. As one resident noted, “property rights is a sacred thing out here in the West" (personal interview). In their resistance efforts, WNRD members reported speaking not only of their own rights to protect their property values from the proposed UOGD facility, but also recognizing the rights of the landowners who would be hosting the facility on their property, as well as the rights of the operator to develop their mineral property (personal interviews).

WNRD members reported distancing themselves from fracktivists by avoiding a “leave it in the ground” approach to preventing the project from occurring. Rather, WNRD only sought to challenge the *location* of the project (personal interviews). One WNRD member discussed their approach to speaking at a state-level oil and gas meeting about protecting their home from the proposed UOGD facility, “I needed help right then…and that approach—keeping it in the ground—that wasn’t going to help me. And if I had a sign and protested and said ‘keep it in the ground,’ they’ve would have just piled over me” (personal interview). Another WNRD member said of the group’s strategy, “I think the fact that we came from a moderate, alternative solution approach, as opposed to a ‘no fracking’ approach, helped temper” skepticism of WNRD’s efforts (personal interview).

Front Range residents I interviewed adopted a strategy of establishing a relationship with the industry and local officials as part of their resistance efforts. One resident described her strategy as “working *closely* with the city, and *closely* with the oil and gas industry—not because I thought they were doing the right, but because that’s the only way to have a conversation” (personal interview). However, she remarked, “the irony is, I was accused of being a ‘fracktivist’ by the establishment, and by the ‘fracktivists’ as being kind of a

collaborator" (personal interview). A WNRD member remarked that they "probably have more contacts and friends in the industry than 'fracktivists' or environmentalists…but that's probably because…I've worked more with the industry, which I think has really helped us here---you can't not work with them" (personal interview).

The Front Range residents participating in this study also distanced themselves from fracktivism and sought to establish legitimacy and credibility through demonstrating knowledge of the oil and gas industry. Part of this was through understanding oil and gas-related laws and regulations. Many residents interviewed discussed spending countless hours of personal time researching and reviewing COGCC rules and regulations, as well technical aspects of horizontal drilling and hydraulic fracturing (personal interviews). For residents that were part of neighborhood groups resisting UOGD, this information was often shared among members at group meetings (personal interviews). One resident stated that possessing this legal, regulatory, and technical knowledge allowed them to construct sophisticated and compelling arguments as part of their resistance efforts against UOGD (personal interview).

Another way through which residents sought to distance themselves from fracktivists and establish legitimacy and credibility was through identifying industry practices and differences among operators. Several interviewees discussed their concern over the vast amount of water being used in hydraulic fracturing processes, particularly in an arid climate such as Colorado's. Yet, many of these residents praised the industry practice of reusing the 'waste' water after the hydraulic fracturing process is complete—in fact, these residents reported that the industry has noted better subsequent 'fracs' when reusing this water (personal interviews).

Additionally, residents made distinctions between both 'good' and 'bad' oil and gas developments and operators. Several interviewees remarked that it was inaccurate to paint all operators or extractive projects with a broad brush—differences exist among operators' business model and operators vary with respect to responsiveness to resident concerns (personal interviews). Interviewees discussed different operators and their projects by name, with one resident referring as an operator as a "predatory driller" that does not care how their facilities impact surrounding neighborhoods (personal interview). Speaking about the same operator, another resident said of their choice of drilling sites, "they'd put it in your kitchen sink, in my opinion, if they could" (personal interview). WNRD members praised the operator that had proposed a project in their neighborhood for changing their business model following the controversy—the operator now seeks project locations that exceed regulatory requirements regarding distances from homes (personal interviews). One resident remarked that "there's a lot of very ethical, conscientious oil companies out there…but a lot of these smaller guys come in for a fast buck and create huge messes" (personal interview).

A couple of Front Range residents I interviewed identified what UOGD facilities would be appropriate in residential neighborhoods—namely those in which UOGD facilities were constructed first. Following our interview, one resident showed me a nearby UOGD facility largely concealed behind berms with landscaping around which a residential subdivision was being built. He explained that "this is the proper way to do it"— the residents who purchase those homes will be choosing to live near oil and gas development (personal interview). Another resident spoke of the same development, "those houses and housing development

were built around the oil and gas, their mitigations were in place, and people k*now* what they're buying into" (personal interview).

Objective knowledge

In addition to, and also related to, distancing themselves from 'non-neutral' or 'biased' activism, individuals resisting UOGD may also produce and disseminate knowledge with greater perceived objectivity and neutrality (Luke et al., 2018). These activities may include an overt avoidance of information perceived as biased, abstaining from the use of lay or emotive evidence, and enlisting the expertise of scientific or technical professionals. Several of these strategies were adopted by Front Range residents contesting UOGD in their neighborhood, and I also identify other types of strategies not discussed by Luke et al. (2018).

As part of its strategies to contest the UOGD project slated for their neighborhood, WNRD hired oil and gas experts, including a petroleum geologist, to examine the feasibility of alternative locations for the production facility (Bluemel, 2015; personal interviews). These experts explored a variety of options through which the operator could relocate the project site away from existing residential development, while still ensuring the ability to develop the targeted minerals. One of the options identified by these experts ultimately became the project site and design adopted by the operator (Bluemel, 2015).

WNRD had a video professionally produced and posted on YouTube as part of their resistance strategy. WNRD members stated that the intent of creating the video was to draw attention to issues associated with UOGD in residential neighborhoods, but not convey an anti-industry viewpoint (personal interviews). In describing the video, one WNRD member stated

that “we made clear that we are not anti-industry…we just think oil and gas development should be done the right way, not that they should disappear, not that they don’t have the right to recover all of these minerals, because they *do* under the state constitution and under the laws—they *do* have a right to recover those minerals” (personal interview).

Similar to findings identified by Luke et al. (2018), several Front Range residents interviewed as part of this study noted the importance of avoiding appeals to emotion in opposing UOGD. One resident said that “information is everything when dealing with the energy sector,” “when you give reasonable information to reasonable people, they make reasonable decisions” (personal interview). He explained that it is natural to express emotion regarding oil and gas projects proposed in one’s neighborhood; however, emotions do not contribute productively to discussions and negotiations regarding such projects. Furthermore, information must be accessible to “everyday people”—you cannot be disparaging or dismissive of individuals like a “stay-at-home mom” (personal interview). One resident stated that displays of emotion are unhelpful when speaking against UOGD in communities. In attending meetings and COGCC hearings to speak against UOGD, she noted that, during their time to address public officials, members of the public would cry when speaking about UOGD impacting their homes and neighborhoods—“the regulators, the attorneys…they’re immune to that” (personal interview).

Several interviewees noted that drawing on findings in peer-reviewed scientific studies in their efforts to resist UOGD were, in many cases, ineffective. This finding stands in stark contrast to those of Luke et al. (2018). Residents reported that state regulators and some local officials are dismissive of scientific studies on potential impacts of UOGD. One resident stated

that her initial strategy at hearings was to focus on the health impacts of oil and gas development on surrounding neighborhoods, hoping those facts would be persuasive. However, facts and research had no impact—"there was not leverage really to make those more sophisticated arguments…and it was more back down to quality of life in the community and traffic, because that was the one leverage we had in terms of the laws" (personal interview). Another resident discussed her experiences testifying at local and state-level hearings regarding UOGD projects, in which she prepared immensely—"I've got this peer-reviewed research and I thought it was going to change their minds – I thought it was going to have a huge impact. And it didn't" (personal interview).

As discussed above, the suburban residents in this study engaged in a number of strategies to resist UOGD, but in such a way so as to work within existing rules and laws, appeal to the broader public and avoid being labeled a 'fracktivist.' Such strategies included challenging UOGD projects based on their compliance with state regulations, demonstrating oil and gas-related legal and regulatory knowledge, as well as understanding industry practices and differences between operators and UOGD facilities.

Conclusion

This study uses the case of the Front Range of Colorado to investigate perceptions of fracktivism among rural farms and suburban residents. To do so, I built a conceptual framework based on Luke et al. (2018) to examine fracktivism in the Front Range area through the American West region as a place. I add to Luke et al. (2018) by including suburban perspectives and highlighting differences between techniques of oil and gas development—vertical versus

horizontal. I found additional themes beyond those identified by Luke et al. (2018, including complexities in defining 'activist' ('fracktivist'), how residents position their viewpoints in relation to fracktivists, and the importance of issues of credibility and legitimacy in resisting UOGD.

This study contributes to the UOGD literature by illustrating the nuances and complexities of viewpoints on UOGD besides those of industry proponents and vocal activists. Furthermore, this study highlights differences in findings from that of Luke et al. (2018) by including the perspectives of suburban residents, in addition to those of rural farmers. I also note differences in perspectives on oil and gas development in relation to the types of drilling technology—vertical or horizontal—used.

Future research should further build on the themes identified by Luke et al. (2018) and this study to provide a fuller understanding of varying perspectives and resistance efforts to UOGD. Such studies might attend to issues of regional differences in hydrocarbon extraction practices, setting (e.g., urban, suburban, rural), as well as variations among physical landscapes of the regions in which UOGD occurs.

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- Chapter 5 –
Conclusion

This dissertation sheds new light on what is, arguably, one of the most contentious environmental issues of the present day—unconventional oil and gas development (UOGD). This research project uses Colorado's Front Range area as a case through which to illustrate various controversies surrounding this new phenomenon of hydrocarbon extraction. Although UOGD can certainly stir controversy and be met with significant resistance regardless of the geographic location in which it occurs, the unique characteristics of the Front Range position the area well for an investigation of conflicts surrounding the development of hydrocarbon resources. Notably, Front Range communities, such as Greeley, have grappled with balancing competing land uses of housing and commercial development with hydrocarbon extraction since the 1980s. Although these issues have never entirely disappeared, they have certainly taken on new significance as processes of rapid urbanization and UOGD activities increasingly intersect and overlap due to a boom in hydrocarbon extraction encouraged by horizontal drilling and hydraulic fracturing technologies. This dissertation examines three types of controversies associated with UOGD that have emerged in the Front Range—those of competing capital interests as operators vie for rights of access to hydrocarbon resources, municipal challenges regarding oil and gas development in residential areas, and perceptions among residents of efforts to resist UOGD. Each of these three controversies is addressed in a chapter of this dissertation.

In Chapter 2, I used an access analysis framework through which to examine how the changed spatial dimensions of horizontal drilling has not only increased access to oil and gas

resources, but complicated laws and regulations governing such extractive activities.

I examined the how laws and regulations designed for vertical development of oil and gas resources have been complicated by the changed spatial dimensions of hydrocarbon extraction brought about by horizontal drilling. I argued that horizontal drilling, as a technological mechanism of access, has introduced spatial complexities requiring a reconsideration of rights-based mechanisms of access to oil and gas resources in choosing between competing claims to these minerals.

In Chapter 3, I provided a comparative study examining local government challenges regarding oil and gas development in residential areas through the cases of vertical development in Greeley during the 1980s and a horizontal development project in contemporary Windsor. In this chapter, I demonstrated that the different spatial dimensions of these two drilling technologies presented unique challenges that influenced the politics of urban growth. Vertical drilling presented significant urban growth challenges for Greeley, largely due to the dispersed nature of vertical well siting—challenges which horizontal drilling technology has largely alleviated, as illustrated through the case of Windsor. However, the spatial aspects of horizontal drilling creates new significance of municipal political boundaries when drilling in cities by facilitating the ability of operators to engage in *strategic siting* of oil and gas production facilities for more favorable conditions of development. Furthermore, I found that the subterranean space of cities and the extractive activities occurring therein play a significant role in shaping resident and municipal responses to urban oil and gas development.

Chapter 4 demonstrated that polarized portrayals of perspectives on unconventional oil and gas development—a binary between proponents and opponents—are an

oversimplification. This chapter contributes to existing geographic and social sciences literature on UOGD through an analysis of more 'middle ground' perspectives of Front Range farmers and suburban residents regarding unconventional oil and gas development. I examined the role that place identity and social identity played in these residents' perceptions of fracktivists, in addition to alternative resistance strategies adopted by suburban residents to contest extractive activities in their communities. Both farmers and suburban residents were critical of fracktivist perspectives on and efforts to resist UOGD. However, several suburban residents indicated that potential exists to collaborate with fracktivists to achieve more mutually acceptable outcomes regarding UOGD in communities. Suburban resident largely sought to avoid being labeled as a fracktivist and directed their resistance efforts toward appealing to the broader public, presenting objective knowledge, and establishing legitimacy and credibility of their claims.

Themes and significance of research

This research provides two major interventions which contribute to the literature in resource geography and urban geography—consideration of the impacts and implications of the shift from vertical to horizontal drilling technologies, and an examination of challenges, consequences, and controversies surrounding extractive activities in urban and suburban environments. Much of the popular media and scholarly literature has focused on issues related to hydraulic fracturing, while largely neglecting to give attention to the implications of its partner technology—horizontal drilling. This is not to dismiss the importance of research investigating the impacts of hydraulic fracturing. But this dissertation demonstrates that the

spatial aspects of horizontal drilling technology have greater significance than an initial examination might suggest. Horizontal drilling has led to disputes between oil producers over rights of access to subsurface hydrocarbon resources, it has presented challenges for municipalities in controlling conditions of development to mitigate unwanted impacts on communities, and it has resolved issues associated with oil and gas development on agricultural land while creating new controversies and resistance by allowing UOGD to occur within populated areas. This latter idea points to another major theme within this dissertation.

The Front Range is only one of a few (sub)urban areas in the US experiencing UOGD. Much of the existing geographic and social sciences research on oil and gas development, as well as other types of resource extraction, has been limited to investigations of such activities in rural settings. As this research demonstrates, industrial processes of resource extraction present a different set of concerns when they occur in populated areas of urban and suburban environments. This is particularly true when considering that horizontal drilling allows for production facilities to be condensed onto individual sites and located within residential areas. At a superficial level, this would imply that a larger number of residents would be subject to the impacts of UOGD than perhaps in a rural area. However, as this dissertation illustrates, the consequences run much deeper. Oil and gas development and residential and commercial development in (sub)urban locations are competing land uses and their co-presence has significant implications for where and how a community grows. This raises particular challenges for planners in accommodating oil and gas development while attending to matters of urban growth and the character of communities.

A third theme running through this dissertation are relationships between the surface and subsurface. These take the form of physical connections, such as oil and gas wells themselves and production equipment located at the surface. The surface locations of these physical connections have impacts on the surrounding urban environment. The extensions of surface boundaries to the subsurface—including those of the PLSS, property ownership, and municipal political boundaries—also have important ramifications regarding access to hydrocarbon resources and the ability to benefit from their development. Additionally, this dissertation illustrates theoretical connections between the surface and subsurface. The subsurface spaces and hydrocarbon resources contained therein not only serve as spaces of opportunity, but extractive activities can also render the subsurface a space of conflict over access, as well as a space of potential hazard. This dissertation contributes to geographic literature on vertical and volumetric spaces by moving beyond larger-scale geopolitical matters to more micro-scale analyses of controversies over matters of property, access, and territory as they relate to subsurface resource extraction.

Limitations

In addition to the limitations discussed in each of the preceding chapters, other limitations to this research exist. Notably, I was only able to secure a small (twenty-two) number of interviews. Although a significantly larger number of letters and emails were sent requesting interviews, I received a very limited response from these requests. This is not altogether surprising, however, since the focus of my research project is a highly contentious topic and it seemed to me that many individuals I encountered during my fieldwork—including

those who agreed to an interview—held a certain degree of apprehension regarding my project, particularly since several were uncertain of my motivations. Indeed, a few individuals sought to ascertain the motivations underlying my project through email or by telephone before agreeing to an interview. Other potential interviewees did not respond to interview requests sent directly by myself, but agreed to an interview after a research participant contacted them to allay any reservations they might have had. Because of the limited number of research participants, this research relied on the depth of interviews with those who *were* willing to speak with me.

Some of the meetings and hearings I attended as part of my fieldwork for observation purposes exceeded several hours and, due to matters of time constraints, hunger, and fatigue, it was not always possible to remain for the entire duration of these events. However, audio recordings for these meetings and hearings were often available through the government and agency websites for analysis of those portions I was not present for.

Another limitation to this research pertains to the fact that certain aspects of the controversies discussed in this dissertation are related to specific state laws and regulations governing oil and gas development in Colorado. While many hydrocarbon-producing states in the US have similar laws and regulations, the specifics of these may not translate well to oil and gas extractive activities occurring in other geographic locations in the US.

Future research

Several avenues exist for future research regarding oil and gas development in Colorado, as well as other states in the US, or even globally. As mentioned above, variations

exist regarding state- or even basin-specific laws and regulations, such as those establishing spacing requirements. Future research may explore the implications of variations among these laws and regulations on oil and gas development. Furthermore, although compulsory pooling received limited attention in Chapter 2, to date, geographic and other social sciences literature has neglected to substantially engage with issues regarding the practice. Research on compulsory pooling is ripe for investigating issues of fairness and equity in the development of oil and gas resources. Related to this point, I contend that future research on hydrocarbon extraction ought to give more explicit attention to the role that property and private ownership of hydrocarbon minerals play in controversies surrounding their extraction, since this is a characteristic almost entirely unique to mineral ownership in the US. Although mentioned briefly in Chapters 2 and 3, a more thorough investigation of (slant) directional drilling may provide additional useful insight as to the implications of drilling technologies on spaces of extraction. Finally, future research might consider the role that other stakeholders besides operators, residents, regulators, and local governments—for example, property developers—play in shaping UOGD projects, as well as the impacts of extractive processes and UOGD facilities on these stakeholders.

APPENDIX A: GLOSSARY OF TERMS

Area of drainage: The area surrounding an oil and gas well from which hydrocarbon resources are depleted during production.

Horizontal drilling: A drilling technique which allows the drill bit to deviate from a vertical position and enter a target geologic formation laterally.

Hydraulic fracturing ("fracking"): A technique of stimulating hydrocarbon production from oil and gas wells by pumping a mixture of typically water, sand, and chemicals into a well under high pressure, thereby fracturing the geologic formation and releasing hydrocarbon resources.

Operator: In the oil and gas industry, an operator is a company that designs, manages, and oversees an oil and gas development project, including exploration and production activities, as well as securing a drilling contractor and service companies.

Pooling: Pooling allows for the aggregation of two or more tracts of mineral ownership for sufficient acreage to meet spacing unit requirements. Pooling ensures that mineral owners receive their equitable share in the production from a given well, typically determined by the pro rata percentage of land ownership within the spacing unit. Pooling statutes vary by state.

Spacing: Well spacing regulations establish minimum distances both between wells and between wells and property or lease lines. Well spacing is intended to prevent 'waste' of oil and gas resources by deterring overdrilling and damage to natural reservoir pressure. Regulations governing well spacing often vary by state and geologic formation.

Spacing unit: Spacing units are exclusive spaces designated to individual wells in order to account for areas of drainage surrounding oil and gas wells.

Vertical drilling: A conventional method of extracting of oil and gas resources by drilling a vertical well straight down into a target geologic formation to extract oil and gas resources.

APPENDIX B: INTERVIEW QUESTIONS

Residents

1. How long have you lived at your current residence? Where are you from originally?
2. Are there fracking wells located on or underneath your property, and is the presence/absence of wells a product of your own decision-making?
    a. What factors did you consider when deciding whether to allow/not allow fracking on/under your property?
    b. How do you feel about your decision to allow/not allow fracking on your property?
3. What impacts, whether positive or negative, do you feel fracking has had on Greeley/Weld County? Or, have you noticed or experienced any changes in Greeley/Weld County since fracking began, if so, what?
    a. Politics? Social tensions? Economics? Physical landscape?
    b. What about the State of Colorado? Or the American West as a region?
4. Do you feel that outside perceptions of Greeley/Weld County/Colorado have changed since fracking began in the area? If so, how?
5. Are you a member of any groups organized for purposes of promoting or contesting fracking, whether at a local, state, or other level?
    a. If so, what motivated you to organize or join the group, and what are the groups goals/activities?
    b. Is the group affiliated with other similar groups?
6. What risks, if any, do you associate with fracking?
    a. Who or what are impacted by these risks?
    b. Do you feel these risks vary by location and, if so, how?
7. What benefits or opportunities, if any, do you associate with fracking?
    a. For whom or what do these benefits or opportunities exist?
    b. Do you feel that these benefits or opportunities vary by situation or location and, if so, how?
8. Do you feel that your perceptions or understanding of risks, benefits, or opportunities associated with fracking differ from that of others? If so, from which individuals or groups of people, how so, and why do you think this is the case?
9. Where have you or do you currently get information about fracking (and its risks and benefits), and why that particular source(s)?
    a. Are there sources you avoid for fracking-related information and, if so, why?
10. What are your thoughts on the 2013 secession movement? Did you support the movement? What do you feel were the primary underlying factors or motivations behind the movement?

11. How do you feel about the removal of fracking-related initiatives from the 2014 ballot and the subsequent creation of the Colorado Oil and Gas Task Force?
    a. What are your thoughts about the Task Force (composition, mission, etc.) and their final recommendations?
12. What are your thoughts on the May 2016 Colorado Supreme Court ruling on overturning municipal/local bans/moratoria on fracking/oil and gas development?
13. What are your thoughts on the fracking-related initiatives slated to appear on the upcoming November 2016 ballot?
14. Who do you feel ought to have a say in decisions over fracking/oil and gas development siting? At what level should these types of decisions be made (individual, community, county, state, other/combination), and why?
    a. Are there certain individuals/groups/agencies that ought to be excluded from decision-making on siting and permitting of fracking wells?
15. What factors do you feel underlie the controversies over fracking in Colorado?

<u>Windsor Neighbors for Responsible Drilling members</u>

1. How long have you lived at your current residence? Where are you from originally?
2. How did you learn of the proposed fracking project on the Pace property?
3. How did the Windsor Neighbors for Responsible Drilling (WNRD) group form and for what purpose(s)?
4. What were circumstances and purpose behind WNRD hiring an oil and gas attorney and oil and gas experts? How were these individuals identified? How did their expertise help WNRD? Were there instances where their expertise hindered goals of WNRD?
5. Do you feel that the risks and/or benefits/opportunities posed by the proposed well siting on the Pace property are unique to that particular development, or are similar to risks, benefits, and/or opportunities of other fracking developments?
6. How was annexation chosen as a strategy to influence the siting of the fracking development on the Pace property? Were other strategies considered?
7. How were Town of Windsor officials approached regarding possible annexation of the neighborhoods around the Pace property, and can you explain your role in the annexation process?
8. How has Windsor and the surrounding area changed as a result of the oil boom/fracking, whether in positive ways or perhaps less desirable ways?
    a. Do these changes extend beyond the county boundaries and, if so, how?
9. Do you feel that outside perceptions of Windsor/Weld County/Colorado have changed since fracking began in the state? If so, how?
10. What risks, if any, do you associate with fracking?
    a. Who or what are impacted by these risks?

    b. Do you feel these risks vary by location and, if so, how?
11. What benefits or opportunities, if any, do you associate with fracking?
    a. For whom or what do these benefits or opportunities exist?
    b. Do you feel that these benefits or opportunities vary by location and, if so, how?
12. Do you feel that your perceptions of risks, benefits, or opportunities associated with fracking differ from that of others? If so, from which individuals or groups of people, and how so/why do you think this is the case?
13. Where have you or do you currently get information about fracking (and its risks and benefits), and why that particular source(s)?
    a. Are there sources you avoid for fracking-related information and, if so, why?
14. What are your thoughts on the 2013 secession movement? Did you support the movement? What do you feel were the primary underlying factors or motivations behind the movement?
15. How do you feel about the removal of fracking-related initiatives from the 2014 ballot and the subsequent creation of the Colorado Oil and Gas Task Force?
    a. What are your thoughts about the Task Force (composition, mission, etc.) and their final recommendations?
16. What are your thoughts on the May 2016 Colorado Supreme Court ruling on overturning municipal/local bans/moratoria on fracking/oil and gas development?
17. What are your thoughts on the fracking-related initiatives slated to appear on the upcoming November 2016 ballot?
18. Who do you feel ought to have a say in decisions over fracking/oil and gas development siting? At what level should these types of decisions be made (individual, community, county, state, other/combination), and why?
    a. Are there certain individuals/groups/agencies that ought to be excluded from decision-making on siting and permitting of fracking wells?
19. What factors do you feel underlie the controversies over fracking in Colorado?

<u>Greeley City Council</u>

1. How long have you served on the city council?
2. What factors did you and/or the city council as a whole figure into the decision to overturn the planning commission's denial of the permit for the Triple Creek project?
3. What is your understanding of why the city planning commission denied the permit, and what are your thoughts about it?
4. Did the Triple Creek project/permit application differ from previously proposed projects in Greeley and, if so, how?
5. What changes, whether positive or negative, has fracking brought to Greeley? Weld County? Colorado? the U.S.?

6. Do you feel that outside perceptions of Greeley have changed since fracking began in the city? If so, how?
7. What risks, if any, do you associate with fracking?
    a. Who or what are impacted by these risks?
    b. Do you feel these risks vary by location?
8. What benefits or opportunities, if any, do you associate with fracking?
    a. For whom or what do these benefits or opportunities exist?
    b. Do you feel that these benefits or opportunities vary by location?
9. Do you feel that your perceptions of risks, benefits, or opportunities associated with fracking differ from that of others? If so, from which individuals or groups of people, and how so/why do you think this is the case?
10. Where have you or do you currently get information about fracking (and its risks and benefits), and why that particular source(s)?
    a. Are there sources you avoid for fracking-related information and, if so, why?
11. What are your thoughts on the 2013 secession movement? What do you feel were the primary underlying factors or motivations behind the movement?
12. How do you feel about the removal of fracking-related initiatives from the 2014 ballot and the subsequent creation of the Colorado Oil and Gas Task Force?
    a. What are your thoughts about the Task Force (composition, mission, etc.) and their final recommendations?
13. What are your thoughts on the May 2016 Colorado Supreme Court ruling on overturning municipal/local bans/moratoria on fracking/oil and gas development?
14. What are your thoughts on the fracking-related initiatives slated to appear on the upcoming November 2016 ballot?
15. Who do you feel ought to have a say in decisions over fracking/oil and gas development siting? At what level should these types of decisions be made (individual, community, county, state, other/combination)?
16. What factors do you feel underlie the controversies over fracking in Colorado?

<u>Windsor Town Board</u>

1. How long have you served as a town board member?
2. How were you approached by the Windsor Neighbors for Responsible Drilling (WNRD) group regarding potential annexation of the neighborhoods surrounding the Pace property?
3. What information/evidence did you and/or the other board members examine/consider as part of the decision to pursue annexation? What were the deciding factors in pursuing annexation of the neighborhoods? Were other potential strategies to influence the siting of the drilling considered by the town board?

4. Do you feel that the risks and/or benefits/opportunities posed by the proposed well siting on the Pace property are unique to that particular development, or are similar to those of other fracking developments in Windsor or elsewhere? How so?
5. What were the main points of contention or debate at the COGCC hearing on development of the Pace property?
6. What is your understanding of why Great Western Oil & Gas decided to move the proposed drilling to a site not on the Pace property?
7. Do you feel that annexation is a useful strategy in influencing siting decisions for oil and gas development?
    a. What were the benefits of annexing the neighborhoods?
    b. What were the risks of annexing the neighborhoods?
8. What sorts of challenges or opportunities did the annexation and subsequent hearing process with the COGCC present?
9. Do you feel that outside perceptions of Windsor/Weld County/Colorado have changed since fracking began in the state? If so, how?
10. What risks, if any, do you associate with fracking?
    a. Who or what are impacted by these risks?
    b. Do you feel these risks vary by location and, if so, how?
11. What benefits or opportunities, if any, do you associate with fracking?
    a. For whom or what do these benefits or opportunities exist?
    b. Do you feel that these benefits or opportunities vary by location and, if so, how?
12. Do you feel that your perceptions of risks, benefits, or opportunities associated with fracking differ from that of others? If so, from which individuals or groups of people, and how so/why do you think this is the case?
13. Where have you or do you currently get information about fracking (and its risks and benefits), and why that particular source(s)?
    a. Are there sources you avoid for fracking-related information and, if so, why?
14. What are your thoughts on the 2013 secession movement? Did you support the movement? What do you feel were the primary underlying factors or motivations behind the movement?
15. How do you feel about the removal of fracking-related initiatives from the 2014 ballot and the subsequent creation of the Colorado Oil and Gas Task Force?
    a. What are your thoughts about the Task Force (composition, mission, etc.) and their final recommendations?
16. What are your thoughts on the May 2016 Colorado Supreme Court ruling on overturning municipal/local bans/moratoria on fracking/oil and gas development?
17. What are your thoughts on the fracking-related initiatives slated to appear on the upcoming November 2016 ballot?
18. Who do you feel ought to have a say in decisions over fracking/oil and gas development siting? At what level should these types of decisions be made (individual, community, county, state, other/combination), and why?

    a. Are there certain individuals/groups/agencies that ought to be excluded from decision-making on siting and permitting of fracking wells?
19. What factors do you feel underlie the controversies over fracking in Colorado?

Great Western Oil & Gas Company

1. How long have you been employed by Great Western Oil & Gas? Employed in the oil and gas industry professionally, and in what capacity? Has it been only in Colorado, or also elsewhere?
2. How did Great Western first learn of the intent of Windsor Neighbors for Responsible Drilling (WNRD) group to contest drilling on the Pace property, and what was Great Western's response?
3. In what ways did the information/data gathered and used by the oil and gas experts hired by WNRD differ from that of Great Western? To what factors would you attribute this discrepancy?
4. Do you feel that the risks and/or benefits/opportunities posed by the proposed well siting on the Pace property are unique to that particular development, or are similar to risks, benefits, and/or opportunities of other fracking developments? How so?
5. When did Great Western learn of the Town of Windsor's intent to annex the neighborhoods surrounding the Pace property, and how did they respond?
6. What factors led to Great Western's decision to ultimately move drilling from the Pace property to an alternate location? Were there benefits and/or drawbacks to doing so?
7. Has Great Western gone through COGCC hearing processes for other proposed drilling sites? If so, was the hearing on Pace property project unique from other hearings, and in what ways?
8. What changes, whether positive or negative, has fracking brought to Windsor? Weld County? Colorado? the U.S.?
9. What risks, if any, do you associate with fracking?
    a. Who or what are impacted by these risks?
    b. Do you feel these risks vary by location and, if so, how?
10. What benefits or opportunities, if any, do you associate with fracking?
    a. For whom or what do these benefits or opportunities exist?
    b. Do you feel that these benefits or opportunities vary by location and, if so, how?
11. Do you feel that your perceptions of risks, benefits, or opportunities associated with fracking differ from that of others? If so, from which individuals or groups of people, and how so/why do you think this is the case?
12. What are your thoughts on the 2013 secession movement? Did you support the movement? What do you feel were the primary underlying factors or motivations behind the movement?
13. How do you feel about the removal of fracking-related initiatives from the 2014 ballot and the subsequent creation of the Colorado Oil and Gas Task Force?

14. What are your thoughts about the Task Force (composition, mission, etc.) and their final recommendations?
15. What are your thoughts on the May 2016 Colorado Supreme Court ruling on overturning municipal/local bans/moratoria on fracking/oil and gas development?
16. What are your thoughts on the fracking-related initiatives slated to appear on the upcoming November 2016 ballot?
17. Who do you feel ought to have a say in decisions over fracking/oil and gas development siting? At what level should these types of decisions be made (individual, community, county, state, other/combination), and why?
    a. Are there certain individuals/groups/agencies that ought to be excluded from decision-making on siting and permitting of fracking wells?
18. What factors do you feel underlie the controversies over fracking in Colorado?

CURRICULUM VITAE

Nicholas Schuelke
Department of Geography
University of Wisconsin-Milwaukee
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Milwaukee, WI 53201

EDUCATION

University of Wisconsin-Milwaukee, Milwaukee, Wisconsin
Ph.D., Geography, August 2019 (Ryan Holifield, Advisor)

Dissertation: *Spatial Dimensions of Drilling Technologies: Controversies over Unconventional Oil and Gas Development in Northern Colorado*

University of Wisconsin-Milwaukee, Milwaukee, Wisconsin
M.A., Geography, August 2014 (Ryan Holifield, Advisor)

Thesis: *Urban River Restoration and Environmental Justice: Addressing Flood Risk Along Milwaukee's Kinnickinnic River*

University of Wisconsin-Milwaukee, Milwaukee, Wisconsin
Post-baccalaureate studies, Geography, 2011 – 2012

University of Wisconsin, Madison, Wisconsin
B.A., Communication Arts – Radio, Television, and Film, 2004 (Graduated with Distinction)

Marquette University, Milwaukee, Wisconsin
Communication Studies, 1999 – 2000

PUBLICATIONS

Holifield, R., & Schuelke, N. (2015). The place and time of the political in urban political ecology: Contested imaginations of a river's future. *Annals of the Association of American Geographers*, *105*(2), 294-303.

AWARDS AND HONORS

Mary Jo Read Graduate Fellowship, Department of Geography, University of Wisconsin-Milwaukee; 2014 – 2019

Mary Jo Read Travel Award, Department of Geography, University of Wisconsin-Milwaukee; 2013, 2016, 2017, 2018

Clinton Edwards Field Research Travel Award, Department of Geography, University of Wisconsin-Milwaukee; 2016 – 2017

Distinguished Graduate Student Service Award, Honorable Mention, Department of Geography, University of Wisconsin-Milwaukee; 2015

A.T. Brown Award for the Best Graduate Paper, Department of History, University of Wisconsin-Milwaukee; 2014

Vilas Grant, Department of Communication Arts, University of Wisconsin-Madison; 2003 – 2004

Ignatius Scholarship, Marquette University; 1999 – 2000

INVITED PRESENTATIONS

2017 "Local challenges and controversies over unconventional oil and gas development in Weld County, Colorado." Presented at the University of Northern Colorado, Greeley, CO. (April 12).

CONFERENCE PARTICIPATION

2019 Horizontal drilling, property, and access: Securing subterranean territories of oil and gas extraction." Presented at the American Association of Geographers Annual Meeting, Washington, DC. (April 5).

2018 "Local strategies of contesting oil and gas development: The Pace Project in Windsor, Colorado." Presented at the American Association of Geographers Annual Meeting, New Orleans, LA. (April 12).

2017 "'Honeycombing the underground': Spatial dimensions of controversy over oil and gas development in Greeley, Colorado." Presented at the Graduate History Association Conference at Washington University, St. Louis, MO. (April 1).

2016 "Geographic dimensions of controversy over unconventional oil and gas development in the American West: The case of Weld County, Colorado." Presented at the American Association of Geographers Annual Meeting, San Francisco, CA. (March 29).

2013 "Urban political ecology versus urban (apolitical) ecology: Exploring the transformation of Milwaukee's Kinnickinnic River." Co-presented by Ryan Holifield and Nick Schuelke at the Association of American Geographers Annual Meeting, Los Angeles, CA. (April 10).

CAMPUS TALKS

2018 "Environment, resources, and economic development: Intersections of hydrocarbon development and urbanization along Colorado's Front Range." Invited talk for Geography 115 - Globalization and Economic Development course at the University of Wisconsin-Milwaukee. (November 15).

2018 "Spacing, pooling, and horizontal drilling: Securing subterranean territories of oil and gas extraction." Presented at the UW-Milwaukee Department of Geography Colloquium Series. (March 16).

2016 "Geographic dimensions of controversy over unconventional oil and gas development in the American West: The case of Weld County, Colorado." Presented at the UW-Milwaukee Department of Geography Colloquium Series. (March 25).

2014 "Environmental (in)justice and urban river restoration: Exploring controversy surrounding the rehabilitation of Milwaukee's Kinnickinnic River." Presented at the UW-Milwaukee Department of Geography Colloquium Series. (March 28).

WORKSHOPS

2018 Upper Midwest Nature-Society Graduate Workshop, Co-organizer and Participant. Hosted by University of Wisconsin-Madison. (September 29-30).

TEACHING EXPERIENCE

Instructor, Department of Geography, University of Wisconsin-Milwaukee

Geography 125 – "Introduction to Environmental Geography" (Face-to-face and online)
Geography 215 – "Introduction to Geographic Information Science"

Teaching Assistant, Department of Geography, University of Wisconsin-Milwaukee

Geography 120 – "Our Physical Environment"
Geography 125 – "Introduction to Environmental Geography"
Geography 215 – "Introduction to Geographic Information Science"
Geography 600 – "Perspectives on Geography" (senior capstone course)

EDITORIAL SERVICE

2018 Chapter reviewer, *River Restoration: Social and Policy Perspectives from Practice and Research*, Wiley Publishing.

DEPARTMENTAL/UNIVERSITY SERVICE

Volunteer, UW-Milwaukee Exploring Majors Fair; 2018
Graduate Student Judge, UW-Milwaukee Undergraduate Research Symposium; 2018
Volunteer, UW-Milwaukee Graduate School Open House; 2014, 2015, 2017, 2018
Project Assistant, Public Relations Committee, Department of Geography, University of Wisconsin-Milwaukee; 2016 – 2017
Graduate Student Representative, Department of Geography, University of Wisconsin-Milwaukee; 2015 – 2016
Volunteer, Gendered Rights to the City: Intersections of Identity and Power Conference, University of Wisconsin-Milwaukee; 2015
Graduate Student Judge, UW System Symposium for Undergraduate Research; 2014

PROFESSIONAL AFFILIATIONS

American Association of Geographers